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Architecture and Characteristics of Antenna Systems onboard Inmarsat Spacecraft for Mobile Satellite Communications

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ABSTRACT

This paper describes architecture and characteristics of special antenna systems onboard Inmarsat Geostationary Earth Orbit (GEO) spacecraft for Mobile Satellite Communications (MSC). These spacecraft provides satellite links for communications, tracking, monitoring and logistics solutions between mobile and personal units as a Mobile Earth Station (MES) and Gateways or Ground Earth Stations (GES) achieved via Geostationary Earth Orbit (GEO) satellite constellation. Inmarsat GEO MSS operator is deploying advanced technology and technique to deliver Voice, Data and Video (VDV) for all mobile applications worldwide, excluding Polar Areas. The Inmarsat organization received sufficient funds to implement at first solutions for maritime applications and in the next phase to develop additional services such as land (road and rail) and finally for aeronautical applications. The Inmarsat team overcame all the problems and challenges, gaining the attribute of only one global mobile satellite operator with a significant professional attribute. Regarding the improvement of the space segment and in particular the service for mobile and personal applications, antenna systems on the Inmarsat spacecraft are being considered. Modern spacecraft antenna characteristics and link performance with monobeam and multibeam antenna coverage are presented. Here are presented the possible basic types of antennas installed on board for MSC service.

1. Introduction.

The first commercial maritime GEO Mobile Satellite Communications (MSC) system was proposed and built by the International Maritime Organization (IMO) in London in 1979, known as the International Maritime Satellite Organization (Inmarsat). Inmarsat started out as a non-profit organization providing maritime satellite communications including distress and safety solutions. In subsequent phases, Inmarsat developed additional services for land (road and rail), personal and aeronautical applications. For the first decade of operation, Inmarsat leased the space segment from Comsat (three Marisat satellites F1, F2 and F3), from ESA (two Marecs satellites A and B2) and from Intelsat (three Intelsat V-MCS A, B and D).

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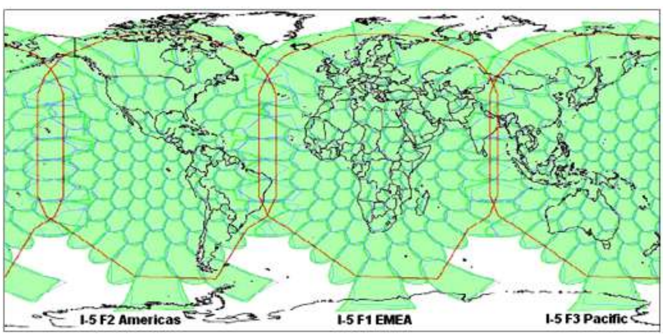
The Inmarsat GEO satellite constellations were originally configured in three oceanic regions: AOR, IOR and POR, each with an operational satellite and one spare in orbit. These satellite constellations are known as the first generation of the Inmarsat GEO network. Inmarsat was not responsible for TT&C, but operations were controlled by the Inmarsat Network Control Centre (NCC) in London. Inmarsat then operated with four 2nd generation Inmarsat-2 birds launched in 1990/92. with a capacity equivalent to about 250 Inmarsat-A voice circuits. These satellites were built to provide coverage of four oceanic regions: AOR-E, AOR-W, IOR and POR by British Aerospace's Space and Communications Division (Matra Marconi Space).

The US company Lockheed Martin has built a new spacecraft bus for the next generation of Inmarsat-3 spacecraft, based on the GE Astro Space Series 4000, with a height of 2.5 m and a radial envelope of 3.2 centered on the thrust cone. Thus, the Matra company built communication cargo, antennas, repeater and other electronic equipment. The payload and solar arrays are mounted on the N and S facing panels, while the receiver (Rx) and transmitter (Tx) L-band reflectors, mounted on the E and W panels, are powered by a cup array. Moreover, the navigation antenna is located on the panel facing the ground. A huge advantage of Inmarsat-3 satellites is to concentrate power on certain high traffic areas within the footprint.

These satellites can also reuse portions of the L-band for non-adjacent spot beams, effectively doubling the satellite's capacity. Responding to the growing demands of corporate mobile satellite users high speed Internet access and multimedia connections, Inmarsat built the fourth generation of Inmarsat-4 satellites as a gateway to a new mobile and personal satellite broadband network. Inmarsat has awarded Europe's Astrium a US$700 million contract to build three Inmarsat I-4 satellites, which will support the new mobile broadband and Broadband Global Network (BGAN).

Figure 1: Inmarsat-5 Global Spot Beam Coverage.



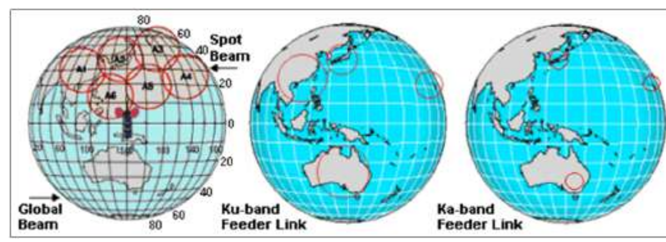
Source: Author.

The mobile broadband and BGAN for personal, fixed and mobile applications have to deliver fast Internet and Intranet content and solutions, video on demand, videoconferencing, facsimile, E-mail, phone and LAN access onboard mobile and at speeds up to 432 Kb/s worldwide, compatible with 4/5G cellular systems. Three Inmarsat I-4 F1 satellite launched March 11th 2005, I-4 F2 launched November 8th 2005, and I4 F3 anticipated launch in 2007 (POR) subject to business case and successful service introduction on IOR and AOR. All three spacecraft have the advanced technology to reduce service costs by 75%, compared to existing Inmarsat-M4 charges. They will be 100 times more powerful than the present generation and BGAN will provide at least 10 times as much capacity as today's network. The BGAN is model used to be designed maritime broadband known as FleetBroadband and aeronautical broadband known as SwiftBroadband.

Finally, Inmarsat has contracted the US Boeing, to build a constellation of new three multipurpose Inmarsat-5 satellites as a part of a global wireless broadband network Inmarsat Global Xpress. The first satellite Inmarsat-5 F1 entered in commercial service on dateMonth6Day30Year201430 June 2014. The second and third I-5 satellites are on course to launch by the end of 2014 and will provide global coverage during 2015. The spacecraft will provide radio spectrum on L/C and Ka-band for both communication and GNSS (navigation) facilities. The most important parts of Inmarsat spacecraft are antenna systems for satellite communications and navigation facilities. The I-5 spacecraft provided a new ground by transmitting in a portion of the radio spectrum never before utilized by the commercial operator of a global satellite system, which will be the extremely high Ka-band RF, in which global beam are situated many spot beams in rage with 3 LES terminals which is shows in **Figure 1.** Each I-5 will carry a payload of 89 Ka-band beams capable of flexing capacity across the globe and enabling Inmarsat to adapt to shifting subscriber usage patterns over their projected lifetime of 15 years.

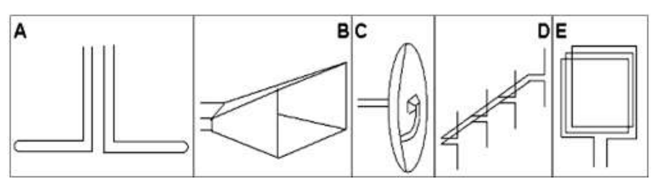
On the other hannd, the Japanese multipurpose GEO satellite MTSAT uses a minimum of seven spot beams and one global beam coverage, shown in **Figure 2 (Left),** a Ku-band feed link, shown in **Figure 2 (Middle),** and Ka-band feederl connection shown in **Figure 2 (Right).**

Figure 2: Japanese Multipurpose MTSAT Spot Beam and Feeder Links.



Source: Author.

Figure 3: Types of Spacecraft Antenna Systems.



Source: Author.

2. Basic Particulars of Spacecraft Antenna.

The spacecraft antenna radiates EM energy to the ground stations in both directions, efficiently and in desired path. Satellite antennas act as matching systems between sources of Electro Magnetic (EM) energy and space. The goal in using antennas is to optimize this matching. Here is a list of some of the properties of antennas:

1. Field intensity for various directions (antenna pattern);
2. Total power radiated when the antenna is excited by a current/voltage of intensity (Power Flux Density);
3. Radiation efficiency which is the ratio of power radiated to the total power (Radiation Pattern);
4. The input impedance of the antenna for maximum power transfer (matching); and
5. The antenna bandwidth or range of frequencies over which these properties are nearly constant.

However, spacecraft antennas can also be classified as electrical devices which convert electric currents into radio waves and vice-versa. They are generally used with a radio transmitter and receiver, which are broadly classified in two categories: Transmitting and Receiving antennas.

The difference is in the mode of operation, different functions etc. as the transmitting as well as the receiving antenna, and also difference is mainly in their environmental conditions which lead to their different designs.

Typically an antenna has an array of metallic conductors that are electrically connected. An oscillating current of electrons focused through the antenna by a transmitter creates an oscillating electric field. These fields are time-varying and radiate from the antenna into the space as a moving electromagnetic (EM) field wave. Certain properties of antennas such as directional characters result into reciprocity theorem.

The different types of spacecraft antennas are:

2.1. Wire Antennas (Monopoles and Dipoles).

The dipole is one of the most common used antennas. This spacecraft antenna consists of a straight conductor excited by a voltage from a transmission line or a waveguide and dipoles are easy to make, which is illustrated in **Figure 3 (A)**. Wire satellite antennas are used primarily at VHF and UHF-band to provide communications for the Telemetry, Tracking and Command (TT&C) systems. They are positioned with great care on the body of the satellite in an attempt to provide omnidirectional satellite coverage. Most communication satellites measure only a few wavelengths at VHF frequencies, which make it difficult to get the required antenna patterns, and there tend to be some orientations of the satellite in which the sensitivity of the TT&C system is reduced by nulls in the antenna pattern.

2.2. Aperture Antennas (Horn Antennas).

A horn is an example of an aperture antenna, which are used in Satellite spacecraft more commonly, shown in **Figure 3 (B).** Rectangular horn antenna is one of the simplest and most widely used antennas. Horns have been used for more than a hundred years, and today they used in radio astronomy, satellite communications, in communication dishes as feeders, in measurements, etc. Horn antenna is used at MW when for global coverage relatively wide beams are required.

A horn is a flared section of waveguide that provides an aperture several wavelengths wide and a good match between the waveguide impedance and free space. It is also used as feeds for reflectors, either singly or in clusters. Horns and reflectors are examples of aperture antennas that launch a wave into free space from a waveguide. It is difficult to obtain gains much greater than 23 dB or beamwidths narrower than about 10º with horn antennas. For higher gains or narrow beamwidths a reflector antenna or array must be used.

2.3. Reflector Antennas.

The parabolic reflector is a good example of reflectors at microwave frequencies, shown in **Figure 3 (C)**. In the past, parabolic reflectors were used mainly in space applications onboard spacecraft but today they are very popular and are used by almost everyone who wishes to receive the large number of television channels transmitted all over the globe.

Reflector antennas are typically used when very high gain or a very narrow main beam is required. Gain is improved and the main beam narrowed with increase in the reflector size. Large reflectors are however difficult to simulate as they become very large in terms of wavelengths. Reflector antennas are usually illuminated by one or more horns and provide a larger aperture than can be achieved with a horn alone.

For maximum gain, it is necessary to generate a plane wave in the aperture of the reflector. This is achieved by choosing a reflector profile that has equal path lengths from the feed to the aperture, so that all the energy radiated by the feed and reflected by the reflector reaches the aperture with the same phase angle and creates a uniform phase front. One reflector shape that achieves this with a point source of radiation is the paraboloid, with a feed placed at its focus.

The paraboloid, however, is the basic shape for most reflector antennas, and is commonly used for earth station antennas. Satellite antennas often use modified paraboloidal reflector profiles to tailor the beam pattern to a particular coverage zone. Phased array antennas are also used on satellites to create multiple beams from a single aperture, and have been used by Iridium and Globalstar to generate up to 16 beams from a single aperture for their Low Earth Orbit (LEO) satellite system.

2.4. Array Antennas.

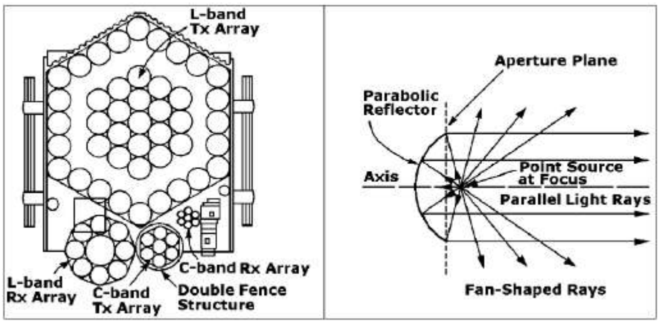
A grouping of several similar or different antennas forms a single array antenna, which is shown in **Figure 3 (D)**. The control of phase shift from element to element is used to scan electronically the direction of radiation. This array antennas are able to produce radiation patterns that combined, have characteristics that a single antenna would not. The antenna elements can be arranged to form a 1 or 2 dimensional antenna array.

A number of specific aspects and features of an antenna array will be stated using one-dimensional arrays for simplicity. This antenna array exhibits a specific radiation pattern, the overall radiation pattern of which changes when several antenna elements are combined in an array. In fact, the array factor quantifies the effect of combining radiating elements in an array without considering the element-specific radiation pattern. The overall antenna radiation pattern results in certain directivity and thus the gain associated with the directivity efficiency. Directivity and gain are equal if the efficiency is 100%.

2.5. Loop Antennas.

A wire loop antenna is used to radiate or receive EM energy. These antennas can also be used at home to record radio or TV channel signals, as illustrated in **Figure 3 (E).** The antenna pattern is a diagram of the field strength in the far field of the antenna infrastructure when the transmitter drives the antenna. At this point, antenna gain is a measure in dB of an antenna's ability to direct energy in one direction rather than all around. Thus, a useful principle in antenna theory is reciprocity, which means that the antenna has the same gain and pattern at any frequency, whether it is transmitting or receiving. The antenna diagram measured during reception is identical to the diagram during transmission.

Figure 4: Spacecraft Antenna Systems.



Source: Author.

As stated earlier, the antenna is providing global, spot and multiple beam coverages, but it can provide scanning and orthogonally polarized beams or coverage zones as well. The pattern is frequently specified by its 3-dB beamwidth, the angle between the directions in which the radiated (or received) field falls to half the power in the direction of maximum field strength. However, a satellite antenna is used to provide coverage of a certain area or zone on the Earth's surface, and it is more useful to have contours of antenna gain with maximum strengths of the signal in the middle of the coverage area and with decreasing of signals to the peripheries.

When computing the signal power received by an GES from the satellite, it is important to know where the station lies relative to the satellite transmit antenna contour pattern, so that the exact EIRP can be calculated. If the pattern is not known, it may be possible to estimate the antenna gain in a given direction if the antenna boresight or beam axis direction and its beamwidth are known.

All parts of spacecraft antennas, which have to be aligned normally are reflector (main reflector and sub reflector), feed and sometimes also support structures. These substructures allow a pre-assembly of reflectors and feeds subsystem level and an easier integration of the complete antenna onboard spacecraft. The goal of the alignment is to bring all the antenna components in a proper geometric configuration and to get the best or at least the designed RF antenna performance in the test facility and later on in the satellite orbit.

3. Satellite Antenna System onboard Spacecraft for Inmarsat MSS.

The antenna array system of Inmarsat-2 satellite for MSC is illustrated in **Figure 4 (Left).** The satellite antenna system mounted on the spacecraft structure, similar to the transponders, is composed of two main integrated elements: the C/L-band and the L/C-band antenna.

3.1. Inmarsat-2 C/L-band Array Antennas.

This uplink is actually the feeder link, which operates in the 6 GHz RF range. The signals sent by LES are detected by a C-band receiving array, comprising seven cup-dipole elements in the smallest circle. On the other hand, the L-band transmit antenna is the biggest segment of the whole system, consisting in 43 individual dipole elements, arranged in three rings around a single central element. Thus, this antenna is providing near-global coverage service downlink for MES in the 1.5 GHz RF spectrums.

3.2. Inmarsat-2 L/C-band Array Antennas.

These arrays are actually the service uplink and operate in the 1.6 GHz RF range. The signals sent by MES in adjacent global coverage region are detected by L-band receiving array, comprising nine cup-dipole elements arranged in a circle. Finally, the C-band transmit antenna consists in seven cup-dipoles for radiation of the feeder downlink to LES in the 3.6 GHz RF spectrum.

4. Characteristics of Satellite Antennas.

Both transmit antenna array systems are providing a global (wide) footprint on the Earth's surface. However, narrow circular beams from GEO or Non-GEO can be used to provide spot beam coverage. For instance, from GEO the Earth subtends an angle of 17.4^o. Antenna beams 5.8^o wide can reuse three frequency bands twice in providing Earth disc coverage. The directional properties of antenna arrays can be exploited to permit RF reuse in space communications, which is similar to several radio stations using the same RF being geographically far apart. Earth coverage by seven spot beams (six spots are set out around one spot in the centre) can be arranged by three pairs of beams: 1 and 4, 2 and 5 and 3 and 6, operating on frequencies f2, f3 and f4, respectively. Mutual interference within pairs is avoided by pointing one beam as far away from the other as possible. Coverage of the centre of the disc is provided by a single beam operating on frequency f1.

The main advantage with this spot footprint that is specific Earth areas can be covered more accurately than with wide beams. Furthermore, a greater power density per unit area for a given input power can be achieved very well, when compared with that produced by a global circular beam, leading to the use of much smaller receiving MES antennas. The equation that determines received power (P_R) is proportional to the power transmitted (P_T) separated by a distance (R), with gain of transmit antenna (G_T) and effective area of receiving antenna (A_R) and inverse proportional with 4π and square of distance. The relations for P_R and G_T are presented as follows:

$$P_R = P_T G_T \frac{A_R}{4\pi R}$$

$$G_T = 4\pi \frac{A_T}{\lambda^2} \tag{1}$$

Where G_T = effective area of transmit antenna and λ = wavelength. The product of P_T and G_T is gain, generally as an increase in signal power, known as an EIRP. Signal or carrier power received in a link is proportional to the gain of transmit and receive antennas (G_R) presented as:

$$P_R = P_T G_T G_R \frac{\lambda^2}{(4\pi R)^2}$$

or

$$P_R = \frac{P_T G_T G_R}{(L_P L_K)}[W] \quad (2)$$

The last relation can be derived with the density of noise power giving:

$$\frac{P_R}{N} = P_T G_T (\frac{G_R}{T_R})(\frac{1}{K L_P L_K}) \quad (3)$$

Where L_P = coefficient of energy loss in free space, L_K = coefficient of EMW energy absorption in satellite channels, T_R = temperature noise of receiver, G_R/T_R is the figure of merit and K = Boltzmann's Constant (1.38 x 10^{-23} J/K or its alternatively value is –228.6 dBW/K/Hz).

At any rate, P_R has a minimum allowable value compared with system noise power (N), i.e., the Carrier and Noise (C/N) or Signal and Noise (S/N) ratio must exceed a certain value. This may be achieved by a trade-off between EIRP (P_T G_T) and received antenna gain (G_R). If the receive antenna on the satellite is very efficient, the demands on the LES/MES are minimized. Similarly, on the satellite-to-Earth link, the higher the gain of the satellite transmit antenna, the greater the EIRP for a given transmitter power. Satellites often use parabolic dish antennas, though there are also other types, such as phased arrays. The principal property of a parabolic reflector is its ability to turn light from a point source placed at its focus into a parallel beam, as shown in **Figure 4 (Right).**

In practice the antenna beam can never be truly parallel, because rays can also be fan-shaped, namely a car headlamp is a typical example. In a microwave antenna the light source is replaced by the antenna feed, which directs waves towards the reflector.

The length of all paths from feed to aperture plane via the reflector is constant, irrespective of their angle of parabolic axis. The phase of the wave in the aperture plane is constant, resulting in maximum efficiency and gain. In such a way, the gain of an aperture (G_a) and parabolic (G_p) type of antennas are:

$$G_a = \eta(4\pi \frac{A_E}{\lambda^2})$$

$$G_p = \eta \frac{(\pi D)^2}{\lambda^2} \quad (4)$$

Where antenna values η = efficiency factor, A = projected area of antenna aperture, $A_E = \eta^A$ is effective collecting area and D = parabolic antenna diameter.

Thus, owing to correlation between frequency and wavelength, f = c/ λ is given the following relations:

$$G_p = \eta(\pi D \frac{f}{c})^2 = 60,7(Df)^2 \quad (5)$$

Where the second relation comes from considering that η ≈ 0.55 of numerical value. If this value is presented in decibels the gain of antenna will be calculated as follows:

$$G_T = 10.Log G_P \quad (6)$$

For example, a satellite parabolic antenna of 2 m in diameter has a gain of 36 dB for a frequency at 4 GHz and a gain of 38 dB for a frequency at 6 GHz. In such a way, satellite parabolic antennas can have aperture planes that are circular, elliptical or rectangular in shape.

Therefore, satellite antenna with circular shape and homogeneous illumination of aperture with a gain of –3 dB has about 47.5% of effective radiation, while the rest of the power is lost. To find out the ideal antenna characteristics it is necessary to determine the function diagram of radiation in the following way:

$$F(\delta_o) = s\frac{\delta_o}{s} \ (\delta_o = 0) \quad (7)$$

Where parameter s (δ_o) = flow density of radiation in the hypothetical satellite angle (δ_o) and s (δ_o=0) = flow density in the middle of the coverage area. Looking the Geometric Projection of Satellite the relation can be presented by the equation:

$$F(\delta_o) = \frac{d_o}{h} = cos\delta \sqrt{\frac{(k^2 - sin^2\delta_o)}{l-k}} \quad (8)$$

Where, as mentioned, k = R/(R + h) = sin δ and if δ_o = δ, the relation is defined by the following equation:

$$F(\delta) = k.cos\delta \quad (9)$$

For GEO satellite the value of ΔL is given as a function of angle δ, which is the distance from the centre of the coverage area, where the function diagram of the radiation is as follows:

F (δ) = ΔL = 20 log = 20 log R/(R + h) cos δ = 10

$$log\frac{R}{1+\frac{2R}{h}} \quad [dB] \quad (10)$$

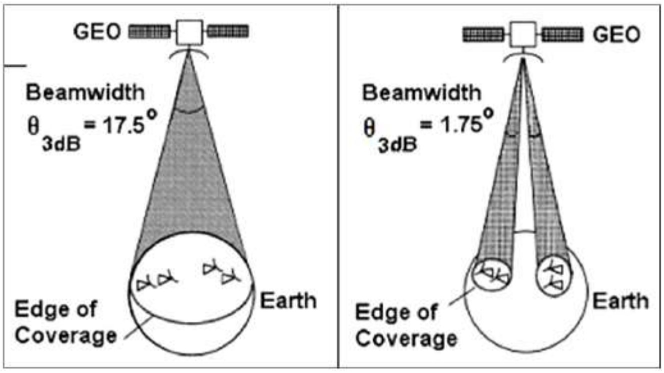
Therefore, in the case of GEO satellites the losses of antenna propagation are greater around the periphery than in the centre of the coverage area for about 1.32 dB. The free-space propagation loss (L_P) and the input level of received signals (L_K) are given by the equations:

$$L_P = (4\pi \ d/ \lambda)^2$$

$$\frac{P_R}{S} = P_T \frac{G_T}{4\pi d^2} L_K \quad (11)$$

The free-space radio propagation loss is caused by geometrical attenuation during propagation from the satellite transmitter to the receiver.

Figure 5: Global Monobeam and Multibeam Antenna Coverage.



Source: Author.

5. Link Performance with Monobeam and Multibeam Antenna Coverage.

As stated earlier, the most important parameter of spacecraft transponder and the overall RF link quality depends on the gain of the satellite antenna. From equation (6), it can be seen that the satellite antenna gain is constrained by its beamwidth, whatever the frequency at which the link is operated. So the antenna gain is imposed by the angular width of the antenna beam covering the zone to be served. If the service zone is covered using a single antenna beam, this is referred to as single or monobeam beam satellite coverage, which displays one of these characteristics:

1. The satellite may provide coverage of the whole region of the Earth, which is visible from the satellite as a global coverage and thus permit long-distance links to be established, for example from one continent to another with 20 dB bandwidth. In this case, the gain of the satellite antenna is limited by its beamwidth as imposed by the coverage.
2. The satellite may provide coverage of only part of the earth (a region or country) by means of a narrow beam (a zone or spot beam), with 3dB beamwidth of the order of 1° to a few degrees.

With single beam antenna coverage, it is therefore necessary to choose between either extended coverage providing service with reduced quality to geographically dispersed GES terminals, or reduced coverage providing service with improved quality to geographically concentrated GES terminals.

Multibeam antenna coverage allows these two alternatives to be reconciled. However, satellite extended coverage may be achieved by means of the juxtaposition of several narrow beam satellite coverages, which each beam providing an antenna gain which increases as the antenna beamwidth decreases (reduced coverage per beam). The link performance improves as the number of beams increases; the limit is determined by the antenna technology, whose complexity increases with the number of beams, and the mass. The complexity originates in the more elaborate satellite antenna technology and the requirement to provide on-board interconnection of the coverage areas, so as to ensure within the satellite payload routing of the various carriers that are unlinked in different beams to any wanted destination beam.

In **Figure 5 (Left)** is presented that a satellite provides global coverage with a single satellite beam (monobeam) of beamwidth and in **Figure 5 (Right**) is illustrates that satellite supports spot beams with beamwidth of a consequently reduced coverage, known as multibeam satellite coverage. In both cases, all GES terminals in the satellite network are within the correspondent satellite coverage or in LOS with satellite. Multibeam coverage is providing the following advantages:

5.1. Impact on the Earth Segment.

The satellite communication link performance is evaluated as the ratio of the received carrier power C to the noise power special density N_0 and is quoted as the C/N_0 ratio, expressed in Hz. The expression for $(C/N_0)_U$ for the uplink (U) is given by the following equation:

$$(C/N_0)_U = (EIRP)_{station}(1/L_U)(G/T)_{satellite}(1/k) \quad [Hz] \quad (12)$$

Assuming that the noise temperature at the satellite receiver input is $T_{satellite}$ = 800 K = 29 dBK and is independent of the beam coverage (this is not rigorously true but satisfies a first approximation), let L_U = 200 dB and neglect the implementation losses. This equation becomes (all terms in dB) and can be presented as:

$$\begin{aligned}(\frac{C}{N_0})_U = (EIRP)_{station}{-}200 + (G_R)_{satellite}{-}29 + 228.6 = \\ (EIRP)_{station} + (G_R)_{satellite}{-}0.4 \quad [dBHz]\end{aligned} \quad (13)$$

Where value $(G_R)_{satellite}$ is the gain of the receiving satellite antenna in the direction of the GES transmitting terminals. This relation is represented by the two cases considered receiver:

1. Global coverage ($\theta_{3\ dB}$ = 17.5º), which implies $(G_R)_{satellite}$ = 29 000/$(\theta_{3\ dB})^2 \approx$ 20 dBi.
2. Spot beam coverage ($\theta_{3\ dB}$ = 1.75º), which implies $(G_R)_{satellite}$ = 29 000/$(\theta_{3\ dB})^2 \approx$ 40 dBi.

The expression for $(C/N_0)_D$ for the downlink (D) is given by:

$$(C/N_0)_U = (EIRP)_{station}(1/L_U)(G/T)_{satellite}(1/k) \quad [Hz] \quad (14)$$

Assume that the power of the carrier transmitted by the satellite is P_T = 10 W = 10 dBW. Let L_U = 200 dB and neglect the implementation losses. Thus, this equation becomes (all terms in dB):

$$\begin{aligned}(C/N_0)_D = 10 - -200 + (G_T)_{satellite}{+}(G/T)_{station} + 228.6 \\ = (G_T)_{satellite}{+}(G/T)_{station} + 38.6 \quad [dBHz]\end{aligned} \quad (15)$$

This relation is represented for the two cases considered transmitter:

1. Global coverage ($\theta_{3\ dB}$ = 17.5º), which implies $(G_T)_{satellite}$ = 29 000/$(\theta_{3\ dB})^2 \approx$ 20 dBi.
2. Spot beam coverage ($\theta_{3\ dB}$ = 1.75º), which implies $(G_T)_{satellite}$ = 29 000/$(\theta_{3\ dB})^2 \approx$ 40 dBi.

In case those values indicate the reduction in $(EIRP)_{station}$ and $(G/T)_{station}$ the transmission system is changing from a satellite with global coverage to a multibeam satellite with coverage by several spot beams. In this case, the multibeam satellite permits an economy of size, and hence cost, of the earth segment. For instance, a 20 dB reduction of $(EIRP)_{station}$ and $(G/T)_{station}$ may result in a tenfold reduction of the antenna size (perhaps from metricconverterProductID30 m30 m to metricconverterProductID3 m3 m) with a cost reduction for the GES terminal for more than 100 times. If an identical GES is retained (a vertical displacement towards the top), an increase of C/N_0 is achieved which can be transferred to an increase of capacity, if sufficient bandwidth is available, at constant signal quality in terms of Bit Error Rate (BER).

5.2. Frequency Reuse.

Frequency reuse consists of using the same frequency band several times in such a way as to increase the total capacity of the satellite network without increasing the allocated bandwidth (B). In the case of a multibeam satellite the isolation resulting from antenna directivity can be exploited to reuse the same frequency band in separate beam coverages.

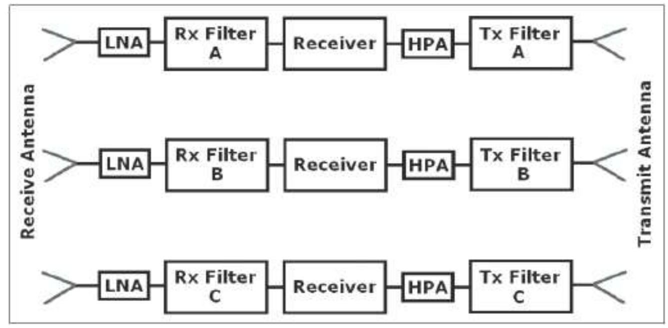
The frequency reuse factor is defined as the number of times that the bandwidth is used. In theory, a multibeam satellite system with M single-polarization antenna beams, each being allocated the bandwidth, combines reuse by angular separation and reuse by orthogonal polarization may have a frequency reuse factor equal to 2M.

This signifies that it can claim the capacity which would be offered by a single beam satellite with single polarization using a bandwidth of M x B. In practice, the frequency re-use factor depends on the configuration of the service area which determines the coverage before it is provided by the satellite. If the service area consists of several widely separated regions (for example, urban areas separated by extensive rural areas), it is possible to reuse the same band in all beams. The frequency reuse factor can then attain the theoretical value of M. In **Figure 5 (Right)** is shown an example of multibeam satellite coverage.

6. Multibeam Antenna Coverage.

Multi-beam antenna technology can effectively mitigate the impact of deep fading caused by multipath propagation on communication quality through spatial diversity and increase the reliability of the MSC systems. An advanced multibeam antenna configuration provides multispot coverage with a smaller number of apertures for Satellite Communications in the K and Ka-Bands. The multibeam antenna coverage is providing the following disadvantages:

Figure 6: Multibeam Antenna Coverage Transponder.



Source: Author.

6.1. Interference Between Beams.

In practical reality the interference generation within a multibeam satellite system is called self-interference. Thus, the effect of self-interference appears as an increase in thermal noise under the same conditions as interference noise between systems. At this point, it must be included the term $(C/N_0)_I$, which expresses the signal power in relation to the spectral density interference.

Taking account of the multiplicity of sources of interference, which become more numerous as the number of beams increases, relatively low values of $(C/N_0)_I$ may be achieved and the contribution of this term impairs the performance in terms of $(C/N_0)_T$ of the total link. As modern satellite systems tend to re-use frequency as much as possible to increase capacity, self-interference noise in a multibeam satellite link may contribute up to 50% of the total noise.

6.2. Interference Between Coverage Areas.

A satellite payload using multibeam coverage must be in a position to interconnect all network Earth stations and consequently must provide adequate interconnection of the entire coverage areas. The complexity of the payload is added to that of the multibeam satellite antenna subsystem, which is already much more complex than that of a single beam satellite. Different techniques, depending on the onboard satellite processing capability (no processing, transparent processing, regenerative processing, etc.) and on the network layer, are considered for interconnection of coverage:

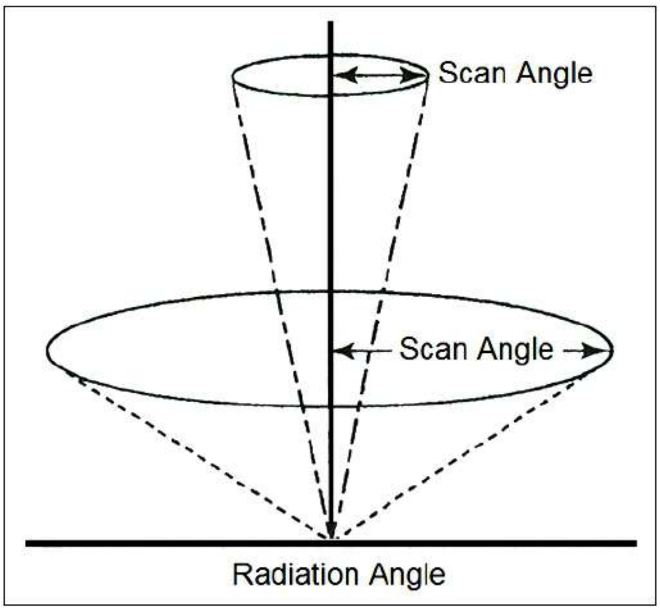
1. Interconnection by transponder hopping (no on-board processing);
2. Interconnection by onboard spacecraft switching (transparent and regenerative processing); and – Interconnection by beam scanning.

Multibeam satellite systems make it possible to reduce the size of GES terminal and hence the cost of the Earth segment infrastructure. Frequency reuse from one satellite beams to other permits an increase in capacity without increasing the bandwidth allocated to the system.

However, interference between adjacent satellite channels, which occurs between beams using the same frequencies, limits the potential capacity increase, particularly as interference is greater with earth stations equipped with small antennas.

The simplest form of a payload with multibeam antenna radiation is illustrated in **Figure 6.** Thus, a three-transponder payload uses one transponder per coverage circle. At this point, there is not connectivity between satellite coverage areas in this simple transponder.

Figure 7: Antenna Scan Angles.



Source: Author.

However, this payload could be designed so each transponder antenna illuminates three coverage circles and provide connectivity, but would cover three times area with just one-third the gain.

The relatively simple changes to multiple small beams have significant consequences as:

1. The area covered by each beam is much smaller, increasing the satellite antenna gain and allowing smaller and less expensive ground and mobile terminals;
2. The same total RF power can be used to carry more traffic, and/or reduce the RF power;
3. The same transponder bandwidth can be used multiple beam antennas, greatly increasing the available bandwidth: a) This allow the same bandwidth to be reused, increasing the amount that can be accommodated within the bandwidth; and b) A terminal has to be tuned to the correct RF to function and retuned if it is moved.
4. Connectivity between satellite beams, if required for the mission, must be provided by additional hardware on the satellite since a single uplink does not encompass the entire coverage area.

The satellite beams may be formed by individual feeds (circles) and by mechanical or electronic satellite beam former. However, mechanical beam formers use fixed wave-guide components to control the RF phase and amplitude. Usually there is one amplifier for each transponder in each composite beam. Electronic beam formers use electronic RF phase shifters, and sometimes provide electronic amplitude control, to produce the multibeam. There are many radiating elements and each usually has its own amplifier.

Satellite antenna radiators fall into two categories, reflector and direct radiating antennas. Reflector antenna uses a feed that indirectly radiates the energy towards the illuminated area of users, while direct radiating antenna radiates the energy direct to the coverage area. The satellite spot beam antenna can be pointed in various directions within a cone characterized by the scan angle, which illustrated in **Figure 7,** while a direct radiating array can radiate at large scan. Such arrays are attractive for LEO communication satellites because they operate over large scan angle than reflectors antenna, so they requires a scan angle of 63° to cover its field of view. In contrary, a GEO communication satellite requires a scan angle of 7° to cover the entire visible coverage circle on the Earth surface.

In addition to the fact that satellite antenna gain decreases as much the scan angle increases, and including polarization purity decreases as well. In such a way, the LEO satellite constellations require a direct radiating antenna. No commercial GEO satellite currently uses this antenna, while reflector antennas. At Medium Earth Orbit (MEO) satellite system the situation is less clear and both direct radiating and reflector antennas have been proposed for this orbit.

Conclusions.

The design and configuration of spacecraft antenna systems for MSS needs to be compact and robust especially for global coverage beam. Spacecraft mounted payloads usually require very accurate tracking performance capabilities for all mobile applications.

For example, a spacecraft mounted flexible antenna applies high accuracy and precision control to perform its mission serving ships, land vehicles (road and rail) and aircraft. The precision and accuracy is necessary to achieve the desired performance typically requires the use of a high gain feedback control system and accurate plant knowledge. On the other hand, the physical characteristics of antennas for ships and aircraft applications may be quite different, but both have to be designed compact for harsh environments and very extreme operating temperatures. These requirements will be difficult to achieve because the compact antenna has two major electrical disadvantages such as low gain and wide beam coverage, and because directional antenna has very heavy components for satellite tracking and getting satellite in the focus. However, a new generation of powerful satellite constellations with values of high EIRP and G/T performances should permit the design of compact and lightweight mobile satellite antennas.

The current Inmarsat-4 Spacecraft user link or mobile antenna system consists of a metricconverterProductID9 meters9 meters deployable reflector and a feed array with 120 helical elements. Over 220 simultaneous RF beams are created by applying vector weights to the feed elements under the control of the onboard Digital Signal Processor (DSP). The simultaneous transmission and reception requires the achievement of very low levels of Passive Inter-Modulation (PIM). The mission requires continuous coverage over fixed ground cells for orbital inclinations of up to 3°. This is achieved by uploading modified beam weights on a daily basis. This requires a large number of beam weights to be pre-synthesized.

In addition to the pervious, the Inmarsat team has placed a contract for the procurement of a fifth generation spacecraft system to fulfill the modern communications requirements of mobile terminal users worldwide into the 21st century. The system requirements for the Inmarsat-5 antenna systems onboard spacecraft is to service the projected communications capacity needs, focusing upon the L, C and Ka-band antenna system requirements which are one of the key technology development areas of the program. The critical technology aspects of the antenna design needed to provide efficient implementation of the system requirements such as global and spot coverages for Voice, Data and Vide (VDV) and VDVoIP transmissions over the globe up to 75^0 of Elevation angles on North and South latitudes.

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Design and Economic Analysis of a Floating Self-Propelled Convention Center in Bangladesh

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ABSTRACT

Convention centers are a noteworthy establishment of every society that is widely used to host various programs. In the perspective of Bangladesh, with its huge populace, convention centers are evident everywhere due to quite a high number of the events. But these convention centers are riddled with issues like difficulty in renting the convention center at the preferred time on an affordable budget. Often, the situation presents itself as the following dilemma, choosing a well reputed and well-furnished convention center with proper amenities by waiting a long time (around 6-12 months) with a huge sum (2-5 thousand US$) or sacrificing any or all aspects of required amenities just to meet the preferred time or budget. In short, not only an acute shortage of aesthetic convention centers in Bangladesh exists, under a reasonable budget and availability; such modern convention centers are not being established either on a noteworthy basis. Here the maritime industry can penetrate the market of convention centers. By designing a vessel specialized for hosting events, it presents itself as an attractive offer to many people looking for their perfect venue. A floating self-propelled convention center has many lucrative features as a venue. For instance, a venue on a journey by river offers a unique experience that is impossible for a land-based convention center. Furthermore, if costs can be managed and a reasonable rental price can be offered there will be no shortage of demand. This paper explores the potential popularity and feasibility of this venture through comprehensive surveys, designing an appropriate vessel and performing an economic analysis to show that it is quite a viable business opportunity that requires further attention, in the form a pilot project.

1. Introduction.

Convention centers are popular venues for hosting community events like wedding ceremonies, corporate outings and seminars. Bangladesh being a densely populated country implies the need for a large number of such convention centers. But there is great deal of concern in the minds of people who are looking for the perfect venue for the desired program. This is because not all of the convention centers are up to the mark. To elaborate, some are ill-maintained and ill-managed while another few don't have the required amenities required to host the desired event. On the other hand, the convention centers that are well-managed and well equipped have their rental prices so high that the majority of the demography cannot afford them. Furthermore, the waiting period of such venues start at a minimum of 3 months if luck favors and can lead up to 2 years. As such, more often than not, it is impossible to avail the services of these highly valued convention centers. Thus almost always, the customers of the convention center service can never get their desired combination of price, date and amenities required to fully enjoy the program. They are forced to make a compromise on one or couple of the aforementioned three attributes. To add to that, new modern and affordable convention centers are not being built on a regular basis that can revitalize the existing stagnant situation. Therefore, there is a dire need of rejuvenating the current scenario.

Surprisingly, the maritime industry can penetrate this mar-

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ket. By constructing a vessel that can effectively host the programs like weddings, seminars, picnics, etc. a new genre of convention centers can be established, the floating self-propelled convention center. On top of being just a new option, the floating self-propelled convention center has many advantages when compared to a conventional land-based convention center. For example, an event in the middle of a river journey can provide a much more unique and scintillating experience for a wedding program that cannot be found even in the most sophisticated of land-based venues. This aspect can attract customers in plenty because when choosing a venue, the experience a venue can provide to enjoy the event is given utmost priority besides budget. To add to that, Bangladesh being a riverine country with a huge demand for wedding and seminar venues positions itself as an excellent and most favorable candidate where the venture of self-propelled floating convention center can succeed should the pricing be positioned as affordable as reasonably possible.

To add to the unique experience, the changing trends in wedding ceremonies also provide a good pretext as to why this new prospect has more chances of being successful. Previously, the trend of wedding ceremonies was a more family-centered wholesome programs that usually took place at the home of the bride or a nearby convention center while the reception ceremony, in a similar fashion, took place at the home of the groom or a nearby convention center. In short, only the family aspect was given priority while the aesthetic element of the venue was mostly neglected. But that was at least a couple decades ago and since then the trend has largely shifted to a more wedding couple-centric marriage ceremony unlike the entire family centered ceremony of the past. Nowadays, the couple wish for a memorable ceremony in a more aesthetically pleasing venue. For this purpose, renting an aesthetically pleasing convention hall with good decoration, enough space to accommodate the invited people, etc. are highly sought for. In this respect, the prospect of the floating self-propelled convention hall is already a lucrative offer to the wedding couple as the scenic beauty the vessel will provide cannot be found in any land-based convention center. Furthermore, for seminars on topics related to climate, river erosion, environment, etc. the background setting on a river journey will help instill the importance of the topic even more than what would have been possible on a more traditional center on land. Besides, as a picnic or a corporate gateway, the new experience can be a very nice change to the monotonous nature of the more conventional venues.

2. Present Scenario of Bangladesh.

The clientele wishing to reserve their ideal venues currently confront a serious problem in the context of choosing the location for wedding celebrations. They frequently discover that their preferred community center is either fully booked and they have to wait a long time to acquire a date there or that it would be too expensive to book there, forcing them to explore elsewhere.

Additionally, wedding and other event patterns are evolving as a result of the changing times. As a result, an immersive environment's aesthetic component and experience have taken precedence. To back up this claim, wedding photography's development demonstrates once more how weddings have changed from being centered on the union of two families to a much more personal setting between the wedding couple1. The convention center's aesthetic quality is a key factor to take into account in order to emphasize this part of weddings.

In another situation, the recent lockdown brought on by the corona virus outbreak had a profound and long-lasting effect on the populace. One of the main concerns for people today is their health and cleanliness. As a result of their reputation as unsanitary, several of the current convention venues are currently losing patronage. Additionally, people's preferences for venues for important events are evolving. People have been effectively taught the value of fleeting moments by the lockdown. People now want to have memorable experiences; thus, they seek out individuality. One of them would undoubtedly be a wedding between a couple in a beautiful place like a river with the sun setting.

With a minimum draft of 1.5 meters and a navigable waterway length of 5968 kilometers (about 3708.34 miles) in the monsoon and 3865 kilometers (about 2401.6 miles) in the dry season, Bangladesh is a riverine nation. The majority of the country's cities can utilize the service of self-propelled floating convention halls. The majority of the market should have access to this service in order to benefit from this element and keep cost in mind. Therefore, it is important to prioritize appealing to middle-class demographics during client segmentation rather than only the top class.

3. International Scenario.

There are many other styles of wedding reception programs visible when looking outside Bangladesh. Taking destination weddings as an example. Additionally, ship weddings are becoming more and more common. Additionally, over the past ten years, the market for wedding tourism has grown due to a variety of factors, such as cheaper prices than domestic weddings, more frequent foreign flights, and a gradually declining cost of getting married abroad. Furthermore, seminars are given in settings that give the subjects they are covering a fully immersive experience for the attendees. For instance, conferences on climate change and sea level rise are conducted in the nations that will be most severely impacted. Such a conference was held on 17^{th} October 2009 in the form of an underwater cabinet meeting between the then President of Maldives and 13 government officials in Girifushi, Maldives.

4. Methodology.

An extensive amount of data is collected through various means including comprehensive literature reviews, surveying of potential stakeholders in the potential venture, route, demography analysis, etc. Stakeholders, namely people who are looking to get married, and their concerned relatives, were approached and a detailed survey is conducted. Furthermore, other primary stakeholders, for instance, various multinational companies, banks, etc. are approached about another survey regarding a potential seminar hosting conference or a picnic spot is also carried out. Moreover, shipyards are visited along with contacting manufacturers of ship parts in order to account for construction cost of vessel. All of these count for primary data. As for secondary data, the market situation around convention halls, marriage, seminar halls, picnic spots, etc. is carried out. Furthermore, information on wedding trends, the importance of the environment in which the seminar or conference is conducted, etc. is taken from the detailed literature review and article review. A professional attitude is ensured in the collection of data through the above-mentioned methods.

Afterwards, the data is analyzed and the requirements for an appropriate vessel that can serve the purpose effectively is set. Following, a preliminary vessel design is carried out.

Then, an economic analysis is carried out utilizing the expected cost obtained from vessel design, determining operating cost and setting a competitive rental fee. The criteria of analysis are Net Present Value. Net present value (NPV) is the present value of difference between cash inflows and cash outflows over a period of time after discounting them.

$$NPV = \frac{Cash\ flow}{(1+i)^t} - initial\ investment \tag{1}$$

where:

i= Required return or discount rate.

t= Number of time periods.

After coming to a decision regarding the profitability of the venture by judging the obtained NPV, a sensitivity analysis is carried out by regression analysis. Sensitivity analysis is a method of determining how the key economic parameter is influenced by changes in some key variables. For this venture of self-propelled floating convention center, the key variables include the number of event bookings per month, discount rate and fuel price.

5. Survey.

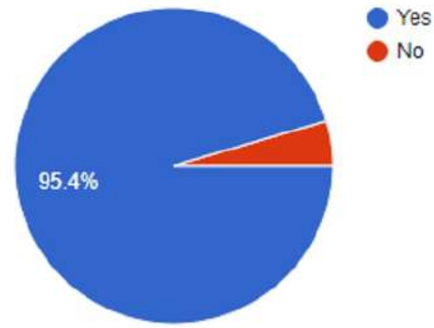
To get an initial understanding of the rich prospect of the venture of a Self-propelled floating convention vessel, an extensive survey is conducted to assess the demand. A total of 2032 participants filled out the survey form.

Figure 1 represents the position of the participants in considering the self-propelled floating convention vessel as an alternative to existing convention centers. It is seen from Figure 1 that about 95.4% of the respondents are positive.

Figure 2 illustrates the perspective on whether the self - propelled convention vessel is a suitable venue for hosting marriage ceremonies. From Figure 2, it is noticed that about 89.1% of the participants think so.

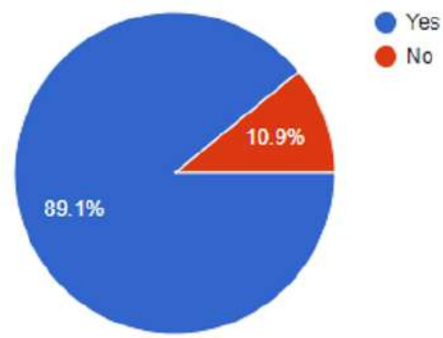
Figure 3 depicts the opinion on whether the self - propelled convention vessel is a suitable venue for hosting picnics and seminars. It is seen from Figure 3 that about 93% of the participants find it suitable.

Figure 1: Capability of Self-propelled floating convention vessel as an alternative to traditional convention centers.



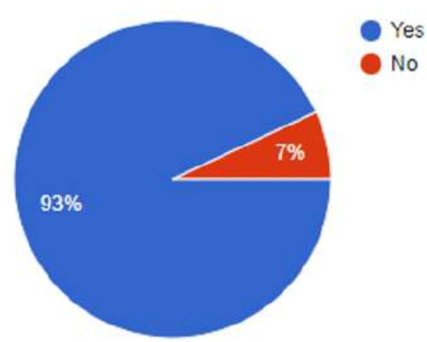
Source: Author.

Figure 2: Suitability of self-propelled convention vessel for hosting marriage ceremonies.



Source: Author.

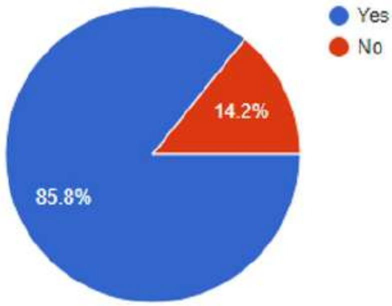
Figure 3: Suitability of self-propelled convention vessel for hosting picnics and seminars.



Source: Author.

Figure 4 shows whether the potential customers are willing to pay an extra amount of money (about 5 ~10 thousand Bangladeshi Taka) to acquire the venue provided by a self-propelled floating Convention Vessel. About 85.8% of the participants are willing to pay additional amount which is shown in Figure 4.

Figure 4: Willingness to pay additional amount of cost for the use of self-propelled convention vessel.



Source: Author.

From the survey results shown in Figures 1-4, it is noticeably clear that the self-propelled floating convention vessel has garnered interest in the sample space of the surveyed lot. Participants of the survey have also agreed to pay a definite amount greater than what they would pay traditional convention halls of similar capacity provided that the pricing is made affordable.

6. Subsequent Design.

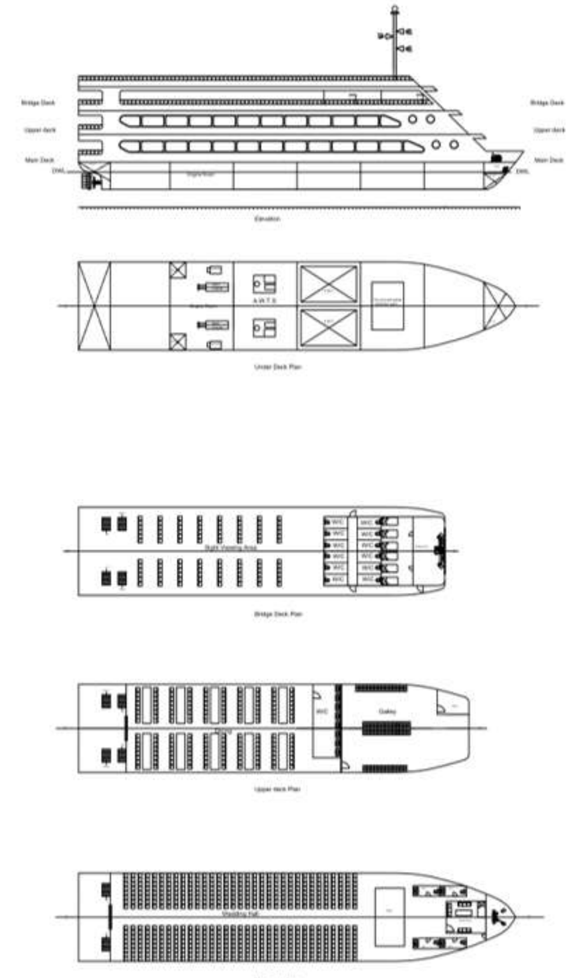
The actual design of a vessel that is well-equipped with the facilities required for the service sought by the customers is the next major obstacle to the fulfillment of this endeavor. That is, in terms of the vessel's overall layout, she must be able to accommodate a number of guests as needed, host the event for a specified period of time, provide adequate space for the event to occur, and have the necessary kitchen space for the required amount of food preparation and other necessities as needed for the event. Furthermore, the vessel must also meet the stability criterion of International Maritime Organization (IMO) and vibration guidelines of international classification society in order to ensure the safety and comfort of the people aboard the ship. Keeping all these aspects in mind a preliminary General Arrangement (GA) Plan of the vessel is developed, which is shown in Figure 5. Table 1 shows the principal particulars of the vessel.

Table 1: Principal particulars of the Vessel.

Item	Symbol	Value	Unit
Length Overall	L_{OA}	56.03	[meter]
Length Between Perpendiculars	L_{BP}	51.00	[meter]
Breadth Moulded	B_{MLD}	11.10	[meter]
Depth Moulded	D_{MLD}	3.40	[meter]
Draft Design	T	2.20	[meter]
Block co-efficient	C_B	0.61	--

Source: Author.

Figure 5: General Arrangement Plan.



Source: Author.

7. Economic Analysis.

With data obtained from the design, customer responses as to how much they are willing to pay for availing the venue offered by a floating self-propelled convention center and investigating the state of the market for operational cost, a preliminary economic analysis can be conducted.

Table 2 is a breakdown of the cost of construction of the vessel as designed above. The highest expenditures include cost of procuring steel, hull fabrication and overhead costs. To ensure safety standards, due attention is provided to have enough life-saving appliances, fire-fighting equipment, etc.

Thus, it is evident that the total cost of construction of a vessel that is to be employed for the venture will cost a little more than **706 thousand US dollars**. The next data required to carry out the analysis is operational cost. It is assumed that there will be **16 events in total per month** and the vessel will be operational for a total **of 5 hours per event**. Furthermore, the specific fuel consumption of the engine that is selected for the vessel is **220g/KWh**. Thus, with a total engine brake power of 550KW, fuel consumption is calculated to be **712 liters per**

Table 2: Construction Cost of Vessel.

Sl.	Item	Price (US$)
1	Steel Cost	332940
2	Painting, Valves and Fittings	37200
3	Propulsion System	61846
4	Anchoring and Mooring System	2570
5	Navigation Lights and Siren	2346
6	Doors and Windows	1958
7	Life Rafts and Jackets	23400
8	Pumps	3980
9	Firefighting Equipment	7870
10	Accommodation	20190
11	Hull Fabrication and Overhead cost	133526
12	Waste Treatment System	2900
Total=		630725

Source: Author.

event. Accounting for monthly maintenance cost and salary to be provided to the crew Table-3 provides a summarized account of operational cost for the self-propelled floating convention vessel per month

Table 3: Operational cost for a Self-Propelled Floating Convention Center per month.

Sl.	Item	Price (US$)
1	Fuel cost per month	10253
2	Maintenance	186
3	Salary	2976
Total=		13415

Source: Author.

Lastly, we have to account for the revenue to be obtained from the venture. For this purpose, the hiring fee per event is set at a reasonably affordable price of **1.5 thousand US dollars**. As a result, with a reasonable assumption of 16 events per month, the monthly revenue equates to **24 thousand US dollars**.

So, as mentioned above, with an outlay cost of 706 thousand US dollars, a monthly net income of around 10.5 thousand US dollars and a yearly discount rate of 10%, the **NPV obtained is almost 335 thousand US dollars**. That is, by undertaking the project we can have an instantaneous monetary gain of over 335 thousand US dollars per vessel. As such, the venture is deemed profitable.

8. Sensitivity Analysis.

At the moment, the main variables affecting NPV are identified to be the number of events per month, discount rate of the venture and the price of fuel. A sensitivity analysis is hereby carried out to determine the degree of influence of these factors over the NPV of the venture. Table-4-6 illustrates the sensitivity analysis. Here, a dataset is created by changing the **variables; increasing and decreasing by 10 percent** respectively and conclusion was drawn by a regression analysis.

$$Y = f(X_1,\ X_2,\ X_3) \tag{2}$$

Where,
Y= NPV (Dependent Variable)
X_1= Events per Month (Independent Variable)
X_2= Discount Rate (Independent Variable)
X_3= Fuel Price per Liter (Independent Variable)

Microsoft Excel is used to perform the regression analysis. It is to be mentioned here that in regression analysis, null hypothesis, H_o is equal to zero means variable has no effect and alternate hypothesis, H_a is not equal to zero means variable has an effect.

Table 4: Data set for Sensitivity Analysis.

Events per month (X_1)	Discount rate (X_2)	Fuel Price (X_3)	NPV (Y)
16	0.1	1	334305
17.6	0.1	1	579495
14.4	0.1	1	89114
16	0.11	1	271934
16	0.09	1	404014
16	0.1	1.1	217921
16	0.1	0.9	450689
17.6	0.11	1	501278
17.6	0.1	1.1	463112
16	0.11	1.1	163073
14.4	0.09	1	141112
14.4	0.1	0.9	205498
16	0.09	0.9	528805
17.6	0.11	1.1	392416
14.4	0.09	0.9	265903
17.6	0.11	0.9	610140
17.6	0.09	1.1	542125
14.4	0.11	1.1	-66271
17.6	0.09	0.9	791707
14.4	0.11	0.9	151452
14.4	0.09	1.1	16321

Source: Author.

Tables 5-7 are the results of regression analysis.

From Tables 5-8, the following points can be addressed.

1. The value of Multiple R is 0.9982, which indicates a strong correlation between the variables and NPV. As in

Table 5, the Multiple R will not tell us if the correlation is positive or negative.

2. R-Squared indicates the 'fit' of the model or regression line. The adjusted R-square is 0.9957, which indicates that 99.57% variance in NPV can be explained by the independent variables which was chosen.
3. The t-value and p-value illustrates that the chosen variables are highly relevant in determining NPV.

Table 5: Results of regression analysis.

Regression Statistics	
Multiple R	0.998184998
R Square	0.996373291
Adjusted R Square	0.995733284
Standard Error	14259.51355
Observations	21

Table 6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	9.49659E+11	3.16553E+11	1556.81516	6.17671E-21
Residual	17	3456673351	203333726.5		
Total	20	9.53116E+11			

Table 7

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-295022.9	58297.32	-5.06	9.6536E-05	-418019.48	-172026.27	-418019.48	-172026.27
Events per month	153695.68	2425.59	63.36	1.2389E-21	148578.13	158813.24	148578.13	158813.24
Discount rate	-6601266	388094.80	-17.01	4.1469E-12	-7420074.2	-5782457.3	-7420074.20	-5782457.28
Fuel Price	-1168070	38809.48	-30.10	3.4602E-16	-1249950.75	-1086189.1	-1249950.75	-1086189.06

From the analysis, the NPV function of floating self - propelled convention center can be defined by equation (3).

$$\begin{aligned} Y &= -295022.873 + 153695.6829X_1 \\ &-6601265.741X_2 - 1168069.907X_3 \end{aligned} \tag{3}$$

It is conclusive that the NPV of the venture is highly sensitive to all of the above variables. Among these, the venture is **most sensitive to the number of events per month** for which the vessel will be hired. So, it is of utmost importance to advertise the venture so that it attracts enough event bookings and a loss is not incurred. Moreover, if fuel price rises in the future, then the owner may have to increase the rental fee in the case that the number of events do not increase appreciably.

Conclusions.

The business venture of the floating self-propelled convention center is very unique with a multitude of advantages that

Table 8

Variables	Sign	Calculated t-value	Comparison with t-test tabular value	Status of Null Hypothesis, Ho	Effect of Alternate Hypothesis
Events per Month	X_1	63.36	High	Rejected	Yes
Discount Rate	X_2	-17.01	High	Rejected	Yes
Fuel Price	X_3	-30.10	High	Rejected	Yes

Source: Author.

can be leveraged. These include, as mentioned above, are unparalleled scenic beauty, experience of river journey, beholden natural presence of forever-cherished events like wedding, etc. Adding a competitive rental fee only adds to the points leading to its potential success. And so far, as observed from the preliminary economic analysis, it promises to be a profitable business venture. Furthermore, it is to be noted that the venture is very sensitive to number of event bookings it receives among other notable ones. If the challenges associated with the venture (Time Management, Catering Management, etc.) can be well-maneuvered after proper advertising and gaining customer satisfaction and acknowledgement, then the prospects of the venture remain boundless.

Recommendations.

Since the initial analysis suggests a favorable business venture so far, the next step would be to go for a small-scale pilot project to assess how accurate the analysis is so far and whether the venture truly proves to be a favorable one. Moreover, the design should also be improved if any opportunity arises. For instance, green technologies like solar panels, sails, sky-sails, etc. may be implemented. Lastly with proper marketing and advertising, the venture should be implemented in Bangladesh at first and internationally afterwards.

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Study On Navigation Method Used by Sea Turtles at Chagar Hutang Turtle Sanctuary Terengganu

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ABSTRACT

One of the most remarkable and mysterious elements of sea turtle is the ability to return to its nest area which is known as natal homing. Sea turtles can go to a specific course upon hatch and emerge from the sand. The migratory pathway of sea turtles does not mainly depend on earth magnetic fields, but previous research has revealed that it combines with another type of navigation. Thus, the purpose of this research is to determine the navigation method used by sea turtles. The types of navigation methods had been observed or tested on turtles at Chagar Hutang. The celestial method was tested by observing the movement of the hatchling on test rigs. The terrestrial method was determined by observing the geomorphology of the island and prominent landmarks of Chagar Hutang Bay. The magnetic method was determined by obtaining the magnetic declination of Chagar Hutang and the number of turtles landed. The result of the test and observation had verified sea turtles have the capability to navigate by using different methods, namely magnetic, celestial, and terrestrial. These navigation methods are used by turtle either separately or by combination any of two at one time.

1. Introduction.

The ability of sea turtle to navigate across the ocean in search of feeding areas and the ability to return to its originated nesting areas to lay egg has fascinated biologists and researchers. The ability of mature female sea turtle to return to nest in the same geographic area from which they originated referred to Natal homing (Lohman et. al, 2013). Sea turtle must rely on an efficient navigation system to guide them on their movement either along shallow water or in the immensity of the ocean. The first information about sea turtle might return to their originated nest came from the result of early tagging program of sea turtle in the 1950s and 1960s, as cited by Lohman et. al (2013). An efficient navigation system also helps sea turtles to find an accurate way to migrate either searching for a feeding spot, avoiding predators, mate, or return to natal beaches to lay eggs. To have an efficient navigation system that guides the sea turtle, a hypothesis has been made to study how mature female sea turtle navigates hundreds of thousand kilometers before return back to the same geographic area which they originated.

2. Literature review.

2.1. *Tagging and Satellites Tracking Studies.*

Southeast Asian Fisheries Development Centre (SEAFDEC) has developed a regional sea turtle tagging program in the Southeast Asian region. Under this program, the migration, reproduction, growth, and mortality of the sea turtle will be better understood and it is possible to estimate the population size of certain species by tagging activities (Ahmad et.al 2006). Flipper tagging of sea turtle is defined as the external attachment, usually at the flippers as shown in Figure 1. The tag is made of metal, plastic, and inconel that inscribed with numbers and words. The tag also inserts with microchips so it can be detected by the electronic device to monitor the sea turtle (Ahmad et.al 2006).

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Figure 1: Flipper Tagging.

Source: Seaturtle.org, 2020.

Tagging is the most important tool in studying sea turtle because it enables scientists to identify individual sea turtle. Information that can gather from tagging studies either by using flipper tagging or PTT tagging. To enable the sea turtle to be tracked, satellite tracking studies of sea turtle were published, Platform Terminal Transmitter (PTT) was attached to the back of sea turtle (Figure 2). PTT is satellite telemetry that allows the researcher to obtain up to date position data every time the sea turtle rises to the water surface to take a breath. Sea turtle usually can hold their breath for 45 minutes to one hour during routine activity, however, sea turtles normally dive for 4 to 5 minutes and they go to the surface for breath for a few seconds (Olive Ridley Project, 2019).

Figure 2: Sea turtle with PTT.

Source: Olive Ridley Project, 2019.

PTT that was attached to the back of sea turtle will transmit message signals that full of information to an orbiting satellite called Argos, which currently has six satellites that offer global coverage that orbiting approximately 900 km above the earth surface. The satellites then re-transmit the data to a receiving station that can be accessed through the researcher computer (ARGOS, 2020).

2.2. *Mechanism Used by Sea Turtle to Determine its Natal Homing.*

Natal Homing is a pattern of behaviour which animal migrates away from its geographical area of origin and they return to reproduce in the same location where they hatch (Brothers & Lohmann, 2015). An animal is capable of true navigation where the ability of an animal to travel to the precise target without the need for familiar landmarks (Gould, 2014). So, it is very important to know the mechanism used by female sea turtle that influences the migratory pathway and its natal homing.

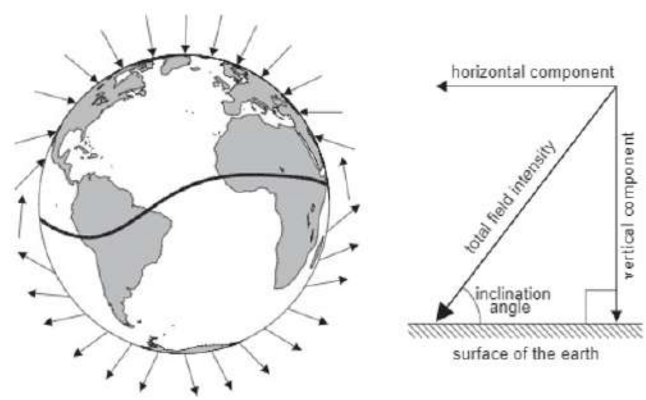
2.3. *Earth Magnetic Mechanism.*

Through a recent study, sea turtle has a significant part that involves magnetoreception. Magnetoreception is the ability of sea turtle to detect or sense the earth's magnetic field as a source of navigational information during their migrations and natal homing in female sea turtle (Kenneth J. Lohmann, 2007).

There are several features of earth magnetic fields that can be predicted across the surface of the earth and might be the principle used in natal homing position finding by a female sea turtle. At each location on the globe, the geomagnetic field lines intersect the earth's surface at a specific angle of inclination (Figure 3). Because of inclination angle vary with latitude, animal able to distinguish between different field inclinations and determine its approximate latitude (Taylor, Lohmann, Hester, & Lohmann, 1999).

Other than the inclination angle of earth magnetic fields, there is at least three other magnetic field element that can be predicted across earth surface and might be used in assessing a position. These include the intensity (strength) of the total field; the intensity of the horizontal field; and the intensity of the vertical field.

Figure 3: Inclination angle.



Source: Taylor et al., 1999.

2.4. *Celestial Method.*

The hatchling sea turtle that emerges from underground nest at night and never before been in ocean has established courses towards open sea. Hatchling sea turtle and female sea turtle that came for lay eggs must immediately reach the sea to avoid terrestrial predators. The course selected to find the sea is not based on an innate preference for a selected direction. While on the beach, hatchling and female sea turtle find the ocean by crawling toward the lower, brighter seaward horizon and away from the dark, elevated surface and dunes (Kenneth J. Lohmann & Lohmann, 1996).

But today hatchling sea turtle and female sea turtle not only has to deal with sea debris such as seaweed and shells that washed ashore but man-made debris such as plastic bottles, cups, and many more. Thus, hatchling sea turtle and female sea turtle must frequently ascertain the seaward direction without viewing the ocean directly.

To ascertain the seaward direction without viewing the ocean directly, hatchling sea turtle and female sea turtle must observe moonlight and starlight at night. Other than that, hatchling sea turtle and female sea turtle also observe the horizon that reflects the moonlight and starlight, this is because the oceanic horizon at night is nearly always slightly brighter than the landward horizon (Kenneth J. Lohmann & Lohmann, 1996).

2.5. Terrestrial Method.

The first theory that sea turtle used terrestrial cues in their navigation came up when the researcher makes a study on hatchling sea turtle that emerge from the underground nest at night. Terrestrial navigation is the method in which the position is determined through static landmarks or terrestrial objects such as an island, sea rock, and lighthouse as a reference point to know current latitude and longitude for the real-time position at sea (navigatorhelps, 2013).

An article about orientation and open-sea navigation in sea turtle by K.J Lohman and C.M.F Lohman, 2010 stated that hatchling sea turtles observe sea horizon that guides them to ocean at night, this is because sea horizon reflects lighter than land horizon. Other than that sea wave also plays an important role in guiding the hatchling sea turtle to the sea.

Adult sea turtles that migrate hundreds of thousand kilometres in the vast ocean will finally migrate back to shallow water in search of a feeding spot. Female sea turtle also will return to its originated natal beaches to lay eggs. So, to have a precise location in searching for feeding areas and return to its natal beaches, the sea turtle will use terrestrial navigation when landmarks are present in its vicinity.

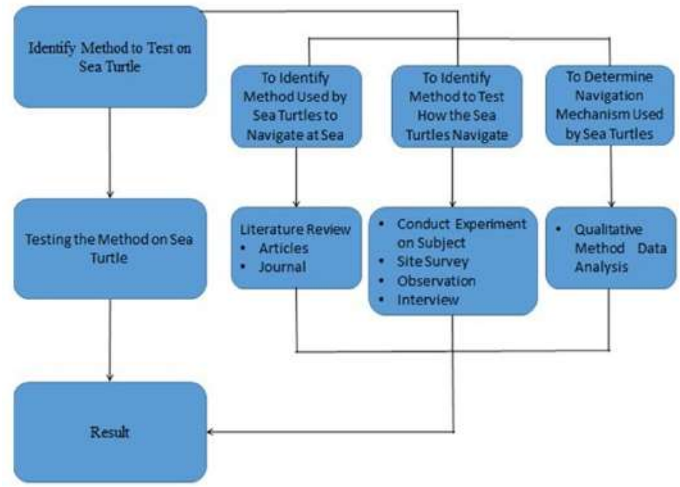
3. Methodology.

The overall research activities are shown in Figure 4 below.

The first step was to identify the method used by sea turtles for navigation. This was done by an extensive literature review on journals and conference proceedings related to methods used by sea turtles and other animals for navigation.

The second step was to conduct three types of tests to determine the type of navigation used by sea turtles, namely celestial, terrestrial, and magnetism tests. The study area is Chagar Hutang turtle sanctuary which is owned and manages by Sea Turtle Research Unit (SEATRU) of Universiti Malaysia Terengganu (UMT). The first was the celestial method test. A set of rigs as shown in Figure 5 was prepared to observe the crawling activity. The rig design was adapted from Rusli, Joseph, Liew, & Bachok (2015). The hatchling green turtles were used in this experiment. The observation on how the turtles set the pathway towards the ocean during the crawling activity would determine the type of navigation used. There are three sets: Set 1 is the

Figure 4: Overall research activities.



Source: Authors.

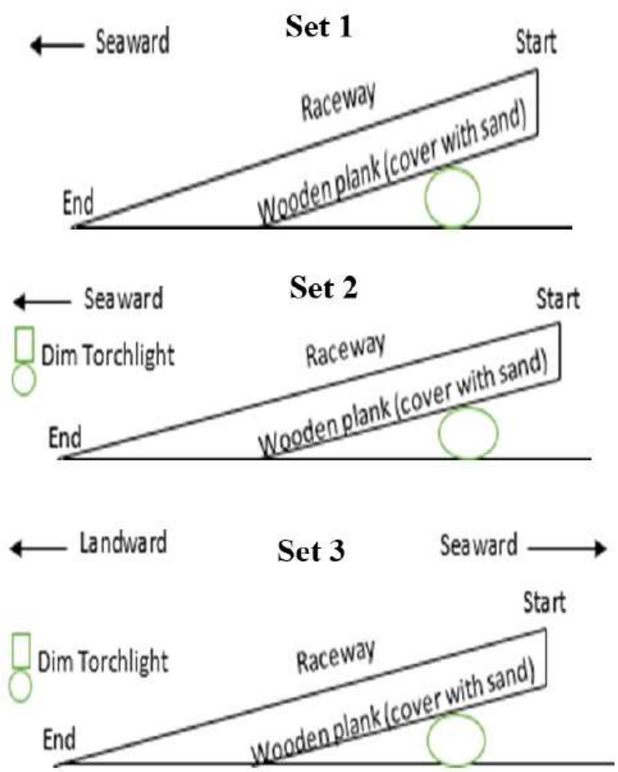
lower part of raceway facing seaward; Set 2 is the lower part of raceway that facing seaward with a dim torchlight put in front of it; and Set 3 is the lower part of raceway that facing landward with a dim torchlight was put in front of it. Set 1 represents lower ground facing the sea without the presence of celestial bodies like moon and stars. Set 2 represents the lower ground facing the sea with the presence of the celestial bodies. Set 3 represents the lower ground facing the land with the presence of celestial bodies.

The second test was the terrestrial method by identifying a possible landmark at Chagar Hutang area and relate it with the number of sea turtle landing. A landmark is an important environmental feature that is unchanged in a location (Breed & Moore, 2012). The identified landmark may be used by sea turtle to determine the location of natal beaches. Observation with the sanctuary's ranger was conducted to identify the landmarks associated with the landing area.

The third test was to determine whether sea turtle is using the earth's magnetic field to navigate to its natal homing. For this purpose, the information on earth magnetic field variation of Chagar Hutang at coordinate (5° 48' 47.0412" N, 103° 0' 34.7184" E) for the past 10 years was determined by using an online Magnetic Field Calculator as shown in Figure 6 (Natural Resources Canada, 2019). Upon determining the earth's magnetic field of Chagar Hutang, the number and positions of sea turtle landing within the last 10 years were obtained from Sea Turtle Research Unit (SEATRU).

Once all the data had been collected, the relationship between the earth's magnetic field variation and the number and position of sea turtle landing within the last 10 years was established. This was achieved by presenting the data in the table and chart form. The result of these tests would determine the type of navigation used by sea turtles.

Figure 5: Rig for Celestial Navigation Test.



Source: Authors.

Figure 6: Natural Resources Canada.

Source: Natural Resources Canada, 2019.

Table 1: Result of literature review on navigation method.

No	Navigation Method	References
1	Earth magneticfield	(Breed & Moore, 2012; Brothers & Lohmann, 2015, 2018; Fuxjager, Eastwood, & Lohmann, 2011; Girard, Sudre, Benhamou, Roos, & Luschi, 2006; C. M. F. Lohmann & Lohmann, 2019; K. J. Lohmann et al., 2008; Kenneth J. Lohmann, 2007; Kenneth J. Lohmann & Lohmann, 1996; P. Luschi, Papi, Liew, Chart, & Bonadonna, 1996; Paolo Luschi,2018; Paolo Luschi et al., 2007; Painter & Plochocka, 2019; Rusli et al., 2015; Shimada, Jones, Limpus, & Hamann, 2016)
2	Celestial bodies	(Breed & Moore, 2012; Girard et al., 2006; K. J. Lohmann et al., 2008; Kenneth J. Lohmann, 2007; Kenneth J. Lohmann &Lohmann, 1996; Painter & Plochocka, 2019; Shimada et al., 2016)
3	Terrestrial	(C. M. F. Lohmann & Lohmann, 2019; K. J. Lohmann et al.,2008; Kenneth J. Lohmann & Lohmann, 1996; Paolo Luschi, 2018; Rusli et al., 2015; Shimada et al., 2016)

Source: Authors.

4. Result and Discussion.

The first objective in this research was to identify methods used by sea turtles to navigate at sea. Results from the literature review show that sea turtles are using the earth's magnetic field, celestial bodies, and terrestrial for navigation as shown in Table 1.

The second objective of this research is to determine the type of navigation used by sea turtles. The first test was a celestial navigation test on turtle hatchling. An observation of turtle hatchling by using test rigs in Figure 5. Results showed that the turtle hatchling crawled towards the dimmed light on Rig 2 and Rig 3, although the dimmed light in Rig 3 was located toward landward. The hatchling thought that the dimmed light was the reflection of the star or moon at the horizon of the sea. This finding is consistent with Lohmann & Lohmann (2019). Another explanation is water reflects more moonlight and starlight than land does, thus the oceanic horizon at night is slightly brighter than the landward horizon (Figure 7). The brighter horizon attracts the hatchlings and led to the hypothesis hatchlings locate the ocean by crawling towards the brightest horizon (Mrosovsky, 1972, 1978; Osovsky & Kingsmiix, 1985).

The second test was to test the terrestrial navigation used by sea turtle to its natal beach by identifying possible landmark at Chagar Hutang area. The Chagar Hutang sanctuary beach is the northernmost beach on Redang Island that facing the open sea (Figure 8). Another beach has a similar feature is Berjaya Redang Resort beach located further south. According to Dr. Uzair Director of SEATRU UMT, the number of turtle nests per year at Chagar Hutang is around 1500, while at Pasir Mat Sempit (Red Triangle in Figure 8) dan Pasir Mat Simpan (Yellow Triangle in Figure 8) is less than 10. Although Berjaya Redang Resort or The Taaras beach (Figure 9) is longer and bigger than Chagar Hutang beach, no turtles have landed there. From the observation, female adult sea turtle started to appear from 4 pm at the shallow water area and lurking the surrounding area. It was believed that the turtles did the visual check on the water to ensure the site is the right place to lay eggs and safe from harm. This finding was verified by the rangers, which prohibit any water activities starting from 3 pm every day. The distinct physical feature of Chagar Hutang beach is the only sandy beach at the northern part of the island; having two horns (cape) with a relatively narrow bay; and the horns can be sighted easily when entering the bay from the sea (Figure 10, Figure 11, and Figure 12). Also, the turtle rock (Figure 13) and Chagar Hutang rock (Figure 14) are prominent landmarks in the area that can be used for terrestrial navigation. These aforementioned distinct physical features of Chagar Hutang bay and the prominent landmarks are possible features used by sea turtles to navigate them to their natal beach. This is supported by a high number

Figure 7: Brighter horizon in front of Chagar Hutang beach. No celestial bodies at the time and the lights were from fishing vessels.

Source: Authors.

of turtle nests in the area. This supports the research hypothesis sea turtle used landmarks for terrestrial navigation to its natal beach.

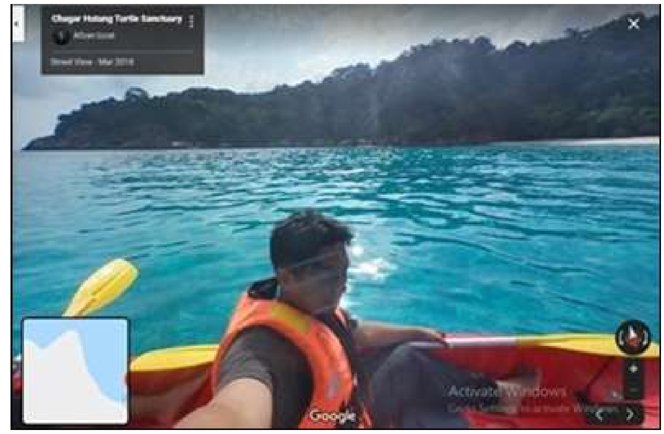
Figure 8: Chagar Hutang sanctuary (red marker) the northernmost beach of Redang Island; Pasir Mat Kepit (red triangle) and Pasir Mat Simpan (yellow triangle).

Source: Google Maps, 2020.

Figure 9: Chagar Hutang sanctuary distinct morphological feature with two capes and a sandy bay.

Source: Google Maps, 2020.

Figure 10: Right cape of Chagar Hutang bay.

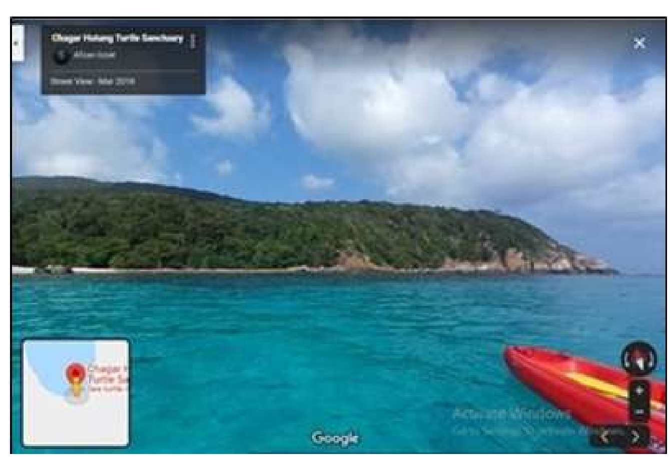


Source: Google Maps, 2020.

Figure 11: Chagar Hutang beach view.

Source: Google Maps, 2020.

Figure 12: Left cape of Chagar Hutang bay.



Source: Google Maps, 2020.

Figure 13: Turtle rock of Chagar Hutang on the right cape. A red triangle in Figure 9.

Source: SEATRU, 2018.

Figure 14: Chagar Hutang rock. Yellow triangle in Figure 9.

Source: SEATRU, 2018.

The fourth test was to determine whether sea turtle is using earth magnetic field to navigate to its natal homing. The information on earth magnetic field declination at Chagar Hutang at coordinate (5° 48’ 47.0412” N, 103° 0’ 34.7184” E) for the past 10 years and a total number of sea turtles landed to lay eggs is shown in Table 2. The second column from left shows magnetic declination during a peak month (June or July) in a year, while the third column shows the annual magnetic declination.

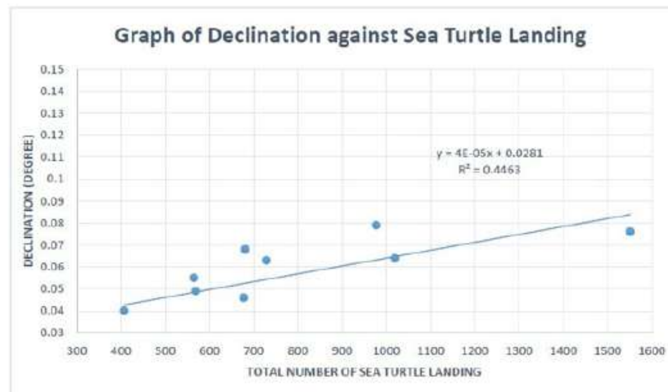
Table 2: Magnetic declination of Chagar Hutang and the total number of sea turtle landed.

year	Declination (degree)	Change per year (degree)	Total no of sea turtle landing to lay eggs
2008	0.021	0.02 W	610
2009	0.04	0.02 W	407
2010	0.046	0	677
2011	0.05	0	569
2012	0.055	0	565
2013	0.06	0	1019
2014	0.063	0	729
2015	0.068	0.02 W	681
2016	0.076	0.02 W	1551
2017	0.083	0.02 W	977

Source: Authors.

Data from Table 2 (column 2 vs column 4) are then being interpreted in the form of a graph as in Figure 15. The data is interpreted and plotted in the form of a graph to determine the R^2. The value of the R^2 is 0.45 and classified as a moderate correlation or a substantial relationship (Guilford, 1956). So, there is a moderate linear correlation between the magnetic declination (column 2) with the number of sea turtle landed to lay eggs (column 4). The number of turtles landed corresponds with the magnitude of magnetic declination.

Figure 15: Total number of sea turtle landed vs Declination of earth magnetic fields.



Source: Authors.

Results of the celestial, terrestrial and magnetic tests conducted at Chagar Hutang showed that sea turtles navigate using the combination of the aforementioned methods to the sea and its natal beach. Sea turtles select type navigation method based on situation and requirement. Turtle used magnetic navigation for long-range navigation that navigates the sea turtles back to Redang Island. The celestial navigation is used by the turtle hatchling to guide them to the sea and used by the turtles towards the landing area. The terrestrial navigation is used by turtle to identify the precise natal beach. These navigation methods may be used independently or by a combination of two methods at one time depends on need.

Conclusions.

Three types of navigation methods had been observed or tested on turtles at Chagar Hutang. The celestial method was tested by observing the movement of a hatchling on test rigs. The terrestrial method was determined by observing the geomorphology of the island and prominent landmarks of Chagar Hutang Bay. The magnetic method was determined by obtaining the magnetic declination of Chagar Hutang and the number of turtles landed. The result of the test and observation had verified sea turtles have the capability to navigate by using different methods, namely magnetic, celestial, and terrestrial. These navigation methods are used by turtle either separately or by combination any of two at one time.

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Dynamic container relocation problem

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ABSTRACT

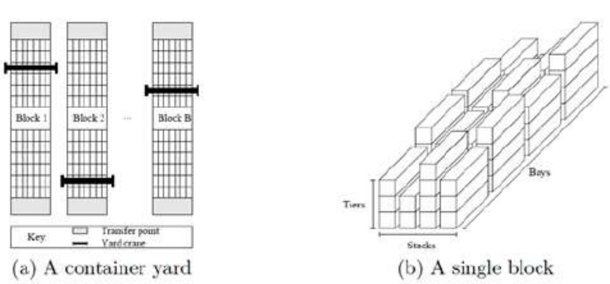
The container relocation problem supposes that the whole retrieval chain is identified in advance. This is practical for vessels where the shipment plan is known ahead in time. But, exact truck arrivals can barely be predicted and are exposed over time. As a result, the retrieval order is not known in advance. This paper deals with a dynamic and more practical version of the container relocation problem, where information about container retrievals becomes revealed over time.

1. Introduction.

1.1. Problem description.

Container terminals have limited information on exact arrival times and on the arrival order of trucks. It is not uncommon, that terminals obtain this information only when trucks check in at the terminal gate. When processing the truck at the terminal gate, a container request is issued to retrieve the corresponding container from the storage area.

Figure 1: Container relocation problem.

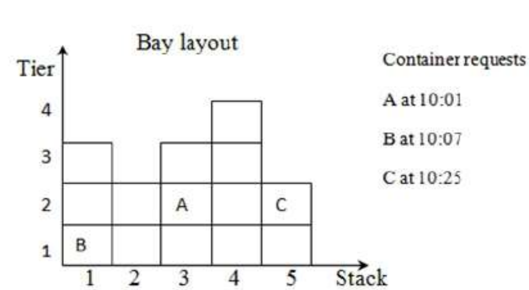


Source: Author.

The terminal operator has to decide in which order to serve the current container requests and where to relocate blocking containers. The yard of such a terminal is illustrated in Figure 1. The yard is divided into different blocks. Each block consists of several bays, each bay of several stacks and each stack of several tiers. Thanks to new technologies, the terminal knows exactly at which position (block, bay, stack, tier) each container is stored and which positions are empty.

The decision is based on known requests, since the terminal operators has no information on future retrievals. Figure 2 illustrates the dynamic container relocation problem. The number of relocations increases with the stacking height of containers and is therefore a bigger issue at terminals using stacking cranes for storage operations.

Figure 2: Dynamic Container relocation problem.



Source: Author.

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The objective is to minimize truck service times. The order in which requests are served impacts truck service times and the number of relocations. Our main objective is to evaluate the benefit of knowing the retrieval sequence ahead in time, rather than evaluating different service policies. We suppose that trucks are served with a first-come, first-served policy. In this case, truck service times depend mainly on the number of relocations. Our objective is to minimize the number of relocations. The problem definition relies on assumptions A1 to A9.

A1: No new containers arrive during the retrieval process.

A2: Only the topmost container of a stack can be picked up. A relocated container can only be put on the top of another stack or on the ground.

A3: Containers are only relocated within the bay since relocations between bays are very time consuming.

A4: The bay size is limited by the maximum numbers of stacks and tiers.

A5: Containers in the same bay have the same size and can be piled up in any order.

A6: The distance traveled within one bay (horizontally and vertically) has little impact on the time to relocate or to retrieve containers.

A7: Only containers located above the current target container may be relocated.

A8: Container requests become known when trucks are processed at the terminal gate.

A9: Trucks are served with a first-come, first-served policy.

Like most other studies, we address the dynamic container relocation problem with precedence constraints among single containers and relocate only containers above the target container (A7). We call these containers blocking containers. We use the notation introduced by Caserta et al. (2012) to represent the container relocation problem. A bay consists of W stacks and H tiers. Each slot within the bay is addressed with coordinates (i, j) where $i \in \{1, \ldots, W\}$ and $j \in \{1, \ldots, H\}$. The initial configuration contains N containers, labeled $1, \ldots, N$. Containers have to be retrieved in ascending order, e.g. container 1 is the first one to be retrieved and container N the last one. At each time period t $(t = 1, \ldots, T)$, container

$n = t$ is retrieved and any blocking containers are relocated. The container labels are not known from the beginning, but revealed over time. To represent partly knowledge about the future retrieval sequences, we introduce a look-ahead horizon D $(D \geq 1)$. It indicates that at each period t the exact retrieval sequence for the next D containers is known: at period t, Da

$t = t$ is the first known retrieval container and Db $t = t + D - 1$ the last known retrieval container.

1.2. Related literature.

To the best of our knowledge no scientific literature exists on the dynamic container relocation problem. But, several articles deal with the related stacking problem. The aim is to find good storage positions for incoming containers based on partial knowledge about their destinations, weights and departure times. The main objectives are to use the storage space efficiently, to reduce traveling times within the terminal and to reduce the number of relocations. Here, we only present studies aiming to minimize the number of relocations.

Dekker et al. (2006) and Borgman et al. (2010) evaluate different stacking strategies and the impact of available information via simulation. The performance of each strategy is measured via the number of relocations, the yard crane workload and the level of occupancy of the yard. They show that stacking containers on ground positions reduces the number of relocations. They compare scenarios with no information on future retrievals with scenarios with imprecise information on future departure times. Results show that using imprecise information increases the efficiency of the terminal. Park et al. (2011) present an online search algorithm to decide where to stack incoming containers. The algorithm tries variants of the best-so-far policy and can easily adapt to changes at the terminal. Results show that this algorithm can reduce quay crane delays, but does not obtain the best results for average truck waiting times.

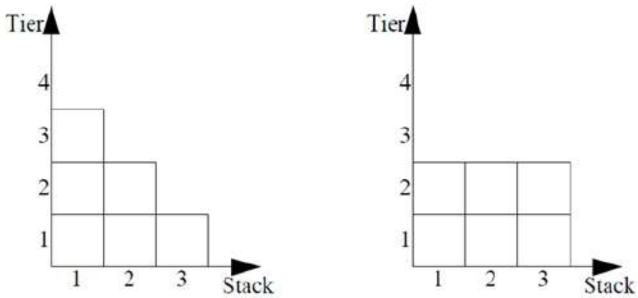
Zhao and Goodchild (2010) use simulation to evaluate the use of information on truck arrivals to reduce relocations during the retrieval process. They run experiments for different levels of information and different bay configurations. Results show that already limited information on future arrivals can reduce the number of relocations. They also show that updating information in real time lowers information requirements. Jang et al. (2013) consider the problem with groups of homogeneous containers. They present a genetic algorithm for the case where the retrieval order of groups is known. They also present a statistical model to estimate the expected number of relocations when no information on future retrievals is available.

Yang and Kim (2006) consider the problem of stacking incoming containers in a way that minimizes the expected number of relocations. They relocate each container at most once. They address a static and a dynamic version of the problem. For the static problem, arrival and due dates of all containers are known in advance; for the dynamic version, arrival and due dates become known when containers arrive at the terminal. They use dynamic programming and a genetic algorithm to solve the static problem and use heuristics based on known departure times to solve the dynamic problem. Preston and Kozan (2001) present a container location model that minimizes the time needed to transfer containers from the storage area to vessels. This model includes traveling and relocation times. Khaled and Faissal (2012) formulate a mixed integer linear programming model and solve the problem via a genetic algorithm. Khaled (2014) develop a formulation and subsequent development of a Six Sigma approach solution for the problem. His work aims to develop a novel method based on a combined ANP and DEMATEL techniques to help container terminals determine critical Six Sigma transportation plans.

2. Expected value of relocations.

This section introduces a criterion to indicate the quality of a given bay layout if we do not have any information on future retrievals. In this case, all containers in the bay are equally likely to be retrieved next. We determine the expected value of relocations, *EVR*, necessary to retrieve one container from the given bay.

Figure 3: Expected value of relocations EVR for two different layouts with 6 containers.



(a) Layout A, $EVR = 0.67$

(b) Layout B with minimal EVR, $EVR = 0.5$

Source: Author.

To do so, we compute the average number of blocking containers. Equation (1) defines the expected value *EVR*. It depends on the number of containers in the bay, *N′*, and on the number of containers per stack, *s(i)* for all *i = 1, . . . ,W*. Figure 3 illustrates the computation on two examples:

$EVR_A = 1/6 \cdot ((0+1+2)+(0+1)+(0)) = 0.67$

$EVR_B = 1/6((0+1)+(0+1)+(0+1)) = 0.5.$

$$EVR = \frac{1}{N'} \cdot \sum_{i=1}^{W} \sum_{j=0}^{s(i)-1} j \tag{1}$$

Lemma 1. *The minimum difference between the lowest stack and the highest stack equals 0*

if N′ mod W = 0 and 1 if N′ mod W 6= 0.

Proof. The minimum difference between the lowest stack and the highest stack is obtained if containers are evenly distributed among stacks. If *N′ mod W = 0*, each stack has a height of *N′/W*; if *N′ mod W 6 ≠ 0* some stacks have height $\lceil N'/W \rceil$and others$\lfloor N'/W \rfloor$.

Lemma 2. *The expected value of relocations EVR is minimal if the difference between the lowest stack and the highest stack is minimal.*

Proof. We assume that for layout 1 the difference between the lowest stack and the highest stack is not minimal. Let *a* be the lowest stack in layout 1 and *b* the highest stack. We obtain layout 2 by moving the topmost container from stack *b* to stack *a*. Let EVR_{ab} be the expected value of layouts 1 and 2 without stacks *a* and *b*. We compare the expected value of layouts 1 and 2.

$$EVR_2 - EVR_1 = \left(EVR_{ab} + \textstyle\sum_{j=0}^{s(a)} j + \sum_{j=0}^{s(b)-2} j\right) - (EVR_{ab} + \textstyle\sum_{j=0}^{s(a)-1} j + \sum_{j=0}^{s(b)-1} j) = s(a) - s(b-1)$$

It is hence possible to reduce *EVR* by moving one container from the highest stack *b* to the lowest stack *a* as long as *s(a)<s(b)-−1*. Consequently, *EVR* is minimal if the difference between stacks *a* and *b* is minimal.

3. Different relocation strategies.

This section presents different relocation strategies that may be applied to the dynamic container relocation problem for a partial known retrieval order of length *D*.

Strategy S1: Random heuristic

For each container to be relocated, the heuristic randomly chooses a stack that is not full.

Strategy S2: Leveling heuristics for D = 1 and D = 2

The objective of the leveling heuristic is to relocate containers in a way that minimizes the expected value of relocations EVR. Lemma 1 and 2 show that containers should be distributed equally over stacks to minimize EVR.

For *D = 1*, only the current retrieval container is known. For each container to be relocated, the heuristic determines current stack heights and relocates the container to the lowest stack. If several stacks have the same height, the leftmost stack among them is chosen.

For *D = 2*, the heuristic uses information about the second retrieval container to keep it accessible. Like before it balances stack heights by relocating containers to the lowest stack.

But containers are only relocated on top of the second retrieval container if no other positions are free. If the second retrieval container itself has to be relocated, it is relocated to the highest stack.

The subsequent strategies S3 to S8 determine a partial solution to retrieve the next *D* containers with a minimum number of relocations.

Strategy S3: Relocations are updated every time new information becomes available

The problem is solved repeatedly for each period *t = 1, . . . , T* with information on containers

$n = D_t^a, ..., D_t^b$. We initialize the model for period *t = 1* with variables and constraints corresponding to periods $t = D_1^a, ..., D_1^b$and solve it. We then adapt the model to the next period *t = t + 1* by adding variables and constraints corresponding to period D_t^b (since variables and constraints corresponding to periods D_t^a to $D_t^b - 1$are already in the model).

Since it is not possible to revoke decisions taken at earlier periods we fix variables representing container positions at the beginning of period *t* according to the solution obtained in the previous iteration. We solve the updated model. The process ends when the time horizon is reached. At each iteration, the objective function (2) minimizes the number of relocations necessary to retrieve all *D* containers for the given initial layout.

$$\min \sum_{i=1}^{W} \sum_{j=2}^{H} \sum_{k=1}^{W} \sum_{t=1}^{H} \sum_{t'=D_t^a}^{D_t^b} \sum_{n=t'+1}^{N} x_{ijklnt'} \tag{2}$$

Strategy S4: Relocations are determined for the next D containers and are not updated

The complete relocation sequence to retrieve the next *D* containers is determined with the information on these *D* containers. The solution is not updated if new information becomes available. The problem is solved repeatedly at periods *1, 1+D, 1+2D, . . .* with information on the next D retrieval containers. We initialize the model for period $t = 1$ with variables and constraints corresponding to periods $t = D_1^a, ..., D_1^b$. and solve it. We then adapt the model to the next iteration at period $t = t + D$ by adding variables and constraints for periods D_t^a toD_t^b. To prevent revoking decisions taken at earlier periods, we set variables representing container positions at the beginning of periods $t - D + 1$ to t to the values obtained in the previous iteration. We solve the updated model. The process ends when the time horizon is reached.

Strategy S5: No detailed information about far-away retrievals

We suppose that we know the exact retrieval sequence of the next D containers. In addition, we know the subsequent $D\prime$ containers to be retrieved, but not their exact retrieval order.

Keeping subsequent retrieval containers $D\prime$ on top of stacks should reduce the number of relocations necessary at the next iteration to retrieve these containers. We introduce integer variables a_{ijnt} that count the number of containers located above the next retrieval containers$n \in D'$:

$$a_{ijnt} = \begin{cases} 0\, if\ container\ n\ is\ not\ located\ at\ position\ (i,\ j)\ at \\ \ the\ beginning\ of\ period\ t, \\ \\ R \end{cases}$$

The objective function (3) penalizes the number of relocations for the current iteration (periods D_t^a to D_t^b). In addition, it penalizes the number of containers above subsequent retrieval containers at the beginning of the next iteration at period$D_t^b + 1$. Constraint (4) defines variables a_{ijnt} for period $D_t^b + 1$for the next $D\prime$ retrieval containers.

$$\min \sum_{i=1}^{W} \sum_{j=2}^{H} \sum_{k=1}^{W} \sum_{l=1}^{H} \sum_{t'=D_t^a}^{D_t^b} \sum_{n=t'+1}^{N} x_{ijklnt'} + w_1 . \sum_{i=1}^{W} \sum_{j=1}^{H-1} \sum_{n \in D'} a_{ijnD_t^b+1} \tag{3}$$

$$\sum_{j'=j+1}^{H} \sum_{n' \in N \setminus \{n\}} b_{ij'n'D_t^b+1} \leq a_{ijnD_t^b+1} + (H-1).(1 - b_{ijnD_t^b+1}) \tag{4}$$
$$\forall i = 1, ..., W, j = 1, ..., H-1, n \in D'$$

With strategies S6 and S7, we want to analyze the impact of different intermediate bay layouts on the total number of relocations. The objective is to be able to determine layouts that are advantageous with regard to unknown future retrievals. We compare two cases: distribute containers evenly among stacks and keep one stack empty. Again, only the initial layout for the next iteration (the layout at period$D_t^b + 1$) is of interest.

Strategy S6: Distribute containers evenly among stacks

The objective is to distribute containers evenly among all stacks to reduce the expected value EVR. We use integer variables a_{ijnt} (introduced above) to count the number of containers located above each container. The expected value EVR is identical to the total of alla_{ijnt}.

The objective function (5) penalizes the number of relocations and to minimize the expected value at period$D_t^b + 1$. Constraint (**??**) defines variables a_{ijnt} for period $D_t^b + 1$ for all containers.

$$\min \sum_{i=1}^{W} \sum_{j=2}^{H} \sum_{k=1}^{W} \sum_{l=1}^{H} \sum_{t'=D_t^a}^{D_t^b} \sum_{n=t'+1}^{N} x_{ijklnt'} + w_1 . \sum_{i=1}^{W} \sum_{j=1}^{H-1} \sum_{n \in D'} a_{ijnD_t^b+1} \tag{5}$$

$$\sum_{j'=j+1}^{H} \sum_{n' \in N \setminus \{n\}} b_{ij'n'D_t^b+1} \leq a_{ijnD_t^b+1} + (H-1).(1 - b_{ijnD_t^b+1}) \tag{6}$$
$$\forall i = 1, ..., W, j = 1, ..., H-1, n = D_t^b + 1, ..., N$$

Strategy S7: Keep one stack free

The objective is to obtain a layout with at least one empty stack. This increases the expected value *EVR*. It might nevertheless be beneficial to have an empty stack to place containers in the next iteration. We add integer variables $f_{it}$and $e_t$to determine if at least one stack is empty.

$$f_{it} = \begin{cases} 0\, if\ stack\ i\ is\ empty\ at\ the\ beginning\ of\ period\ t, \\ \\ 1\ Otherwise; \end{cases}$$

$$e_t = \begin{cases} 1\, if\ at\ least\ one\ stacki\ is\ empty\ at\ the\ beginning\ of \\ \ period\ t, \\ \\ 0\ Otherwise; \end{cases}$$

The objective function (7) penalizes the number of relocations and rewards an empty stack at period$D^b - t + 1$. Constraint (8) makes sure that f_{it} equals 0 only if stack i is empty. Constraint (10) determines if at least one empty stack exists.

$$\min \sum_{i=1}^{W} \sum_{j=2}^{H} \sum_{k=1}^{W} \sum_{l=1}^{H} \sum_{t'=D_t^a}^{D_t^b} \sum_{n=t'+1}^{N} x_{ijklnt'} - w_3 . e_{D_t^b+1} \tag{7}$$

$$\sum_{j'=j+1}^{H} \sum_{n'=D_t^b+1} b_{ijnD_t^b+1} \leq H.f_{i,D_t^b+1} \ \forall i = 1, ..., W \tag{8}$$

$$\sum_{i=1}^{W} f_{i,D_t^b+1} + e_{D_t^b+1} \leq W \tag{9}$$

Strategy S8: First-come, first served policy not necessary

We want to analyze the impact of being able to serve the next D trucks in any order. This should decrease the number of relocations. A container blocking a retrieval container may itself be a retrieval container. In this case, it can be retrieved directly, rather than being relocated. Until now we imposed, that container n is retrieved at period n. Now, container n may be retrieved at any period $n - D + 1, . . . , n + D - 1$.

The objective function (10) minimizes the number of relocations. It takes into account that some containers $n < t$ may be relocated at period t. Constraints (11) imposes that each container is retrieved within its time window. Constraint (12) makes sure that each container is retrieved exactly once. Variables $x_{ijklnt}$and $b_{ijnt}$for $n \leq t$ have to be added to existing constraints. A part from this, constraints remain identical and are not repeated here.

$$\min \sum_{i=1}^{W} \sum_{j=2}^{H} \sum_{k=1}^{W} \sum_{l=1}^{H} \sum_{t'=D_t^a}^{D_t^b} \sum_{n=t'-D+2}^{N} x_{ijklnt'} \tag{10}$$

$$\sum_{i=1}^{W} \sum_{j=1}^{H} \sum_{t'=t-D+1}^{t+D-1} y_{ijnt'} = 1 \qquad \forall n = 1, ..., N \tag{11}$$

$$\sum_{n=t-D+1}^{t+D-1} y_{ijnt} = 1 \qquad \forall t = 1, ..., T \tag{12}$$

4. Computational results.

We test strategies S1 to S8 on the instances sets 3-3, 3-4, 3-5, 3-6, 3-7, 3-8, 4-4, 4-5, 4-6, 4-7, 5-4 and 5-5 introduced by Caserta et al. (2012) and hence on $12 \cdot 40 = 480$ instances. All experiments are carried out on a computer with Inter(R) Xeon(R) CPU clocked at 2.67GHz (dual core), 3.48GB RAM and operating with Windows XP Professional. We limit the run time to 60 minutes per instance. Cplex 12.1 is used to solve the mixed integer programming models for S3 to S8.

Table1 summarizes the experimental settings. We test these strategies with different look-ahead horizons D = *1, 2, 3, 5* and *7*. For S5, we set $D\prime = D$. We impose a strict hierarchy to *i)* minimize the number of relocations per iteration and *ii)* optimize the initial bay layout for the next iteration. Weights w_1, w_2 and w_3 are defined based on the following observations. A relocation has a cost of 1. For S5, the maximum layout cost is obtained if all $D\prime$ containers are located at height 1 and $H - 1$ containers are located above. For S6, the maximum layout cost is obtained if containers are stacked as high as possible. In this case, $\left\lfloor \frac{N}{H} \right\rfloor$stacks contain H containers and one stack contains $N - H \cdot \left\lfloor \frac{N}{H} \right\rfloor$containers. For S7, the maximum benefit from one empty stack should be lower than the cost of one relocation.

Table 2 presents experimental results. It displays the numbers of solved instances (out of 480), the average numbers of relocations and the average run times of service strategies S1 to S8 for different look-ahead horizons D. Strategy SX-Y refers to strategy X with look-ahead horizon Y.

Table 1: Experimental setting for evaluating relocation strategies.

Strategy	Look-ahead horizon D	Weights w
S1	n.a.	
S2	1,2	
S3	3,5,7	
S4	3,5,7	
S5	3,5,7	$w_1 = (D'.(H-1)+1)^{-1}$
S6	3,5,7	$w_2 = (\left\lfloor \frac{N}{H} \right\rfloor \cdot \sum_{i=0}^{H-1} i + \sum_{i=0}^{N-H\left\lfloor \frac{N}{H} \right\rfloor -1} i + 1)^{-1}$
S7	3,5,7	$w_3 = 0.5$
S8	3	

Source: Author.

Table 2: Performance of relocation strategies S1 to S8 for different look-ahead horizons.

Strategy	S1	S2-1	S2-2
Solved inst.	480	480	480
Avg. Relocations	18.9	15.0	14.0
Avg. CPU time [s]	<0.1	<0.1	<0.1

Strategy	S3-3	S4-3	S5-3	S6-3	S7-3	S8-3
Solved inst.	480	480	480	480	480	460
Avg. Relocations	14.9	16.1	13.2	13.8	16.8	13.6
Avg. CPU time [s]	24.8	11.4	11.4	12.1	12.7	66.4
Avg. time per iter.	1.2	1.4	1.4	1.5	1.6	8.0

Strategy	S3-5	S4-5	S5-5	S6-5	S7-5
Solved inst.	480	480	480	480	480
Avg. Relocations	13.1	14.6	12.5	13.2	15.0
Avg. CPU time [s]	28.1	10.6	10.8	12.9	11.4
Avg. time per iter.	1.5	2.2	2.2	2.6	2.3

Strategy	S3-7	S4-7	S5-7	S6-7	S7-7
Solved inst.	480	480	480	480	480
Avg. Relocations	12.4	13.6	12.2	12.7	13.7
Avg. CPU time [s]	38.3	15.9	22.6	35.5	18.4
Avg. time per iter.	2.2	4.4	6.3	9.7	5.0

Source: Author.

SX-Y represents service strategy X with look-ahead horizon Y.

With strategies S1, S2, S3, S4, S5 and S7 all instances can be solved. One instance cannot be solved with S6-7 and 20 instances cannot be solved with S8-3.

Run times for strategies S1, S2-1 and S2-2 are fast enough to be applied in real-time at the terminal. For strategies S3 to S7, run times per iteration increase for bigger look-ahead horizons since the underlying models get bigger. But, for bigger look-ahead horizons less iteration is necessary and the total run time may decrease. If the truck travel time between the gate and the loading and/or unloading area may be used to determine relocation moves, run times per iteration for strategies S3 to S7 are also sufficient.

The numbers of relocations for all service strategies for different look-ahead horizons are presented in more detail in Figure 4. It also compares the dynamic results to the offline solution (Off) where the entire retrieval sequence is known in advance. The x-axis states the service strategy with the associated look-ahead horizon. The y-axis indicates the number of relocations. The box plots represent the number of relocations obtained for 459 instances (those solved by all strategies). Every box plot indicates the median, the upper and lower quartiles and outliers for one relocation strategy.

Relocation strategies S2 to S7 with limited knowledge on future retrievals perform well.

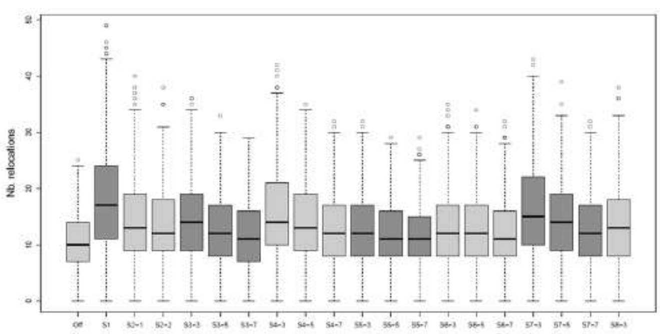
They outperform the random relocation strategy S1, but cannot reach the solution quality of the offline solution with complete knowledge. For each strategy, the number of relocations and their variances decrease when the look-ahead horizon increases.

Comparing strategies S3 and S4 suggests that it is beneficial to update relocation decisions every time new information becomes available. However, results of S1, S2, S3 and S6 show that for little information ($D \leq 3$) seeking a leveled bay layout may be more beneficial than updating relocation moves; for more information ($D = 5, D = 7$) results are similar.

Results for S1, S2 and S6, also show that the benefit of knowing more than the next 3 retrieval containers is limited. Comparing results S5-3 ($D + D\prime = 6$) with S3-5 and S3-7

($D = 5$ and $D = 7$) shows that knowing the exact retrieval order of far-away containers is of little benefit. Results of S7 show that keeping one stack empty decreases the solution quality since containers have to be stacked higher in the remaining stacks. Results of S4-3 and S8-3 show that serving trucks in any order rather than in FIFO order reduces the number of relocations.

Figure 4: Comparison of different relocation strategies for different look-ahead horizons.



Source: Author.

Conclusions.

This paper presented the dynamic container relocation problem that has not been addressed in literature yet. We introduced the expected value of relocations EVR as an indicator to determine the quality of a bay layout with no information on future retrievals.

We proved that EVR is minimal for balanced stack heights.

We presented different relocation strategies for partial knowledge of the retrieval sequence.

We compared their solution qualities - indicated via the number of relocations for different look-ahead horizons. Results were also compared to a random relocation strategy and to the optimal offline solution obtained if the entire retrieval sequence is known in advance. It appeared that relocation strategies perform well and outperform the random strategy, but cannot reach the solution quality of the offline solution. Especially, strategies trying to balance stack heights perform well. Run times seem to be short enough to be applied at a terminal in real time.

To continue this work a more generic heuristic for $D > 2$ could be designed. This heuristic could try to balance stack heights and to relocate known retrieval containers using relocation rules from heuristic HC. It would also be interesting to evaluate the competitiveness ratio of the leveling heuristic to obtain more information on the worst case performance of heuristic S2.

For strategies S5 and S6, the layout obtained among those with the same number of relocations depends on cost parameters w_1 and w_2. The obtained layout strongly influences the number of relocations in the subsequent periods since the solution obtained at one iteration fixes the starting layout for the next iteration. It would be interesting to test how the cost parameters influence the solution quality.

It would also be interesting to evaluate the impacts of information on future retrievals and of the point in time when information becomes available (e.g., Wasesa et al.; 2011). This would make it possible to evaluate the potential benefit of new technologies providing the terminal with more details on truck arrivals.

Another approach to tackle the dynamic version would be stochastic programming to include uncertainty directly into the model. The problem can also be extended to deal with dynamic storage and retrieval requests simultaneously. In this case, the problem is to decide in which order to serve trucks, where to locate incoming containers and where to relocate blocking containers in order to minimize truck service times.

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Analysis of Fishermen Satisfaction Level at Ujong Baroh Fishing Port, Aceh, Indonesia

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ABSTRACT

The data analysis of the performance index and user satisfaction is needed as a basic data to assess the performance of the Ujong Baroh Fishing Port.This study aims to determine the level of manager performance and the level of user satisfaction with the management of Ujong Baroh Fishing Port. Data collection was carried out during February - March by using questionnaires related to six fishing port facilities such as supply and the quality of the service supply facilities section (clean water, fuel, and ice installation), landing and discharging facilities (docks and anchored pool), and marketing facilities (auction Place). Data analysis used performance Index and Customer Satisfaction Index (CSI). Data showed that the Percentage of the Performance Index value is about 32%. The score indicated that the performance of the Ujong Baroh fishing port is poor. While the value of the user satisfaction index was 59.09%, it indicated that the level of satisfaction of the users of the Ujong Baroh fishing port was categorized into a satisfied category. Generally, user satisfaction and the performance of the Ujong Baroh fishing port is still not optimal. This study recommend to relevant parties that there is a need to improve Ujong Baroh Fishing Port management.

1. Introduction.

Ujong Baroh fishing port is categorized as D type as one of the economic equipment infrastructure built to support the success of fisheries development, especially small-scale fisheries (Hasaruddin et al., 2014). The availability of fishing port facilities are expected not only to provide boat parking space and facilities for processing catches but also to maximize the services for fishery port users (Sabana et al., 2016; Syakuro et al., 2017).

The management performance of Ujong Baroh fishing port is still not optimal. Meutia et al. (2019) states that Ujong Baroh fishing port facilities consist of basic facilities, functional and supporting facilities; and almost are good condition and utilized by fishermen but the availability of these facilities has not been able to fulfill their functions optimally.

Sharaan et al. (2017) stated that the availability of port users certainly has a very important role as the main driver in the fishing ports activities. It is not only a place for public services that can meet all user needs but also the efforts to develop a fishing port should be able to provide satisfaction to its users. Putra et al. (2016) also argues that the assessment of fishery port management performance problems can be carried out based on the port function approach. Port performance can be used to determine the level of port service to port users. It depends on the service time of the ship at the fishing port. If a port could provide good service, it can be concluded that the port has a

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high port performance level.

Measuring the performance of a fishing port is closely related to user satisfaction. The level of user satisfaction is important in the development of a responsive service provision system in a fishing port. If port users are satisfied, it means that the service of managing the port is already efficient and effectively implemented. Some related studies have been conducted in several fishing ports espeacially in Indonesia district, such as Pekalongan fishing port (Nasir et al.,2012; Imanda et al. 2016), Pelabuhanratu fishing port (Sari et al., 2020) , Kejawanan Cirebon fishing port (Bayyinah et al., 2016), Nizam Zachman fishing port (Guswanto et al. 2018), and Eretan fishing port (Nurhayati et al.,2018).

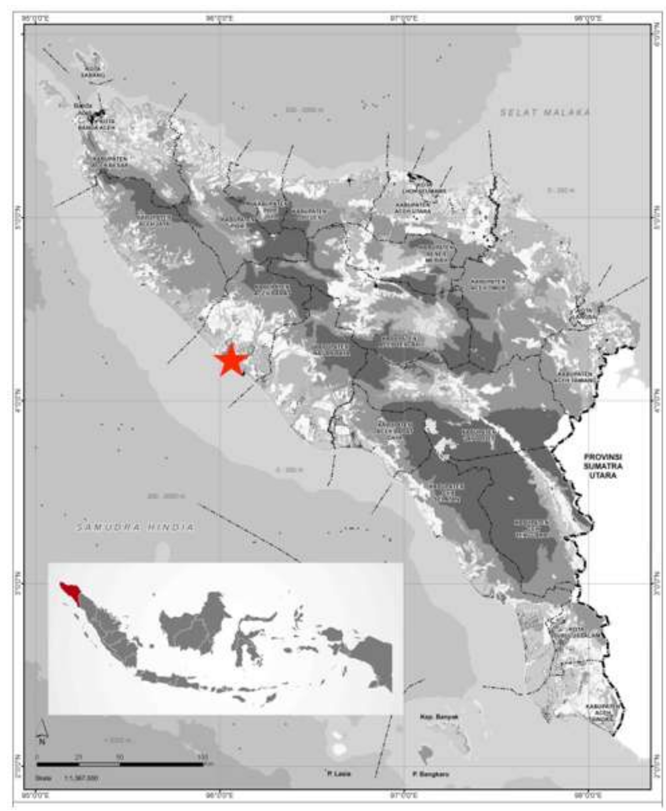
The satisfaction level felt by users will have an impact on the users about repeat usage to fishing ports as service providers and as a guideline for the success of fishery port development as well. Nowadays, no study has conducted at Ujong Baroh fishing port to investigate the level of user satisfaction with the management. Therefore, it is necessary to conduct an assessment of the level of satisfaction of port users. So it can be used as a basis to improve management performance in improving the optimal functionality of the Ujong Baroh Fishing port in the future. As stated by (Mwasenga (2012), the data can be used for quick and accurate decision making in determining the strategy to improve quality of its services as a guideline for the success of the development of fishing ports. Currently, Ujong Baroh fishing port has several basic facilities and infrastructure to support its activities including clean water installation facilities, fuel installation facilities, ice installation facilities, fish auction place, dock and dump pool. However, not all of these facilities operate optimally. Besides, based on the writer experiences, the silmilar researches about the fishing port in Europe countries are still not reported, therefore this research can be used for the premilary references and guede to conduce the similir reaseacr in the future. this study aims to determine the level of manager performance and the level of user satisfaction with the management of Ujong Baroh fishing port.

2. Case studies.

The research method was conducted descriptively to collect data at the fishing port. The research location is showed in figure 1. The research map location is shoed in figure 1. Data was collected by direct interview using a questionnaire. The participants consist of port managers and port users that chosen as a sample by using purposive sampling. The port management participants consisted of port officers including 1 person harbormaster, 4 people harness sections, 1 head fishery division, and 1 person infrastructure and facilities. While the port user participants consist of business operators which consisted of 60 fishermen (skipper handler and the crew/ABK), "fish business owner" is about 10 people, 20 fish traders (big traders (collectors) 5 people, small traders (retailers)) 10 people, mobile fish traders (Muge) 5 traders. Data collected as primary data through questionnaires and interviews with research parameters, and data collected as secondary data through supporting primary data / reports of relevant agencies.

The broadness conducted about a fishing port section. criteria used for performance assessment and customer satisfaction levels was set according to government regulation No. 45 of 2009. Includes special functions of fishing port as mooring and anchoring services for a fishing boat, loading and unloading services, and general functions of fishing port as fishing boat and marketing of catches activities. The parameters set include performance and satisfaction with the provision and quality of service from the supply facility, landing and dismantling facility, and marketing facilities. The assessment of these parameters is based on the answers from respondents. The assessment uses 5 levels (Likert). The analysis used in determining the level of manager performance and user satisfaction includes calculating the achievement matrix of performance indicators and customer / user satisfaction matrix.

Figure 1: Research Location.



Source: Author.

a. Matrix of Achievement of Performance Indicators.

The scores of the respondents' answers that have been collected are then calculated on average. A comparison of the average value with the total target score then converted to percentage, Tabel 1 show the percentage of Ujong Baroh performance (Ngamel et al., 2013).

b. User Satisfaction Level Matrix.

The user satisfaction matrix can be calculated using the Customer Satisfaction Index (CSI) analysis method. The CSI measurement method includes the following steps (Bhattarai and Kharka, 2016):

Table 1: Performance level criteria for fishing port management.

Performance Level Index Value	Criteria
0% ≤ Y < 20%	The fishing port's performance is very poor
20% ≤ Y < 40%	Poor fishing port's performance
40% ≤ Y < 60%	The fishing port's performance is quite good
60% ≤ Y < 80%	Good fishing port's performance
80% ≤ Y ≤ 100%	The fishing port's performance is very good

Source: Authors.

1. Calculating Weighting Factor (WF), obtained from changing the average value of importance to a percentage of the total average importance of all attributes tested and multiplied by 100%, so that the overall WF value is 100%;
2. Calculating Weighted Scored (WS), which is the multiplication value between the average value of the performance level of each attribute with the WF of each attribute;
3. Calculating Weighted Total (WT), is sums the WS of all service attributes, and;
4. Calculate the Satisfaction Index (SI), is WT divided by (L) the maximum scale used, then multiplied by 100%.

The overall level of satisfaction can be seen from the following criteria (Table 2):

Table 2: Criteria for the level of customer and employee satisfaction.

Satisfaction Level Index Value	Criteria
0.00 - 0.34	Very dissatisfied (service really does not meet the needs of customers and employees);
0.35 - 0.50	Not satisfied (service does not meet the needs of customers and employees)
0.51 - 0.65	Quite satisfied (sufficient service to meet the needs of customers and employees);
0.66 - 0.80	Satisfied (the service meets the needs of customers and employees)
0.81 - 1.00	Very satisfied (the service really meets the needs of customers and employees)

Source: Authors.

3. Results and Discussion.

The weight percentage of each parameter shows us how much the influences of the parameter on the performance index assessment of the Ujong Baroh fishing port. In determining the weight value of each parameter, the level of importance score refers to the fishing port situation in the location. The differences in characteristics location and technical infrastructure in each fishing port may affect the success rate of each parameter facility to be measured differently with the appropriate weights. The weight of each parameter is multiplied by the average score at every parameter (Table 3).

Table 3: Achievement Matrix of Management Performance Level at the Fishing Port Ujong Baroh.

N°	Parameter	Weight per parameter (%)	Average	Score
1	Clean water installation facilities	10	2.86	0.29
2	Fuel Installation facilities	15	1.00	0.15
3	Ice Installation facilities	15	1.00	0.15
4	Dock	25	1.71	0.43
5	Dump pool	20	1.43	0.29
6	Fish Auction Place	15	2.00	0.30
Total Score		100%		1.60
Percentage of Index Performance = (Total Score / 5) * 100%				0.32 (32%)
Criteria: Poor fishing port performance				

Source: Authors.

The obtained data showed that the result of a total performance score is about 1.60 to produce a percentage of the performance index is about 32% (Table 3). The data Indicates that the performance of the Ujong Baroh fishing port is categorized as poor. This result is based on the observations and the data obtained. Meanwhile, the assessment of the satisfaction level of fishing port users is carried out using determined parameters Customer Satisfaction Index (CSI) analysis by comparing the scores of importance scores with performance satisfaction scores in a parameter (Table 4).

Table 4: Achievement Matrix of User Satisfaction Level at the Fishing Port Ujong Baroh.

N°	Parameter	RSP	WF (%)	SSR	WS (%)	WS
1	Clean water installation facilities	4.50	16.55	2.89	47.81	0.48
2	Fuel Installation Facility	4.52	16.63	3.01	50.08	0.50
3	Ice Installation Facility	4.50	16.55	4.19	69.33	0.69
4	Dock	4.66	17.12	2.49	42.62	0.43
5	Dump pool	4.49	16.51	2.74	45.31	0.45
6	TPI (Fish Auction Place)	4.52	16.63	2.42	40.29	0.40
Total		27.19	100.00	17.74	295.44	2.95
Total Weight (WT)						2.95
Satisfaction Index (SI) (%) (2.954420 / 5) * 100%						0.59 (59 %)
Criteria: moderately satisfied						

Source: Authors.

The data above showed that the score of the Ujong Baroh fishing port user satisfaction index is 0.59 (59 %) (Table 4). This score between 0.51 - 0.65 (51% - 65%) which indicates that the level of port user satisfaction is in the moderately satisfied category. The result value of the satisfaction index in the category reflects the performance of the Ujong Baroh fishing port. It is still not maximal based on the expectations of the users.

The data of the analysis parameters of the clean water installation facility showed that the fulfillment of the clean water installation facility was still poor which is average performance score is about 2.86. While the fishing port users hope a high expectation on the availability and the service with the average score is about 4.50. This expectation was not covered by the fishing port, so there is only about 2.89 score was obtained with a different point about -1.61. It means that the satisfaction felt by users was still far from the expectations that they want.

The data of the analysis of the fuel installation facilities indicate that the condition of the facility is good but it is not supported by a good performance by the management of the fishing port with an average score is about1.00. The score indicates the performance of the fishing port facility is poor. Meanwhile, the fishing port users hope that the average expectation score is about 4.52. This expectation cannot be covered by the Ujong Baroh fishing port and it can be seen from the result of the satisfaction score is about 3.01 with a different point is about 1.51. It means that the satisfaction felt by users is still under the expectations that they want. This value shows that performance is still needed to be improved in order to meet the expectations of users.

It is similar to the fuel installation facility, the analysis shows that the performance of the ice installation facility is still poor with average performance score is 1.00. Meanwhile, the user's expectation score is about 4.50. It indicates that the availability of ice facilities is also very important for Ujong Baroh fishing port users. Acquiring satisfaction score about 4.19 indicates the satisfaction of the users is satisfied. Moreover, there is still a different point about -0.31 between the expectations and the satisfaction of users, so that the perceived satisfaction is still under the expectations that they want.

Dock facility is the most important facility that provides the greatest influence on the assessment of the performance index of the Ujong Baroh fishing port, so the user's perception is about 4.66. Dataset of the analysis of the performance of the management of the dock facilities are poor with an average score is about 1.71. Along with the poor performance value they got, this expectation cannot be fulfilled, so there is only an average satisfaction score obtained about 2.49. It indicates that the fishing port users are still not satisfied with the presence and service facilities provided by the management. The difference point is about -2.17 and it proofs the unsuccessful achievement of the performance of Ujong Baroh fishing port to fulfill the expectations of its users compared to other facilities.

The user hopes high expectation on docking ship installation facility is about 4.66 average score. It indicates the importance of the presence of the facility as a reflection of the implementation of the function of the fishing port along with the dock facilities. In addition, the poor performance obtained with the average score is about 2.00. The expectations of its users cannot be met, because the average score of satisfaction obtained is about 2.74. The score indicates that the user is still not satisfied with the performance, and it can be seen from the different point is about-1.75.

Data of the analysis showed that the result of the fishing port performance score is about 2.00. It indicates the performance of the manager of the Ujong Baroh fishing port is not good. The perception/expectation score is about 4.50, the score showed that TPI facilities in the market catches are very important. The satisfaction score is only 2.42, and it is the lowest satisfaction score compared to other facilities with -2.08 points. Fishermen are not satisfied with the performance of the management of this fishing port facility which is still far from their expectations.

The service and facilities provider are a must that should be endeavored exist at a fishing port. The presence of good provision and service facilities will greatly determine the success of the development and construction of fishing ports. (Guswanto (2012) states that individual assessments of fishery port service parameters reflect the extent to which the performance of fishing port managers has been carried out to fulfill their functions in satisfying their users. In general, if the value of the level of conformity of each parameter is far below 100%, it means that the provision of facilities and service quality at Ujong Baroh fishing port is still not satisfying users optimally. The absence of management arrangements that are carried out directly from the fishing port manager has affected to the existing facilities and unable to fulfill their function to provide services at fishing ports. Nowadays, the availability of these facilities work as requirements complements in fulfilling its status as a type-D fishing port.

The clean water provider at Ujong Baroh fishing port is equipped by 1 unit of water tank with of 1,500-2,000 liters capacity and it is still used in good way. The growth number of fishing vessels and the current clean water suppler are not able to handle all of the operations at the fishing port so that the fulfillment of the performance of this facility is poor. This condition is contrast to the results of a research conducted by Alfiana et al. (2018) states that the management performance of Brondong fishing port on clean water facilities can be said good because it helps to meet the operational needs of the fishing.

The inability of the performance of the manager to fulfill the expectations its users impact on less satisfied users to Ujong Baroh fishing port with the service and its facilities provider. Similar issue occurs in PPS Kutaraja as stated in the research showed a low level of satisfaction because amount of water supply does not match the operational needs of the fishing (Rizwan et al. 2020) ; (Rizwan et al. 2023) .

The fuel installation facility at Ujong Baroh fishing port is in good condition but is not supported by good performance by the PPI management. The only performance service provided by the fishing port manager is at the fuel distribution permit. It is because the management of the fuel agency is indirect or managed by a private party, called PT. Pertamina. Similar conditions were also found in the research results of Nurhayati et al. (2018) , the fuel provider at PPP Eretan Indramayu it is managed by a private party whose its existence has been able to help the needs of fishermen. Without interference of the Ujong Baroh fishing port management, PT. Pertamina as the owner and manager of the Padang Seurahet facility has been able to provide fuel facilities service that make fishermen satisfied. Even so, the performance that has been carried out is still not able to meet the desired expectations by its users. A similar condition was obtained by Nurhayatin et al. (2016), overall fishermen are quite satisfied with the performance of the diesel supply service at Prigi fishing port.

It is much different with the fuel installation facilities, the management of ice installation facilities is managed by the private sector. The only service provided by the fishing port manager is the ice distribution permit. So that the performance that is carried out is bad. The expectations of the users cannot be fulfilled with small and unfavorable conditions of the ice factory. It shows the inability of the ice installation facility as if it is not too important to the port users so that users are satisfied with the service of this facility provider. The inability of Ujong Baroh's management performance was able to covered the existence of an ice factory outside PPI which became a substitute for the main provider of ice supply at Ujong Baroh fishing port. The existence of an ice factory along the shipping track makes it easier for fishermen to carry out supplies compared to the fishing port ice factory which is located far out there. The discussion about the ice supplies from outside location is also already discussed by Diniah et al. (2012). The research stated that the fulfillment of the ice needs at Karangatu fishing port also comes from outside the port through private companies or ice depots from Baralaja.

Ujong Baroh fishing port has one pier facilities which are also used for mooring and anchoring activities and filling out supplies at sea, so that the dock is unable to accommodate the existing ships. As a facility that has the highest parameter weight compared to other facilities. It means that the facilities in the fishing port have the greatest influences on the Ujong Baroh fishing port performance index assessment. Nowdays, the management of this facility is in the bad category. The narrow dock size only about 72 x 4 m and affects to the level of user satisfaction. This condition creates a queue of ships to unload the catch, so that make the users are not satisfied. A similar condition also occurred in Tanjungsari fishing port (Ardandi et al., 2013). It showed that the length of the Tanjungsari fishing port is still not optimal based on the large number of fishing fleets continues to increase, so that all ships are being able to unload, load supplies, and moor at the dock.

The Ujong Baroh docking pool facility could we say in good condition. The facility condition was formed naturally by utilizing the Krueng Cangkoi river flow. It means that there was no human's construction at this facility. The port pool always has a problem occurs in fishing port and it is in line with a case research conducted by Nugroho et al. (2012). It stated that the port pool facilities in Dadap fishing port are still not optimal on its function due to the large amount of sedimentation. The number of ships that berth irregularly causes the tract of the ship not run optimally due to the absence of berthing operational services carried out by fishing port, so that its performance is at poor category. This condition causes the user's expectations cannot be fulfilled. Port users are still not satisfied with the performance that has been carried out. This situation is contrast to the results of the study conducted by Nurhayatin et al. (2019). In this study the fishermen claim they are satisfied with the service of anchoring pond facilities at Eretan Indramayu fishing port due to have a large area for mooring and landing their catch.

The availability of the Fish Auction Place facility as a place for fish auction is still considered not optimal. It can be seen from the poor performance of the Ujong Baroh fishing port management. In fact, users consider the existence of this facility very important for marketing the catch. User satisfaction scores for this facility are the lowest satisfaction scores compared to other facilities. Fishermen are not satisfied with the capacity and condition of the Fish Auction Place facilities owned by Ujong Baroh fishing port. Meanwhile, when it comes the function, fishermen are satisfied with the use of the Fish Auction Place building as a marketing place by Fish Agent as in Sungai Remas fishing port, who not carry out an auction process as the main function of Fish Auction Place (Primusdhika et al., 2016).

Based on observations, almost the facilities are functioned directly without any regulation from the Ujong Baroh fishing port manager. This is caused by several internal factors that become obstacles in the management of activities and regulations. Lack of human resource availability and limited fishing port development management budget are the main factors inhibiting performance that have caused the current management to remain dormant since the transition period (West Aceh Regent Decree Number 061.2/701/2018 on April 19 2018). Other factors are caused by the lack of coordination between stakeholders in fishing port, the absence of Ujong Baroh optimization regulations, and the lack of understanding of fishermen about the functionalities of each fishing port facility which also causes fishing port operational activities does not controlled properly.

As a result, existing facilities cannot fulfill their function to provide services at fishing ports based on the user expectations. The impact is not all users have the same opportunity to take advantage of the existing facilities. Thus, the level of satisfaction obtained by users is still in the standard range or tends to spread. Some users are satisfied with the equipments and service of existing facilities.

Conclusions.

Based on the results of the analysis about the achievement matrix of the Ujong Baroh fishing port performance level indicators in carrying out the supply function and service quality of the 6 facilities studies; clean water installation facilities, fuel installations, ice installations, docks, anchoring ponds, and TPI, the value was 32% indicate that the PPI Ujong Baroh's performance is categorized poor. Ujong Baroh fishing port performance is also measured from the fishing port user satisfaction index using the *Customer Satisfication Index* (CSI). It received a satisfaction index about 59.09% which indicates that Ujong

Baroh fishing port users are quite satisfied. Overall this value is in the standard range, where fishermen are neither satisfied nor satisfied. This value reflects that Ujong Baroh fishing port still needs to improve its performance based on the user expectations. The government should to fix the infrastructures to support fishing activities in the fishing port Ujong Baroh. Besides, the socialization about the maximize and maintenance the fishing port facilities in Ujong Barong fishing Port are needed.

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A Comprehensive Approach to Structural Integrity Analysis and Maintenance Strategy for Ship's Hull

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ABSTRACT

The structural integrity of the ship's hull is an important aspect of ensuring safety of navigation. The ship's hull is its main element and is vital for the safety of the ship and its crew. During ship operation, the hull is exposed to various factors, such as mechanical loads, corrosion, material fatigue and other actions that can lead to a violation of its structural integrity. One of the ways to ensure the structural integrity of the ship's hull is to maintain it regularly, including inspection, maintenance and repair. This article presents a comprehensive approach for analyzing the structural integrity of ship hulls and developing an effective maintenance strategy. The study encompasses various principles, formulas, and risk assessment techniques to evaluate the hull's condition, probability of damage, potential losses, and associated costs. The analysis incorporates factors such as corrosion rate, probability of damage occurrence, potential damages, and the cost of maintenance. By utilizing these calculations, informed decisions can be made regarding maintenance prioritization, resource allocation, and the development of a robust maintenance plan. The proposed approach aims to enhance the longevity and reliability of ship hulls, ensuring safe and efficient maritime operations.

1. Introduction.

Despite the development of hull maintenance technologies, shipowners still face problems related to hull damage, which can lead to accidents and loss of the vessel. Insufficient attention to the condition of the hull and lack of regular maintenance are also factors that increase the likelihood of accidents. Therefore, the condition of the hull is an important maintenance step that helps to identify problems and prevent possible accidents.

The structural integrity of a vessel's hull is one of the key characteristics that affects its operational safety and service life. Damage to the hull structure can lead to serious consequences, including ship sinking. An analysis of the literature allowed us to synthesize the necessary information and create a comprehensive overview of the topic of structural integrity of the ship's hull. In particular, article [1] discusses methods and models for assessing the strength and reliability of ship hulls, as well as problems associated with damage and loss of strength. Paper [2] discusses the basic principles of assessing the strength and reliability of ship hulls, as well as the methods used to study them. Paper [3] is devoted to the methodology for assessing the strength of a ship's hull when damaged. Papers [4-6] discuss the principles and methods of hull design, as well as structural integrity control and deformation monitoring. A general overview of the design and construction of the ship's hull is provided, including consideration of the most important components and their functions, methods and tools for monitoring structural deformations, including ship structures and practical aspects of ship hull design and construction, as well as assess-

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ment of its strength and reliability. Paper [7] also discusses methods and tools for monitoring the structural integrity of the ship's hull, including non-destructive testing methods. Scientific work [8] is devoted to the mechanical properties of materials used for the construction of the ship's hull, as well as methods for assessing their strength and reliability. The study [9] investigates the relationship between global ship accidents and ocean swell-related sea states, providing insights into the impact of sea conditions on ship safety. Article [10] presents a navigational safety assessment method using a Markov-model approach, offering a framework for analyzing and improving ship safety during navigation. Study [11] focuses on the development of an underwater robotics complex for laser cleaning of ships from biofouling, highlighting experimental results and the potential application of laser technology in hull maintenance. The paper [12, 14] explores the antifouling potential of Subtilisin A immobilized onto maleic anhydride copolymer thin films, contributing to the understanding of effective strategies to combat biofouling on ship hulls. The study also focuses on the development of advanced technologies for maintaining the integrity of ship hulls. In [13] discussed advanced nanostructures developed within the EU Integrated Project AMBIO for controlling biofouling, providing insights into innovative approaches for managing fouling organisms on ship surfaces. Paper [15] discuss the use of advanced nanostructures for the control of biofouling. The study explores the FP6 EU Integrated Project AMBIO and its contribution to preventing and managing biofouling on marine surfaces. In [16] investigated the settlement behavior of zoospores of Ulva linza during surface selection using digital holographic microscopy. The study provides insights into the colonization process of marine organisms on different surfaces. Paper [17] examined the antifouling potential of Subtilisin A immobilized onto maleic anhydride copolymer thin films. The study explores the use of enzymatic coatings to inhibit the adhesion of marine fouling organisms. In [18] presented an integral approach to vulnerability assessment focusing on ship's critical equipment and systems. The study aims to enhance the safety of maritime transportation through the application of probabilistic models. The concept of autonomous ships and the application of mathematical models in their steering process control discussed in [19]. In [20] presented a modeling approach for the dynamics of project portfolio structure in organizations, considering the resistance of information entropy. The study focuses on managing and optimizing project portfolios. Paper [21] proposed a stereoscopic approach for three-dimensional tracking of marine biofouling microorganisms. The study aims to enhance the understanding of the behavior and movement patterns of biofouling organisms. The application of imaging surface plasmon resonance for in situ studies of surface exploration by marine organisms demonstrated in [22]. The study provides insights into the interaction between marine organisms and different surfaces. The settlement and adhesion of algal cells on self-assembled monolayers with systematically changed wetting properties investigated in [23]. The study focuses on understanding the factors influencing the attachment of marine organisms. In [24] utilized digital in-line holography as a three-dimensional tool to study motile marine organisms during their exploration of surfaces. The study provides valuable information about the behavior and interactions of marine organisms on different surfaces. Articles [25, 26] propose an acoustic method for estimating the parameters of marine low-speed engine turbochargers. The study focuses on the development of non-intrusive techniques for engine performance evaluation. In [27, 28], the authors investigate the environmental efficiency of ship operations concerning the effectiveness and safety of freight transportation provision. In [29] presented a comprehensive multicriteria approach for determining the optimal composition of technical means and equipment. The paper [30] explored modeling of organizational energy and entropy creation, focusing on the complex dynamics of energy and entropy in organizational systems.

In addition, important information about the structural integrity of the ship's hull is provided by the standards and recommendations of international organizations, in particular the International Maritime Organization (IMO), the International Association of Classification (IACS), and the American Society of Mechanical Engineers (ASME). These documents contain requirements for the design and construction of the ship's hull, as well as methods for monitoring structural integrity. Therefore, the analysis of condition monitoring methods and methods for assessing the structural integrity of the ship's hull, studying the basic principles of ship hull maintenance to develop strategies and ensure the safety of ship operation is of a certain degree of relevance.

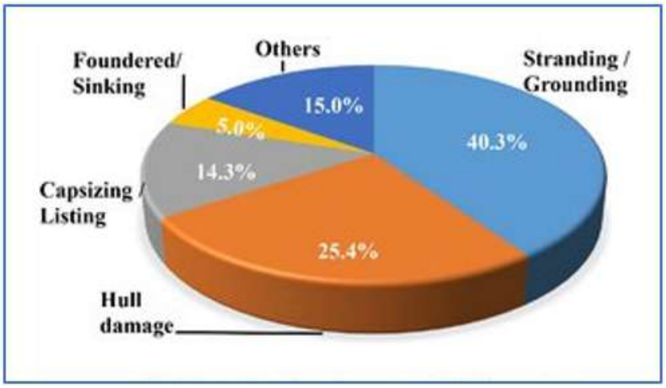
2. Materials and methods.

According to the International Maritime Organization (IMO), in 2019 alone, there were 2256 ship hull-related accidents. This amounted to 34.5% of the total number of accidents in the world's maritime transport. A year earlier, according to a report by the US Bureau of Labor Statistics, there were 59 fatal accidents on US-flagged vessels. Of these, 18 cases were related to ship hull causes. According to a report by Lloyd's Register, a ship classification society, there were 378 ship hull-related accidents over the past decade, including 17 ship losses.

This data shows that damage to the hull can lead to serious accidents and mishaps, and emphasizes the importance of regular maintenance and inspection of the hull for safety at sea (Fig.1).

The hull is the most important part of any seagoing or river vessel, as it provides the necessary strength and rigidity required for safe and efficient navigation. However, due to various factors, such as mechanical damage, corrosion, physical and chemical environmental influences, the hull can lose its structural integrity and strength. This can lead to serious consequences, such as accidents at sea and loss of life. Therefore, ensuring the structural integrity of the ship's hull is one of the most important tasks that requires constant monitoring and periodic maintenance. In this context, it is important to have a proper understanding of the technologies and methods for monitoring the structural integrity of the ship's hull, as well as to use the most modern methods of maintenance to ensure the safety and efficiency of the vessel's movement. The condition of a

Figure 1: Weather-related ship accidents based on initial events.



Source: Authors.

ship's hull can be damaged by various factors that can affect it individually or in combination, some of them presented in Table 1:

Table 1: Factors Affecting the Condition of a Ship's Hull.

Factors	Impact on the ship's hull
Impact of the marine environment	The marine environment, including salt water, sea air, and tides, can adversely affect the hull. This can lead to corrosion, warping and other types of damage;
Adverse weather conditions	Adverse weather conditions, such as storms and strong winds, can cause damage to the hull, such as cracks, tears, and deformations;
Intense	Maneuvers, such as collisions with other vessels, can cause damage to the hull;
Maneuvering	Errors in the operation of the vessel, such as overloading or improper use of the control system, can lead to hull damage;
Errors during vessel operation	The time the vessel has been in service may cause the hull to wear naturally, which may result in damage or loss;
Service life of the vessel	Failure to regularly maintain and repair the hull may result in the accumulation of damage and deformation that may adversely affect its structural integrity;
Lack of regular maintenance	Certain species of animals and vegetation, such as crayfish and algae, can cause damage to the hull, especially if the vessel is left in one place for a long time;

Source: Authors.

To prevent damage and ensure the safety of the ship's hull, it is crucial to take appropriate measures for regular maintenance, repair, and protection. This includes conducting periodic inspections, applying protective coatings to prevent corrosion, addressing identified damages through timely repairs, implementing cathodic protection systems, and implementing effective cleaning and fouling control measures. By implementing these measures, ship owners can maintain the structural integrity of the hull, extend its lifespan, and enhance the overall safety and performance of the vessel.

Undoubtedly, underwater inspection of the ship's hull is a critical procedure for ensuring safe operation of the vessel. It allows to identify potential problems, such as hull damage, corrosion coating integrity, hidden defects and other causes that may lead to a shipwreck. Underwater inspection is carried out with the help of special equipment, such as unmanned underwater vehicles (UAVs) and cleaning robots, which can visually inspect the hull and collect data on the condition of its surface (Fig.2).

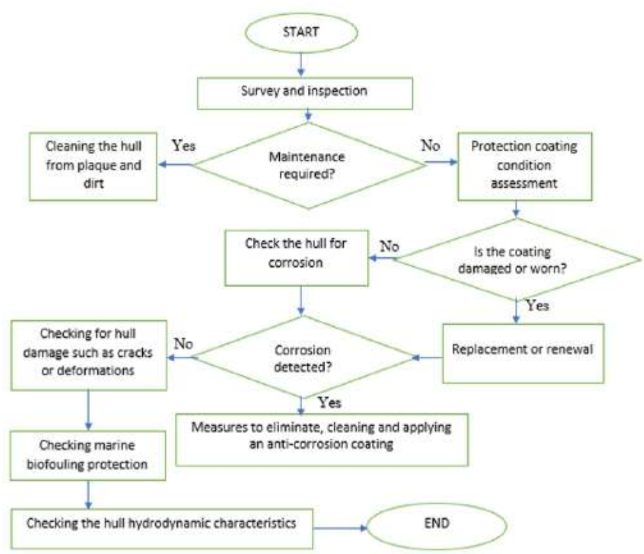
Figure 2: Condition of the outer shell of the ship's hull.

Source: Authors.

This data is then analyzed by specialists to determine the extent of wear and tear and potential issues that may require repair. The importance of underwater inspection is emphasized by the fact that hull defects can lead to extremely dangerous situations, such as loss of vessel stability, leakage of fuel or other harmful substances, water penetration into the internal compartments of the vessel, and other serious consequences. Therefore, regular underwater inspection is an important part of hull maintenance and guarantees safe operation.

The ship's hull maintenance algorithm may include the following steps (Fig.3):

Figure 3: Algorithm of ship hull maintenance.



Source: Authors.

Visually inspect the case for defects and damage. Cleaning the housing from plaque and dirt. Various methods can be used for this purpose, for example, mechanical cleaning, chemical treatment, waterjet cleaning, etc. Assess the condition of the protective coating. If the coating is damaged or worn, it should be replaced or renewed. Check the body for corrosion. If corrosion is detected, measures must be taken to eliminate it, for example, by cleaning and applying an anti-corrosion coating. Checks for damage to the hull, such as cracks or deformation. Check the marine biofouling protection system and take corrective action if it is not working properly. Check and replace fasteners such as bolts, nuts, rods, etc. Inspection and replacement of trim elements, if necessary. Check and adjust the ballast tank system. Checking the state of hydrodynamic characteristics of the hull, such as surface smoothness and coating thickness, and taking the necessary measures to improve these characteristics. The hull maintenance algorithm can be supplemented or modified depending on the type and characteristics of the vessel, its operating conditions and the presence of specific hull problems.

Figure 4: Traditional Underwater Hull Cleaning Methods.

Source: Authors.

Some general principles used for analyzing the structural integrity of a ship's hull include (Table 2):

Table 2: Principles of analyzing the structural integrity of a ship's hull.

Principle/Analysis Method	Description/Details
Strength Analysis	This involves assessing the strength and stability of the hull structure under various loads and conditions, such as static, dynamic, and environmental loads. It considers factors such as material properties, structural design, and load distribution
Fatigue Analysis	Fatigue refers to the degradation of material and structural integrity due to repetitive loading over time. Fatigue analysis involves evaluating the hull's resistance to fatigue failure and predicting the fatigue life of critical components, considering factors such as cyclic loads, stress concentrations, and material properties
Buckling Analysis	Buckling is the sudden and catastrophic failure of a structural element due to compressive loads. Buckling analysis assesses the stability of the hull structure against buckling, considering factors such as geometric imperfections, material properties, and applied loads
Hydrodynamic Analysis	This involves studying the interaction between the hull and water, considering factors such as wave loads, hydrodynamic forces, and fluid-structure interaction. It helps assess the hull's resistance to wave-induced loads and its hydrodynamic performance
Non-Destructive Testing (NDT)	NDT techniques, such as ultrasonic testing, magnetic particle inspection, and visual inspection, are used to detect and assess any defects, cracks, or corrosion in the hull structure. NDT plays a crucial role in identifying potential structural issues and ensuring the integrity of the hull

Source: Authors.

These are just a few examples of the principles used in the analysis of a ship's hull structural integrity. The specific methods and techniques employed may vary depending on the type of vessel, its operating conditions, and applicable industry standards and regulations. Main principles used for analyzing the structural integrity of a ship's hull include:

1. Stress (σ) and Strain (ε) based on the Hooke's Law:
$$\sigma = E \cdot \varepsilon \tag{1}$$
where E - modulus of elasticity of the material.

2. Bending Stress (σ_b): Bending Moment Formula:
$$M = \sigma_b \cdot S \tag{2}$$
where M is the bending moment, and S is the moment of inertia of the cross-section.

3. Strength Criteria (e.g., von Mises criterion) based on von Mises Criterion Formula:
$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 \leq \sigma_{\text{yield}}^2 \tag{3}$$

where σ_1 , σ_2, σ_3 are the principal stresses, and σ_{yield} - the strength of the material.

3. Results and discussion.

The following steps can be taken to develop a maintenance strategy and conduct a hull condition assessment and risk assessment using the available calculations:

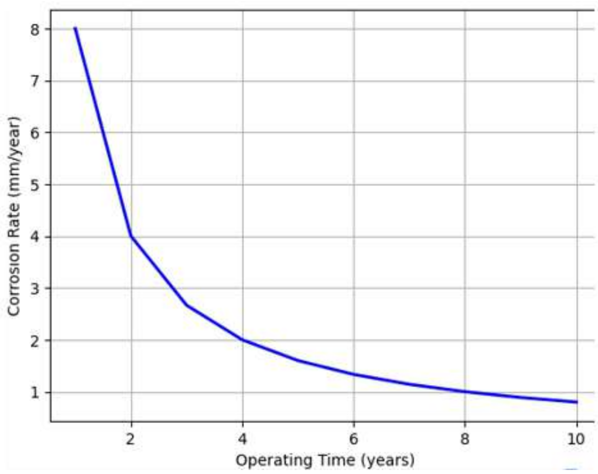
- Calculation of corrosion rate;
- Estimation of damage probability;
- Evaluation of potential losses;
- Calculation of maintenance costs.

Once the calculations for the level of corrosion, probability of damage, potential losses, and associated costs have been performed, it is essential to analyze the results to make informed decisions regarding the maintenance strategy. By considering these factors, such as the extent of corrosion, likelihood of damage, potential losses, and the associated costs, maintenance activities can be prioritized, resources can be allocated efficiently, and a comprehensive maintenance plan can be developed for the ship's hull. This analysis allows for a proactive approach to address critical issues, optimize maintenance efforts, and mitigate risks to ensure the long-term structural integrity and operational efficiency of the vessel.

1. Calculation of corrosion rate:
$$K_S = \left(\frac{K_1 \times K_2 \times K_3 \times Z \times A}{T}\right) \times \left(1 - e^{-K_4 \times T}\right) \tag{4}$$
Where: K_S is the corrosion rate (mm/year), K_1, K_2, K_3, and K_4 are coefficients that depend on various factors influencing corrosion, Z - coefficient accounting for the condition of the hull surface, A - the surface area of the hull (m^2), T - time of ship operation (years), *exp*- exponential function.
The coefficient K_4 determines the rate at which the corrosion rate approaches a maximum value over time. This can represent phenomena such as the development of a protective layer or a saturation effect in the corrosion process. It's important to note that the specific values for the coefficients K_1, K_2, K_3, K_4, and Z would depend on the specific conditions and materials being considered. These values would typically be determined through experimental data, expert knowledge, or published corrosion rate guidelines for the particular ship or material.
Suppose: $K = 0.1$ (coefficient for this type of corrosion), $Z = 0.8$ (coefficient that considers the condition of the hull surface), $A = 100$ (hull surface area, in m^2), $T = 10$ (time of operation of the ship, in years). Thus, in this

example, the corrosion rate is 0.8 mm/year. This rate can be used to predict the decrease in the thickness of the hull walls during the year (Fig.5).

Figure 5: Relationship between corrosion rate and the ship operating time.



Source: Authors.

2. Estimation of damage probability:

$$P = \frac{N \times F \times S}{T \times R} \tag{5}$$

where: P - probability of damage occurrence, N - number of ship operation cycles, F - frequency of damage occurrence per one cycle, S - coefficient considering the influence of additional factors (for example, operation conditions, maintenance, ship age), T - time of ship operation, R - coefficient taking into account the risk of damage occurrence.

Above formula allows to consider not only the number of operating cycles and the frequency of damage occurrence, but also additional factors that may influence the probability of damage occurrence. The S and R coefficients can be determined based on data analysis, expert estimates or statistical methods. It is important to note that the specific values for S and R factors will depend on the specific conditions and factors you are considering. They can be determined by analyzing the raw data or by applying appropriate industry standards and guidelines.

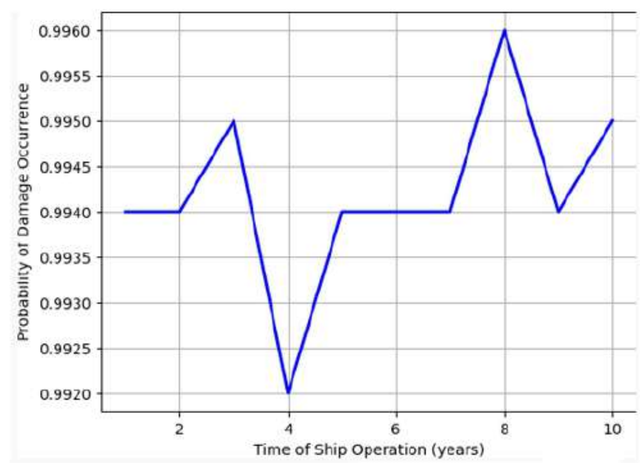
$$P = 1 - e^{-\lambda T} \tag{6}$$

where: P is the probability of damage occurrence, λ is the intensity of a random event (e.g., the intensity of damage occurrence per unit time), T is the operating time of the vessel.

This formula is based on an exponential distribution and assumes that the probability of damage decreases exponentially with time. The intensity λ can be determined on the basis of statistical data, studies or expert evaluations.

More sophisticated statistical analysis or modeling techniques can be used to more accurately estimate the probability of damage occurrence depending on the ship's operational time. One possible approach is to use Monte Carlo simulation. The Monte Carlo simulation generates random events of damage occurrence with specified probabilities and distributions. The results are then analyzed to estimate the probability. This code implements a Monte Carlo method to estimate the probability of damage occurrence vs. the lifetime of the ship. In this example, a large number of simulations are performed where damage events are randomly generated for each cycle of operation. The results of the simulation are analyzed to estimate the probability of occurrence of damage as a function of the ship's time of operation (Fig.6).

Figure 6: Estimation of Probability of Damage Occurrence.



Source: Authors.

3. Evaluation of potential losses:

$$U = P \times C \tag{7}$$

where: U - potential damage; P - probability of problems; C - cost of fixing the problem.

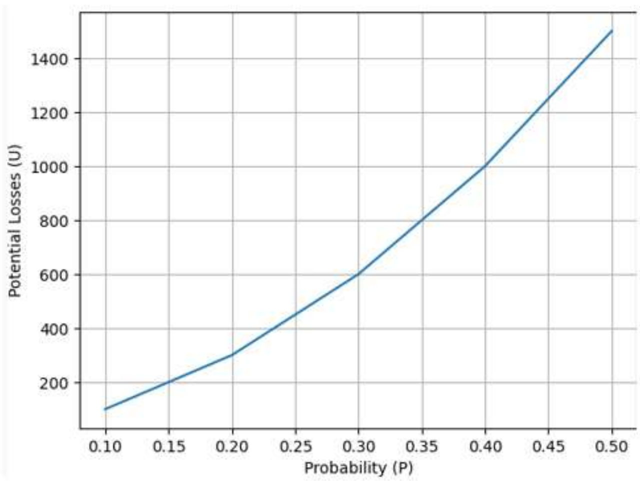
For example, let's assume the following values:

P = [0.1, 0.2, 0.3, 0.4, 0.5] # probabilities of problem occurrence;

C = [1000, 1500, 2000, 2500, 3000] # costs of problem resolution.

In the given example, we utilize the lists P and C to represent the values of probability and cost, respectively. By using a function, we compute the potential losses U by multiplying the corresponding elements of P and C. The resulting values of potential losses are then plotted on a graph, allowing us to visualize the relationship between potential losses and probability. This graphical representation enables us to analyze the impact of probability on the magnitude of potential losses, providing valuable insights for decision-making and risk assessment in various scenarios (Fig.7).

Figure 7: Relationship between the probability of problem occurrence and the potential losses.



Source: Authors.

From the graph, we can observe the relationship between the probability of problem occurrence (P) and the potential losses (U). As the probability of problem occurrence increases, the potential losses also tend to increase. This indicates that a higher likelihood of problems occurring can result in greater potential financial losses. The graph shows a linear relationship, suggesting that the potential losses are directly proportional to the probability of problem occurrence. This implies that the impact of the probability on the potential losses is consistent and predictable. The slope of the line represents the cost per unit probability. A steeper slope indicates a higher cost for each incremental increase in probability, while a shallower slope indicates a lower cost. By analyzing the graph, decision-makers can assess the potential financial risks associated with different probabilities and make informed decisions regarding risk mitigation strategies or resource allocation.

4. Calculation of maintenance costs:

$$M? = C_1 + C_2 + C_3 + \ldots + C_n \tag{8}$$

where: M_C – maintenance cost; C_1, C_2, C_3 - cost of each individual service measure; n – number of service measures.

In general, a maintenance strategy should be a comprehensive approach that includes assessing the condition of the hull, identifying risks, developing a maintenance plan, and monitoring the effectiveness of the measures taken. optimal maintenance interval:

$$I_{\text{opt}} = \frac{C_p}{C_f + (C_h \cdot (1 - \exp(-r \cdot T))) + C_m} \tag{9}$$

In the given formula, additional complexity is introduced through the inclusion of an exponential term and a rate parameter (r) that represents the rate of deterioration over time. The term $(1 - exp(-r \cdot T)$ accounts for the accumulated damage or deterioration of the hull over the maintenance interval *(T)*. The numerator C_p - represents the cost of preventive measures to reduce the probability of hull failure. The denominator consists of three components: C_f which represents the cost of hull failure, C_h - represents the cost of downtime during repairs, and C_m - represents the cost of routine maintenance.

By incorporating the exponential term and rate parameter, the formula considers the accumulation of damage over time and adjusts the cost of downtime accordingly. This allows for a more accurate estimation of the optimal maintenance interval that balances preventive measures, repair costs, and routine maintenance.

Thus, the optimal hull maintenance interval is defined as the inverse of the root value of the product of coefficients characterizing various aspects of ship operation. These coefficients should be determined based on the analysis of a particular situation and the specific characteristics of the ship's hull.

The process of ensuring the structural integrity of a ship's hull can include mathematical models that allow analyzing and predicting the behavior of the hull under various conditions. One of the main models used in this field is the Finite Element Model (FEM). A finite element model divides a ship's hull into a finite number of elements, called finite elements. Each finite element has certain mathematical characteristics such as geometry, material, and properties. The model then uses mathematical equations and numerical analysis techniques to solve these equations and predict the behavior of the ship's hull under various loads and conditions. The finite element model allows the analysis of stresses, deformations, stability and other parameters that affect the structural integrity of the ship's hull. The model can be used for determination of optimum hull design, optimization of material and component distribution as well as for prediction of hull behavior under operating conditions. From the calculation results it is possible to draw stress or strain diagrams in the ship hull, which help to visualize stress distribution and identify critical areas or points with high stresses.

Ship hull insurance is one of the most important aspects of ensuring maritime safety. Hull insurance protects the shipowner from financial losses related to damage or loss of the ship's hull. The main types of hull insurance are hull insurance and marine insurance. Hull insurance provides protection against financial losses associated with damage to or loss of the ship's hull as a result of collision, fire, explosion, pirate attack and other similar events.

Maritime insurance provides protection against financial losses related to damage or loss of the vessel's hull as a result of adverse weather conditions, flooding, cargo accidents and other similar events. It is worth noting that the terms and conditions of hull insurance may vary significantly depending on the type of vessel, its technical characteristics, operating conditions and other factors.

Therefore, when choosing insurance coverage, it is necessary to consider all the features of the vessel. In general, hull insurance is an important tool for ensuring safe navigation and protecting the interests of shipowners. In this case, it is necessary to choose the optimal insurance coverage, considering all the features of a particular vessel and its operating conditions.

New technologies in hull maintenance include various innovations and methods that help improve efficiency, safety and cost-effectiveness. Some of them may include inspection of the ship's hull without the need for divers to dive, which reduces labor costs and risks to human life, automatically cleaning the hull from algae, sea shells and other unwanted formations. This helps to reduce hull drag and improve hydrodynamics, which in turn can reduce fuel consumption helps to improve hydrodynamics and reduce fuel consumption and extend the life of the ship's hull.

For example, unmanned underwater vehicles that have recently gained popularity can operate without human intervention and be used for various tasks, including inspection and survey of the ship's hull, and are equipped with a high-quality camera and other sensors, such as thermal cameras and laser scanners, which can detect damage, corrosion and other problems that may not be visible to the naked eye. This allows for surveys to be carried out without risking human life, as there is no need for divers to dive. Drones can be used to search for and detect hull damage, inspect inaccessible areas, and monitor the hull cleaning process. They can operate in a variety of conditions, including at depths of up to several thousand meters, which allows them to be used to inspect both large ships and small boats and yachts. The use of marine drones in ship hull maintenance has a number of advantages. Firstly, it reduces the cost of surveys and reduces the time required for work. Secondly, it improves work safety, as there is no need to dive into dangerous areas to inspect the hull. Thirdly, it provides more accurate and complete information about the condition of the ship's hull, which helps prevent problems and damage in the future.

Nano- and micro-coatings are technologies used to protect the surface of a ship's hull from various types of contamination and corrosion. These coatings are applied to the surface of the ship's hull in the form of thin films and have micro- and nanoscale structures that can reduce water resistance and corrosion resistance. Nanoshells are thin coatings composed of nanoparticles that can change surface properties such as hydrophobicity (water repellency) or hydrophilicity (water attraction). This can help reduce water resistance, which in turn can reduce the energy consumption of the vessel. In addition, nanoshells can have anti-corrosion properties, protecting the hull of a ship from rust and other types of corrosion.

Microshells are thin films that have microstructures on the surface, creating thousands of microscopic air pockets. This can help reduce water resistance and improve the hydrodynamic

Figure 8: Navigator drone built by a team of engineers from Rutgers University.

Source: Rutgers University.

properties of the ship's hull. Microshells can also prevent the formation of algae, shells and other marine organisms on the surface of the ship's hull. They can also reduce the operating costs of ships by improving their energy efficiency and reducing the need for frequent hull cleaning.

Robotic cleaners are automatic devices that can clean the hull of a ship from algae, shells, microorganisms, and other deposits that can reduce the speed and maneuverability of a vessel. These robots are used for hull maintenance and can operate both on the surface and underwater. The cleaning robots are equipped with different types of brushes that can clean the hull of the ship from different types of deposits. They can also use a water jet to remove deposits that are difficult to remove with a brush. In addition, some robotic cleaners are equipped with vacuum cleaning systems that can collect deposits from the surface of the ship's hull.

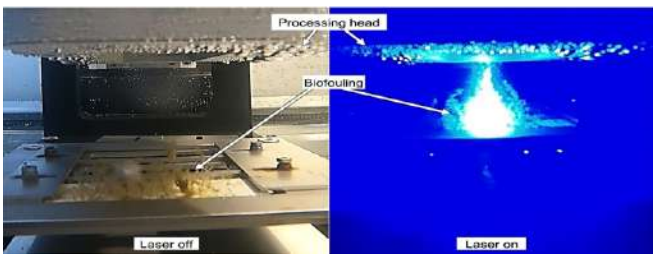
There are several advantages to cleaning the hull with robotic cleaners. Firstly, it reduces the cost of ship maintenance, as there is no need to involve a large number of workers in cleaning. Secondly, it improves the quality of cleaning, as robotic cleaners can work more accurately and efficiently than humans. Thirdly, it reduces the risk of injuries and other problems associated with working in water, as there is no need to immerse oneself in water to perform cleaning. Robotic cleaners are used in a variety of fields, including shipbuilding, marine industry, fishing, and other areas where hull maintenance is required.

Figure 9: The developed ROV device for the remote inspection and laser cleaning of ship hulls.

Source: Lasersystemseurope.com.

Laser radiation has emerged as a promising technology for effectively removing marine fouling from the underwater surfaces of ship hulls without causing damage to the underlying coating. Scientists at LZH (Laser Zentrum Hannover) have developed a process that utilizes laser radiation to selectively damage the cells of the fouling organisms, leading to their demise. The damaged fouling is subsequently dislodged and washed away by the natural flow of water over time. This innovative approach offers a potentially environmentally-friendly and efficient solution for maintaining clean hulls and optimizing the performance of ships, while minimizing the need for more invasive and environmentally harmful fouling removal methods.

Figure 10: The underwater laser process in side view.



Source: LZH.

There is no doubt that service life is one of the most important factors affecting the condition of a ship's hull. Each material has its own service life, which is determined not only by the quality of the material, but also by the operating modes, operating conditions and maintenance. In general, the service life of a ship's hull can vary from a few years to decades, depending on the materials, operating conditions and maintenance. There are several factors that affect the service life of a ship's hull, including: materials, operating conditions, maintenance, operating mode, lack of regular maintenance.

Ship hulls are made of various materials, such as steel, aluminum, composites, etc. Each material has its own characteristics and service life, which may vary depending on the operating conditions. Operating conditions such as exposure to salt water, corrosion, impacts, etc. can shorten the service life of a ship's hull. Regular maintenance can extend the life of the hull and reveal hidden defects. Improper operating conditions, such as overloading or improper handling of the vessel, can shorten the life of the hull. Lack of regular maintenance is one of the factors that can negatively affect the condition of the hull. Regular maintenance includes checking the hull for defects, cleaning it from plaque and contaminants, and repairing damage.

If the vessel does not undergo regular maintenance, its hull may develop defects and damage that can lead to serious consequences. For example, corrosion of metal surfaces can lead to a loss of structural strength of the hull, which can lead to accidents. The accumulation of plaque and contaminants on the hull surface can also lead to a decrease in the speed and maneuverability of the vessel, which can affect its safety. Therefore, regular hull maintenance is an important element of maintaining its condition and safety of operation. It allows for early detection and repair of defects and damage, which reduces the likelihood of accidents and extends the life of the hull.

Conclusions.

In conclusion, it is important to develop effective strategies for maintaining the structural integrity of the ship's hull. Various factors such as corrosion, fatigue, and hydrodynamic forces can affect the condition of a ship's hull. Using techniques such as strength analysis, fatigue analysis, buckling analysis, hydrodynamic analysis, and nondestructive testing, structural integrity can be assessed, potential problems identified, and an effective maintenance strategy developed. In addition, the use of advanced technologies, such as laser light to remove marine contamination, promises to maintain the integrity of the hull without damaging the main coating. Considering factors such as corrosion rates, likelihood of damage, potential losses and associated costs, informed decisions can be made about prioritizing maintenance activities and allocating resources. Ultimately, a comprehensive maintenance plan and regular evaluations are critical to ensure the long-term safety and performance of the ship's hull.

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Causal Analysis of the Posture of the Indonesian Navy and the Development of the Strategic Environment in Supporting the Archipelago's Sea Defense Strategy

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ABSTRACT

An understanding of these threats forms the basis for the Indonesian Navy in developing its strength, capability, operational doctrine and strategy, regional collaboration and enhancing maritime security and defense in Indonesia's jurisdiction. This study aims to identify variables from perceived threats and developments in the strategic environment to support the development of the Indonesian Navy's posture in supporting the implementation of the Archipelago Sea Defense Strategy using the Delphi method of analysis. Furthermore, the authors use the DEMATEL method to analyze the causal relationship between the criteria of the threat variable and developments in the strategic environment to determine strategies that can be applied in the development of the Indonesian Navy's posture for deploying Archipelago Sea Defense Strategy. From this analysis, it was obtained 8 (eight) variables that had an influence on the implementation of the SPLN which became the basis for the strategy for developing the Indonesian Navy's posture strength prioritizing the development of War ship, Naval Bases, Aircraft, Marines, and Special Forces. Meanwhile, the development of the Indonesian Navy's posture capabilities prioritizes increasing the capabilities of Defence, Security, maritime intelligence, Diplomacy, Support and Empowerment of marine defense environment. While the strategies that can be implemented in supporting the title of Archipelago Sea Defense Strategy include Increasing maritime diplomacy cooperation, Increasing the degree of maritime security and sea combat operations in selectively vulnerable areas such as hot areas and chock points and Integrating weapons systems that are adapted to Indonesia's geographical and geostrategic conditions.

1. Introduction.

In this rapidly changing era, an understanding of the strategic environment and threat perception is very important for every country that wants to maintain the security and stability of its territory. The development of the strategic environment which refers to changes and dynamics in the global and regional environment that can affect the national interests of a country affects the perception of threats or the perspective of a country towards potential threats that exist around it. In the defense context, it is important to understand the strategic environment to detect and identify threats that may arise and to formulate appropriate defense policies to anticipate these potential threats.

With the development of technology that can change the dimensions of warfare such as unmaned systems, stealth technology, cyber, artificial intelligence, IoT and weapons of mass destruction increase the speed, precision, explosive and multidimensional warfare in the future. In addition to this, current developments in geopolitical issues, such as the development of inter-state forces which are leading to an arm race to strengthen their military (arm race), economic crises, resource and food crises, environmental damage and the trend of minilateralism

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have also increased the challenges and risks of the Indonesia Navy's duties. thus demanding an increase in military capability, increased regional cooperation, flexibility, adaptability and toughness of the Indonesian Navy.

To anticipate the negative impacts of technological developments and potential threats arising from the constellation of regional and global geopolitical issues, the development of the Indonesian Navy's posture is directed at realizing the strength and capability of the Indonesian Navy which is modern, has a global projection and has a strong deterrent effect. Adoption of technologies such as artificial intelligence, automation systems and smart defense systems is needed in efforts to early detect and identify all forms of threats, increase the capability of defense equipment in terms of speed, radius of reach, precision and destructive power. In addition to this, increased defense and intelligence capabilities are also needed to protect oneself from weapons, cyber and espionage attacks from opponents.

In this study, the authors aim to identify threat variables and developments in the strategic environment and then formulate a strategy for developing the Indonesian Navy's posture to support the archipelago's maritime defense strategy. This research is important to do considering the need for the Indonesian Navy to develop the Indonesian Navy's strength posture for 2025-2044 which is currently the final stage of the Strategic Plan 2020-2024 in the phasing of the development of the Indonesian Navy's posture for 2005-2024. To identify using the threat variables and strategic environmental developments, the authors use the Delphi method analysis, then to determine the causal interconnection relationship between the criteria of the variables above the authors use the DEMATEL method analysis approach as a basis for determining the Indonesian Navy's posture development strategy. This research can provide several contributions, including: Providing an evaluation and understanding of perceived threats arising from the current developments in the strategic environment. This research can be used as a reference in planning and developing the posture of the Indonesian Navy, besides this research also provides information for leadership. TNI AL in strategic decision making.

2. Literature Review.

2.1. Threat Perception.

Yarger (2006) explains that the strategic environment is a variety of contexts, conditions, relationships, trends, issues, threats, opportunities, interactions, and impacts on the internal and external of a State entity that affect its success in establishing relationships with the physical world, other State entities. (state actors), non-state actors, opportunities and possibilities in the future These non-state actors can be in the form of organizations in the private sector, both profit-oriented and non-profit oriented. Therefore, the strategic environment becomes a space and time where state entities grow, develop, or experience destruction.

What happened or will happen in the strategic environment is basically possible, predictable, reasonable, and unknown / unknown (Bandoro, 2013). However, the strategic environment shows two characteristics at once, namely randomness and order so that it is not completely unpredictable, random or uncontrollable (Yarger, 2006). The above situation makes the strategic environment a phenomenon with high complexity.

Owen Jacobs (in Gerras, 2010) reveals that the strategic environment has VUCA properties, namely volatility, full of uncertainty, very complex, and ambiguous. Volatility is the nature of the strategic environment that changes so quickly. When the rapid nature of change creates uncertainty in the strategic environment. The relationship between elements in a strategic environment is so complex. Planning and decision making becomes increasingly difficult in a strategic environment due to ambiguity.

Changes and developments in the strategic environment have implications for policy output and the direction of orientation of political institutions. This will have implications, both positive and negative at the same time. Positive implications will bring benefits in supporting political ideals, goals and interests, while negative implications will cause an increase in potential threats to political sustainability. Therefore, the development of the strategic environment needs to be scrutinized by analysts, designers, makers and political decision makers in order to achieve survival of the fittest (Bhakti, 2004). Changes in the strategic environment, according to Yarger (2006), may result from the change opportunity itself (by chance) or it can also be engineered or designed (by design). Surely, every single element changes or certain actors in the strategic environment make changes, it will have an impact on the entire strategic environment. The strategic environment can be scanned through multiple dimensions. Bandoro (2013) states that the dimensions of security, economics, politics, society, technology, and so on are studied to scan the strategic environment. Meanwhile, David (2013) explains that the dimensions of politics, government, law, economy, socio-culture, environment, technology, and competition between entities need to be viewed in a strategic environment. economics (economics), politics (politics), social (society), technology (technology), and so on are studied to scan the strategic environment. Meanwhile, David (2013) explains that the dimensions of politics, government, law, economy, socio-culture, environment, technology, and competition between entities need to be viewed in a strategic environment. economics (economics), politics (politics), social (society), technology (technology), and so on are studied to scan the strategic environment. Meanwhile, David (2013) explains that the dimensions of politics, government, law, economy, socio-culture, environment, technology, and competition between entities need to be viewed in a strategic environment.

2.2. Indonesian Navy Posture.

The posture of the Indonesian Navy is the composition of the forces, capabilities and patterns of deployment of the Indonesian Navy which are aimed at implementing the national defense policy at sea in maintaining sovereignty and territorial integrity, protecting the interests and safety of the nation and taking an active role in safeguarding regionally and internationally. The development of the Indonesian Navy's posture is oriented in dealing with various forms of threats that are aligned with the government's policies and vision in realizing the world maritime axis, the country's long-term development plan and paying attention to the national defense strategy, military strategy and Archipelago Sea Defense Strategy. (Perkasal no 6, 2016).

The rationale in developing the posture of the Indonesian Navy is to realize Indonesia as a world maritime axis by establishing five main pillars, namely by rebuilding a maritime culture, committing to protecting and managing marine resources with a focus on building seafood sovereignty through developing the fishing industry by placing fishermen as the main pillar , commitment to encourage the development of maritime infrastructure and connectivity by building sea highways, seaports, logistics, the shipping industry and maritime tourism, maritime diplomacy that invites all Indonesian partners to work together in the maritime sector and finally by building a maritime defense force. (Ministry of Maritime Affairs and Fisheries, 2021).

To support this government policy, the Ministry of Defense and related institutions are committed to realizing national security that supports economic independence by securing maritime resources and reflecting Indonesia's personality as an archipelagic country, strengthening identity as a maritime country, and realizing Indonesia to become an independent, advanced maritime country, strong and based on national interests. The Indonesian Navy translates this policy into a national sea defense strategy by taking into account all geographical aspects of Indonesia as an archipelagic country. The national defense strategy is structured in layers and shifts in the battlefield are organized in a universal defense system based on three interrelated pillars starting from the aspect of deterrence, layered defense and control of the sea which is embodied in the Archipelago Sea Defense Strategy. (Perkasal no 6, 2016). The development of the Indonesian Navy's posture takes into account various aspects with a planning approach based on threat scenarios, policies for strengthening the national defense system, PMD policies, RPJPN 2005-2025, operational capabilities and technological developments.

2.3. Archipelago Sea Defense Strategy.

Archipelago Sea Defense Strategy is a defense strategy implemented at sea that is dynamically influenced by developments in the strategic environment and the availability of national resources which are carried out through joint operations, dimension operations and assistance operations supported by national forces. Archipelago Sea Defense Strategy is oriented towards the concept of an archipelagic state, which means that the sea defense of the archipelago must consider the geographical conditions of Indonesia as an archipelagic country. The government's vision of establishing Indonesia as the world's maritime axis is a thought that needs to be carried out in building strength based on Indonesia's geographical conditions as an archipelagic country. The existence of the Indonesian Government's vision to make Indonesia a world maritime axis has implications for the country's defense strategy including the Archipelago Sea Defense Strategy. The three main concepts that underlie Archipelago Sea Defense Strategy are the concept of layered defense, shifting the battlefield, and universal defense. The Archipelago Sea Defense Strategy's strategic objectives are to prevent the intentions of disruptive parties, to overcome various kinds of threats, and to create controlled maritime jurisdiction conditions. These three targets will be achieved by Archipelago Sea Defense Strategy which contains three main generic strategies namely deterrence strategy, layer defense strategy and sea control strategy. The formulation of the Archipelago Sea Defense Strategy itself is translated into aspects of marine defense which include: These three targets will be achieved by Archipelago Sea Defense Strategy which contains three main generic strategies namely deterrence strategy, layer defense strategy and sea control strategy. The formulation of the Archipelago Sea Defense Strategy itself is translated into aspects of marine defense which include: These three targets will be achieved by Archipelago Sea Defense Strategy which contains three main generic strategies namely deterrence strategy, layer defense strategy and sea control strategy. The formulation of the Archipelago Sea Defense Strategy itself is translated into aspects of marine defense which include:

a. Deterrence Strategy, directed to prevent the intentions of parties who will interferestate sovereignty and territorial integrity of the Republic of Indonesia, as well as those that will harm national interests through naval diplomacy, presence at sea, especially in border areas that have the potential to become a source of conflict in the future, as well as building the capabilities and strength of the Indonesian Navy.
b. The Layered Defense Strategy is directed at eliminating and destroying external threats through the deployment of combined sea and air forces in the buffer defense field, the main defense field and resistance areas by involving the Indonesian Navy and all major maritime components supported by the Indonesian Air Force. A layered defense strategy was applied during wartime in the form of sea combat operations which have a forward defense concept while taking into account the concept of shifting the battlefield.
c. Sea Control Strategy, directed at ensuring the use of the sea for one's own strength and preventing the use of the sea by opponents, breaking the opponent's sea communication lines as well as preventing and eliminating various aspects of maritime threats from within the country through the deployment of forces in the form of daily sea operations and combat alert operations sea with the support of the Indonesian Air Force in selectively vulnerable waters.

The Archipelago's Sea Defense System will continue to develop dynamically in accordance with the dynamics of increasingly complex threat developments. The main objective is to maintain the sovereignty of the Republic of Indonesia, protect national resources and interests and ensure the stability and security of Indonesian waters.

2.4. Indonesia Sea Power.

Sea power is a term that refers to the power and influence possessed by a country through its dominance in the seas. The concept of sea power involves the use of military, economic and political power in territorial waters to influence policies and relations between nations. Sea power involves several aspects, including:

a. Naval Power: Sea power is closely related to a nation's naval capabilities, including warships, seaplanes, submarines, and amphibious forces. Military power in the seas can give countries the influence and ability to defend national interests and support military operations in the maritime area.
b. Maritime Domination: Sea power involves the domination or control of a country over a large area of water. This includes controlling strategic shipping lanes, maintaining a presence that isstrong around national waters, and able to control access and use of natural resources in the oceans.
c. Maritime Security and Defense: Sea power involves efforts to maintain maritime security and defense from threats that may arise, including threats from other countries, piracy, illegal trade, and non-traditional threats such as terrorism and the spread of weapons of mass destruction.
d. Economic Influence: Sea power also includes the ability of a country to use its maritime economic potential. This involves the exploitation and protection of natural resources in the oceans, the development of a maritime industry, international trade, and the ability to influence the global economy through a presence on major trade routes.
e. Maritime Diplomacy: Sea power can be used as a diplomatic tool to build good relations with other countries through maritime cooperation, maritime law enforcement, handling natural disasters, and cooperation in managing fisheries resources and the marine environment.

Success in building and maintaining sea power can provide strategic advantages for the country in a geopolitical and geoeconomic context. Countries that have strong sea power can influence regional policies, maintain national security, and expand their influence in the maritime world.

3. Methodology.

In this study the authors used a research framework that described all the steps taken by the authors to complete this research. The research framework is as follows (Figure 1).

3.1. DEMATEL.

DEMATEL (Decision-Making Trial and Evaluation Laboratory) is an analytical method used to model and analyze causal relationships between elements in a system. This method provides a framework for analyzing and understanding the complexity of the relationships between elements in a complex problem or system. DEMATEL is usually used in making decisions that are complex and have a significant impact. This method involves an iterative process involving modeling, analysis, and evaluation of the interactions and influences between elements in the system. (Lee et al., 2013)

DEMATEL is a useful method in understanding complex causal relationships in systems and can be used to identify key factors that affect performance or problems in a system. This method has been used in a variety of fields, including management, finance, engineering, environment, and others. The steps in the DEMATEL method include:

Identify Variables: The first step is to identify the variables and criteria associated with the problem being studied. This element can be in the form of variables, decisions, environmental factors, or other factors that are relevant in the context of the problem to be solved.

Making a Direct Relationship Matrix: this matrix is obtained by carrying out pairwise comparisons between criteria. Next, a causal matrix is created which describes the causal relationship between the elements that have been identified. This matrix is used to record the positive or negative influence between each pair of elements.

Direct Relationship Matrix Normalization. The normalization step for the direct relationship matrix is carried out by multiplying the matrix by the identity matrix, so that the value of the diagonal elements of the matrix is equal to zero. The matrix normalization formulation is as follows:

$$M = k.A \tag{1}$$

Where,

$$k = \left(\frac{1}{\sum_{j=1}^{n} |a_{ij}|} , \frac{1}{\sum_{i=1}^{n} |a_{ij}|} \right)$$

Calculating the Total Relationship Matrix. This step is done by inverting the normalized direct relationship matrix and then multiplying it by the direct relationship matrix. The formulation in this step is as follows:

$$S = M + M^2 + M^3 + \cdots = \sum_{i=1}^{\infty} M^i$$

Where,

$$S = M(1 - M)^{-1} \tag{2}$$

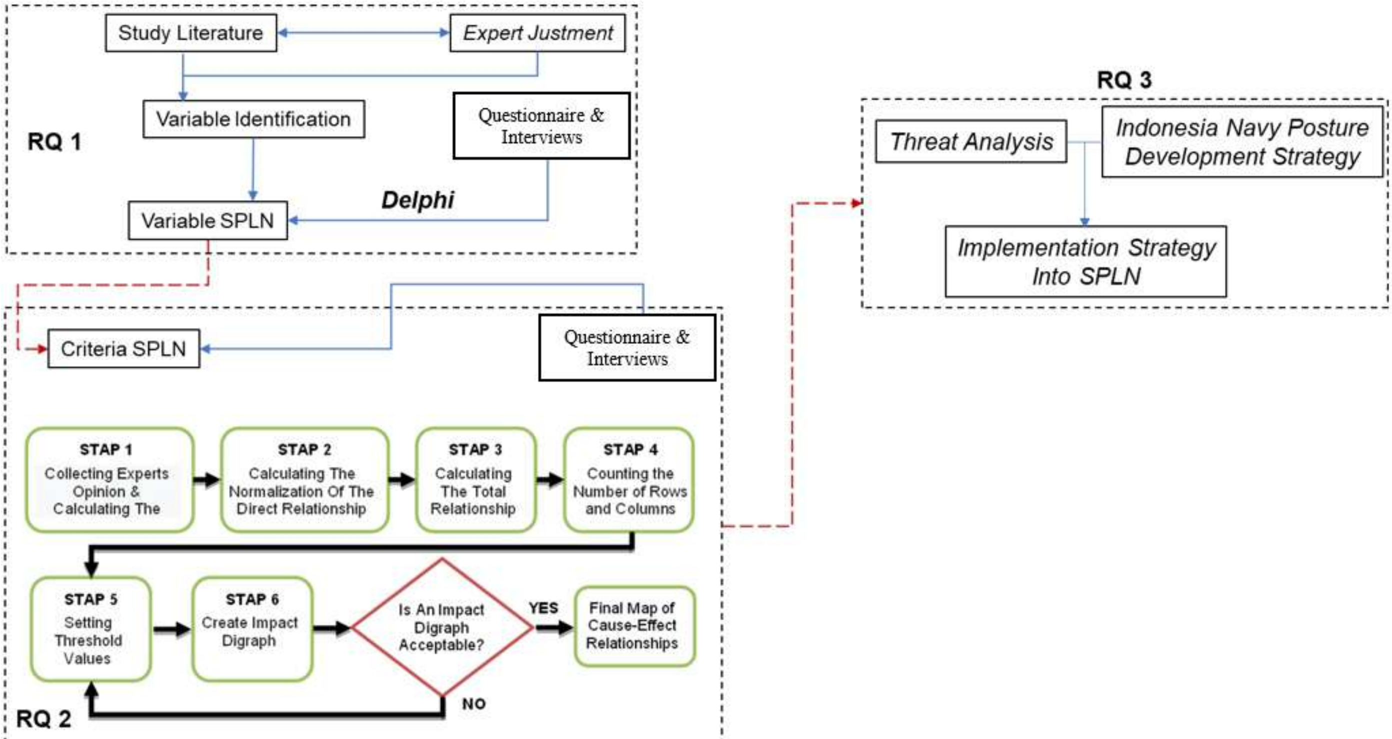
Define Dispatcher and Receiver Groups. The grouping of criteria into the Dispatcher or Receiver group is determined from the D + R and DR values, where the R value is obtained from the sum of each column while the D value is obtained from the sum of each row in the total relationship matrix. The value of D + R indicates the level of dominance of a variable over other variables, while the DR value indicates that this variable acts as an influencing variable (if the DR value is positive) and acts as a variable that receives influence if the DR value is negative. The formulation forms of D and R are as follows:

$$D = \sum_{j=1}^{n} S_{ij} \tag{3}$$

$$R = \sum_{t=1}^{n} S_{ij} \tag{4}$$

Set threshold values and create Impact Digraph maps. To get the relationship on the Impact Digraph map, it is determined

Figure 1: Research Framework.



Source: Author.

by reference to the threshold value. Only a few criteria that have a value greater than the threshold value can be selected and converted into an Impact Digraph map. The threshold value can be determined from the discussion of experts or obtained from the average value on the total relationship matrix. The results obtained at this stage can be used to provide an understanding of causal relationships in the system. This information can be used to identify the most important variables, understand the main causative factors, and assist in making decisions regarding system improvement or management.

4. Results and Discussion.

In this section, the results of the data processing performed in this study are displayed, while the results of data processing are as follows.

4.1. Key Variable Identification.

At this stage, the authors conducted a questionnaire to 5 experts to identify variables and criteria from threat perception, Indonesia Navy posture and developments in the current strategic environment. The results of this identification step are as we can see at Table 1.

4.2. Looking for Causal Interconnection.

To obtain the causal interconnection of each variable and criterion, the authors use the DEMATEL analysis method, where the steps taken are as follows.

1. Calculating the Direct Relationship Matrix. In this step, the total relationship matrix is obtained from the average value of the questionnaire that has been conducted by the author to 5 experts.
2. Normalization of the direct relationship matrix. In the normalization stage of the direct relationship matrix, this step uses formulation 1.
3. Calculating the Total Relationship Matrix. To obtain the total relationship matrix, the authors apply formula 2.
4. Define Dispatcher and Receiver Groups. The results of this step are shown in Table 2:
5. Define threshold values and create an Impact Digraph map. From Table 2, an impact digraph map can be made as we can see at Figure 2.

4.3. Threat perception.

The nature of threats can be viewed from a variety of perspectives which really depend on how an entity views it. (Nengah Putra et al., 2013) mentions threats as all kinds of good things that are still in potential or in the form of activities that threaten sovereignty, integrity, and include efforts to change the essence of a sovereign country both coming from outside and within the country's territory. Meanwhile (David et al., 2017) states that a threat is something that is referred to by an organization because it can affect the sustainability of an organization's existence and operations so that it becomes the center of attention and needs to be addressed carefully.

Table 1: Identification of Variables and Criteria.

VARIABLE	CRITERIA	SUB-CRITERIA
Threat Perception	Potential Threats	Threat of Military Aggression
		LCS conflict
		Conflict related to the issue of SARA Separatism and radicalism
		Trouble Spots
		Chock Point
Indonesia Navy posture	Ability	maritime intelligence
		Defense
		Security
		Diplomacy
		Empowerment of marine defense environment
		Support
	Strength	War Ship
		Aircraft
		Marines
		Naval Base
		Special force
		Personnel
	Degree of Strength	Deployments
		Employment
Strategic Environmental Development	Political	Political Tensions in the Asia Pacific Region
		Potential Border Conflict
		Political contest towards the 2024 election
	Economy	Free trade
		Resource limitations
		The economic growth of China, India and Australia can increase their political gain in the Asia Pacific region
		The competitiveness of Indonesia's workforce and products is still weak
	Defense and security	Israeli-Palestinian conflict
		Russia-Ukraine conflict
		Development of separatist groups affiliated with Global Terosis
		Building the military strength of neighboring countries that have the support of superpower countries
		Cyber threats and Intelligence are still very vulnerable for Indonesia
	Technology	Development of war technology (Weapons of mass destruction, long range weapons, supersonic weapons, drones)
		Development of information and communication technology
		The development of artificial intelligence (AI) technology, IoT and Big data

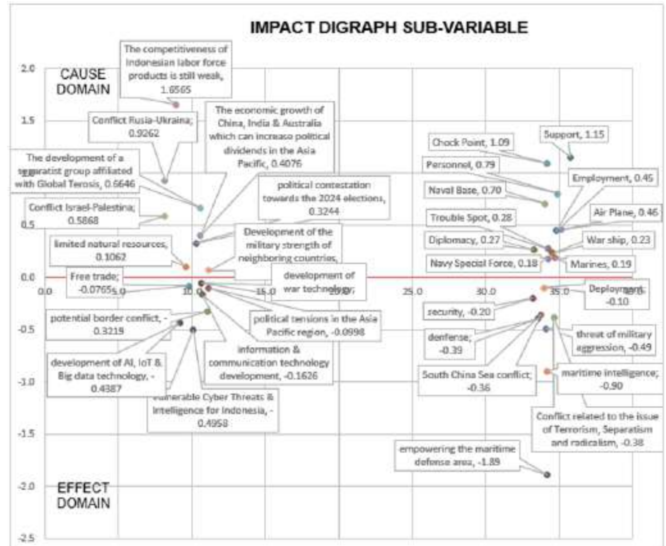
Source: Authors.

To analyze the threat perception formed from the development of the strategic environment, it is carried out by taking into account the results of DEMATEL data processing on the value or weight of influence on the threat sub-criteria in the D + R column which can be used to assess the risk of the threat. In Table 3.

4.4. Indonesia Navy Posture.

The development of the Indonesian Navy's posture takes into account various aspects with a planning approach based on threat scenarios, policies for strengthening the national defense system, PMD policies, RPJPN 2005-2025, operational capabilities and technological developments. Based on the above considerations and also with the development of the strategic environment and perceptions of potential threats, the development of the Indonesian Navy's posture focuses on strength that is oriented towards increasing the ability of the Indonesian Navy in carrying out its duties and responsibilities as the main element of national defense at sea. In the analysis of the DEMATEL method on the sub-criteria of the Indonesian Navy's posture, the priority for the development of the Indonesian Navy's posture is obtained as we can see at Table 4.

Figure 2: Impact Digraph Sub-Criteria.



Source: Authors.

4.5. Implementation in Archipelago Sea Defense Strategy.

As a form of implementation of the Archipelago Sea Defense Strategy based on an analysis of the threat perception and posture of the Indonesian Navy, the Indonesian Navy's strategy for deploying the Archipelago Sea Defense Strategy is as follows:

Deterrence Strategy directed at preventing the intentions of parties that would disturb the sovereignty of the state and the territorial integrity of the Republic of Indonesia and which would harm national interests through naval diplomacy, the presence at sea is prioritized in border areas which have the potential to become a source of conflict and build the strength and capabilities of the Indonesian Navy. Deterrence strategies can be carried out through the following steps:

1. Naval Diplomacy. The realization of naval diplomacy in the deterrence strategy is carried out through: Cooperation in the field of war technology, advanced defense systems, and integrated information and communication systems, intelligence and cyber as well as regional cooperation in the form of joint exercises and maritime patrols.
2. Presence at Sea. The presence of Indonesia Navy forces at sea is carried out through operations: Monitoring, patrolling and law enforcement at sea, Security operations in support of the government to overcome conflicts related to SARA issues, terrorism, separatism and radicalism and maintain stability in the territorial waters of the Archipelago.

Table 2: Grouping of Dispatchers and Receivers.

VARIABLES AND CRITERIA		D	R	D+R	RANK	D - R	RANK	INFORMATION	
POTENTIAL THREATS	threat of military aggression	5,459	5.2555	10.7140	12	0.2031	12	dispatchers	CAUSE
	South China Sea conflict	5,434	5.4747	10.9087	8	-0.0408	22	Receivers	EFFECT
	Conflict related to the issue of Terrorism, Separatism and radicalism	5,096	4.6864	9.7820	29	0.4093	6	dispatchers	CAUSE
	Trouble Spots	5,168	4.8850	10.0526	26	0.2826	10	dispatchers	CAUSE
	Chock Point	5,26	4.7269	9.9868	27	0.5330	5	dispatchers	CAUSE
ABILITY	maritime intelligence	5,404	5.4911	10.8956	9	-0.0866	25	Receivers	EFFECT
	defense	5,789	6.1350	11.9242	1	-0.3458	32	Receivers	EFFECT
	security	5,566	5.7145	11.2805	2	-0.1485	28	Receivers	EFFECT
	Diplomacy	5,344	5.1126	10.4567	19	0.2314	11	dispatchers	CAUSE
	empowering the maritime defense area	5,224	5.0661	10.2901	21	0.1579	14	dispatchers	CAUSE
	support	5,269	5.1132	10.3822	20	0.1558	15	dispatchers	CAUSE
STRENGTH	war ship	5,668	5.5874	11.2558	3	0.0810	19	dispatchers	CAUSE
	Air Plane	5,357	5.5073	10.8642	10	-0.1504	29	Receivers	EFFECT
	Marines	5,356	5.2616	10.6175	14	0.0943	18	dispatchers	CAUSE
	Naval Base	5,482	5.6275	11.1094	5	-0.1455	27	Receivers	EFFECT
	Navy Special Forces	5,19	4.8667	10.0570	25	0.3235	9	dispatchers	CAUSE
	Personnel	5,309	5.1696	10.4782	17	0.1390	16	dispatchers	CAUSE
OPS DEGREE	Deployments	5,078	5.0565	10.1348	23	0.0219	21	dispatchers	CAUSE
	Employment	5,313	5.1450	10.4578	18	0.1678	13	dispatchers	CAUSE
POLITICAL	political tensions in the Asia Pacific region	5,506	5.6059	11.1120	4	-0.0998	26	Receivers	EFFECT
	potential border conflicts	5,379	5.7012	11.0805	7	-0.3219	31	Receivers	EFFECT
	political contestation towards the 2024 elections	5,286	4.9620	10.2483	22	0.3244	8	dispatchers	CAUSE
ECONOMY	Free trades	4,865	4.9412	9.8058	28	-0.0765	24	Receivers	EFFECT
	limited natural resources	4,851	4.7444	9.5949	30	0.1062	17	dispatchers	CAUSE
	The economic growth of China, India & Australia which can increase political dividends in the Asia Pacific	5,481	5.0736	10.5548	15	0.4076	7	dispatchers	CAUSE
	The competitiveness of Indonesian labor force products is still weak	5,276	3.6197	8.8958	32	1.6565	1	dispatchers	CAUSE
DEFENSE	Israeli-Palestin conflict	4.39	3.8034	8.1935	33	0.5868	4	dispatchers	CAUSE
	Russia-Ukraine conflict	4,553	3.6266	8.1793	34	0.9262	2	dispatchers	CAUSE
	The development of a separatist group affiliated with Global Terosis	5,608	4.9439	10.5524	16	0.6646	3	dispatchers	CAUSE
	Development of the military strength of neighboring countries	5,587	5.5222	11.1090	6	0.0646	20	dispatchers	CAUSE
TECHNOLOGY	Vulnerable Cyber Threats & Intelligence for Indonesia	4,795	5.2911	10.0864	24	-0.4958	34	Receivers	EFFECT
	development of war technology	5,308	5.3589	10.6666	13	-0.0512	23	Receivers	EFFECT
	information & communication technology development	5,279	5.4414	10.7202	11	-0.1626	30	Receivers	EFFECT
	development of AI, IoT & Big data technology	4,347	4.7852	9.1317	31	-0.4387	33	Receivers	EFFECT

Source: Authors.

Sea Control Strategy directed at guaranteeing the use of the sea for one's own strength and preventing the use of the sea by the opponent, breaking the sea link of the opponent and preventing and eliminating various forms of threats to aspects of the sea both from within and from outside through the deployment of forces in the form of daily sea operations and sea combat alert operations supported by the strength of the Indonesian Air Force in selectively vulnerable waters. Deterrence strategies can be carried out through the following steps:

1. Sea combat alert operations are carried out by holding Purla operations in selectively vulnerable waters, hot spot areas, chock points and border areas as well as outer islands.
2. Daily sea operations realized through maritime security operations to prevent smuggling and address threats to national economic interests. Carrying out humanitarian assistance operations (civil missions), assistance to the Police, assistance to the civilian government, shipping security, search and rescue assistance, evacuation assistance and natural disaster management.
3. Opposition to destroy opposing forces. The development of the capabilities of the Indonesian Navy is based on three basic capabilities, namely surface and sub-surface warfare capabilities and force projection from sea to land.
4. Operations to blockade the opposing forces are carried out through operations in the jurisdictional areas of Indonesian waters which are points of conflict (Trouble spots) and strategic shipping lanes (choke points) which require increased supervision and require the presence of military forces to be able to prevent (anti-access) opponent's strength.
5. Own sea line protection operation. This step is a strategy of the Indonesian Navy to protect vital lines of communication and sea transportation for the national interest. This effort is carried out by supervising and monitoring vital sea connecting lanes including monitoring ship activities, identifying potential threats and analyzing real-time sea/operational areas and Empowerment of marine defense environment.

Layered Defense Strategy directed to destroy threats from outside through the deployment of combined sea and air forces in the buffer defense field, the main defense field and resistance areas by involving all the forces of the Indonesian Navy along with all maritime components. The Layered Defense Strategy is implemented in times of war in the form of sea combat operations that are defensive in nature while still paying attention to

Table 3: Threat Perceived Priorities.

NO	SUB-CRITERIA	MARK	RANK
1	Threat of military aggression	10.71	6
2	LCS conflict	10.91	4
3	Conflict related to issues of SARA, separatism and radicalism	9,782	14
4	Trauble Spot	10.05	11
5	Chock point	9,987	12
6	Political tensions in the Asia Pacific region	11,11	1
7	Potential border conflicts with neighboring countries.	11.08	3
8	Political contest towards the 2024 election	10.25	9
9	Free trade	9,806	13
10	Resource limitations	9,595	15
11	Israeli-Palestinian conflict	8.194	17
12	Russia-Ukraine conflict	8,179	18
13	The development of separatist groups affiliated with global terrorism	10.55	8
14	Building the military strength of neighboring countries that have the support of superpower countries	11,11	2
15	Cyber threats and Intelligence are still very vulnerable for Indonesia	10.09	10
16	Development of war technology (Weapons of mass destruction, long range weapons, supersonic weapons, drones)	10.67	7
17	Development of information and communication technology	10.72	5
18	The development of artificial intelligence (AI) technology, IoT and Big data	9.132	16

Source: Authors.

Table 4: Priorities for the Development of the Indonesian Navy's Posture.

Indonesian Navy POSTURE				
POWER	D	R	D+R	RANK
War ship	5,67	5.59	11.26	1
Naval Base	5,48	5,63	11,11	2
Aircraft	5,36	5,51	10.86	3
Marines	5,36	5,26	10.62	4
Personnel	5,31	5,17	10.48	5
Special force	5,19	4.87	10.06	6
CAPABILITIES	D	R	D+R	RANK
Defense	5.79	6,13	11.92	1
Security	5.57	5,71	11.28	2
maritime intelligence	5,40	5,49	10.90	3
Diplomacy	5,34	5,11	10.46	4
Support	5,27	5,11	10.38	5
Empowerment of marine defense environment	5,22	5.07	10,29	6

Source: Authors.

the concept of shifting the battlefield. A layered defense strategy can be carried out through the following steps:

1. Support field. The strategies carried out include carrying out sea security patrol operations, monitoring using radar and satellites, air defense systems and law enforcement at sea.
2. The main line of defense. It is carried out through sea combat operations using a strategic strike force assisted by the Indonesian Air Force.
3. Battle field. The title of Indonesia Navy strength includes all the strengths and resources owned by the Indonesia Navy which are organized through permanent titles (deployment) and enforcement titles (employment) in the implementation of the Universal Defense Strategy, assisted by the projection of the TNI's strength from land to sea as well as all national forces.

Implication

The theoretical benefit of this research is to provide an evaluation and understanding of perceived threats posed by current developments in the strategic environment and can be used as a reference in planning and developing the Indonesian Navy's posture.

While the practical benefit is being able to carry out analysis using the Delphi and DEMATEL method approaches in identifying variables and formulating strategies for developing the Indonesian Navy's posture to support the archipelago's maritime defense strategy.

Conclusions.

From the discussion above it can be concluded as follows:

1. The priority for building the strength of the Indonesian Navy focuses on increasing KRI, Bases, Aircraft, Marines and Special Forces of the Indonesian Navy.
2. Meanwhile, the capacity building of the Indonesia Navy prioritizes the aspects of Defense, Security, Maritime Intelligence, Diplomacy, Support and Empowerment of marine defense environment.
3. Strategies that can be carried out in support of the Archipelago Sea Defense Strategy operation degree include:
4. Increasing naval diplomacy through cooperation in the fields of war technology, advanced defense systems, and integrated information and communication systems, intelligence and cyber as well as regional cooperation in the form of joint exercises and sea patrols.
5. Operation Kamla and Purla in selectively vulnerable sea areas, points of conflict and strategic shipping lanes to block enemy forces and protect SLOT and SLOC from enemy interference.
6. Carry out the integration of the Indonesia Navy weaponry system in accordance with Indonesia's geographical and geostrategic conditions.
7. One of the weaknesses of the Delphi method is that there is panel bias, which is caused by the tendency of experts to only look for information that supports their views and the tendency to follow the views of the majority in the panel. To overcome these weaknesses, in the variable identification step, the Fuzzy-Delphi method can be used to overcome possible biases.
8. In the next research conducted, it can be continued using the System Dynamics method to be able to simulate and analyze strategic policies and find out the effects they have.

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Thermodynamic-based comparison of ORC, TFC and OFC systems for waste heat recovery from a marine diesel engine

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ABSTRACT

The aim of this research is to comparatively evaluate the thermodynamic performance of three different systems, namely the organic Rankine cycle (ORC), trilateral flash cycle (TFC), and organic flash cycle (OFC), for the purpose of recovering waste heat on ships. To analyze their performance, simulations were conducted using specific working fluids with favorable thermophysical properties, namely n-butane (R600), i-butane (R600a), n-pentane (R601), i-pentane (R601a), and toluene. The results indicate that, within the operating parameters considered in this study, the ORC system achieves higher thermal efficiency compared to the TFC and OFC systems. However, the TFC system exhibits the advantage of a lower specific volume of the working fluid at the end of the heat addition process (expander inlet) since it remains in a liquid state. This characteristic allows for the use of smaller-sized expanders, making the TFC system particularly appealing for marine applications. Furthermore, it was observed that all the selected working fluids outperform R245fa in terms of power generation within the ORC system. In the case of the TFC and OFC systems, only R601, R601a, and toluene surpass the performance of R245fa.

Nomenclature.

$\dot{Q}$: Heat transfer rate (kW).
s: Entropy (kJ/kgK).
T: Temperature (K).
v: Specific volume (m^3/kg).
x: Quality.
h: Specific enthalpy (kJ/kg).
$\dot{m}$: Mass flow rate (kg/s).
p: Pressure (bar).
$\dot{W}$: Power (kW).

Greek symbols.
η: Isentropic efficiency.
ρ: Density (kg/m^3).

Subscripts.
cond: Condenser.
evap: Evaporator/Heater.
exp: Expander.
f: Fluid.
p: Pump.
th: Thermal.

1. Introduction.

Traditional marine propulsion systems encounter challenges related to energy and environmental issues, specifically the imperative to decrease air pollution and carbon emissions. To tackle these concerns, waste heat recovery (WHR) systems are considered a viable solution. Notably, the organic Rankine cycle (ORC), a proven technology for converting low-grade heat into usable power, has garnered interest for recovering waste heat from marine diesel engines. Studies have demonstrated

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that implementing ORC systems on ships can lead to fuel savings of at least 3%, with a payback period of approximately 4 years (Konur et al., 2022).

The majority of prior research on waste heat recovery (WHR) power systems in marine settings primarily concentrated on the organic Rankine cycle (ORC) due to its established and mature status as a technology for extracting energy from low-grade heat sources (Bounefour, 2021). However, there have been investigations into other WHR power systems as well (Larsen et al., 2014; Zhang et al., 2022). For a more comprehensive understanding, interested readers can consult review papers that delve deeper into this subject (Shu et al., 2013; Singh and Pedersen, 2016; Mondejar et al., 2018; Konur et al., 2022).

In contrast, the trilateral flash cycle (TFC) and the organic flash cycle (OFC) have received relatively less attention in the context of marine applications. Choi and Kim (2013) proposed a waste heat recovery system that integrates a trilateral cycle and an organic Rankine cycle on a 6800 TEU container ship. The results demonstrated a propulsion efficiency improvement of 2.824% compared to a baseline engine. Rijpkema et al. (2019) conducted simulations for fifty different working fluids and four WHR cycles, both with and without a recuperator, including an ORC, a TRC, a TFC, and an OFC. These systems were simulated using various heat sources from a heavy-duty diesel engine. The results highlighted significant performance variations among the simulated scenarios. The maximum power output was achieved by harnessing heat from the charge air cooler, exhaust, and EGR cooler using ORC and TRC systems with working fluids such as acetone, methanol, cyclopentane, ethanol, or isohexane.

The aforementioned literature underscores the predominant focus on ORC-based power cycles for waste heat recovery from marine engines, while relatively few studies have specifically compared ORC-based configurations like TFC and OFC. Therefore, this paper conducts a thermodynamic comparison of ORC, TFC, and OFC systems to identify the optimal choice for waste heat recovery from marine engines.

2. Methodology.

2.1. The marine engine.

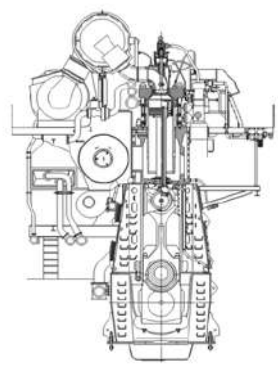
Figure 1 illustrates a cross-sectional view of the engine analyzed in this study, along with its corresponding specifications. The engine in question is a two-stroke marine diesel engine with 14 cylinders, capable of generating a maximum power output of 84.28 MW at a rotational speed of 104 rpm (Man, 2014).

2.2. Description of the systems.

Figure 2 displays the schematics and corresponding cycles, depicted on T-s (temperature-entropy) diagrams, for the three waste heat recovery (WHR) power systems examined in this study: ORC, TFC, and OFC.

All three systems share a common initial phase in the cycle, which involves the compression of the liquid by the pump (1-2) and the process of isobaric heat addition (2-3). The point

Figure 1: Cross section and specifications of the engine used.



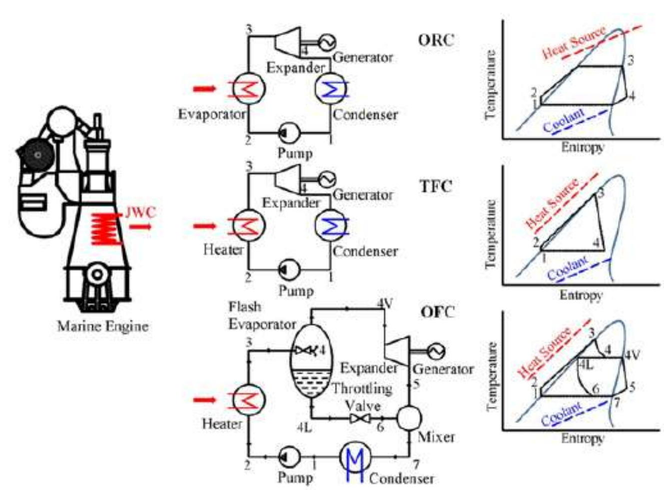
Model	14K98ME-C7.1
Bore, mm	900
Stroke, mm	
Maximal power, MW	84.28
SFOC, g/kWh	177
Speed, rpm	10'4
EG mass flow rate, kg/s	202
EG temperature, °C	284

Source: Authors.

of differentiation between the systems arises when the working fluid reaches the high-pressure saturated liquid state (3).

In an ORC system, the expansion of the working fluid commences from the high-pressure saturated vapor state (3-4). In contrast, in a TFC system, the expansion begins directly from the high-pressure saturated state, leading to a low-pressure two-phase state (3-4). As for the OFC system, prior to expansion, the working fluid undergoes a flashing process, transitioning to an intermediate pressure and separating into saturated liquid (4L) and saturated vapor (4V). The saturated vapor then expands to generate useful work (4V-5). Simultaneously, the saturated liquid undergoes a throttling process (4L-6) and subsequently mixes with the expanded fluid (7). Finally, the working fluid is condensed back to a saturated state (7-1) to initiate a new cycle.

Figure 2: Schematics and corresponding *T-s* diagrams of the three power cycles studied.



Source: Authors.

Due to their favorable thermophysical characteristics, specifically high critical pressure and temperature, low specific volume, and latent heat, n-butane (R600), i-butane (R600a), n-pentane (R601), i-pentane (R601a), and toluene have been chosen as the working fluids for the system under investigation. These fluids, as indicated in Table 1, are expected to deliver optimal performance due to their excellent properties. It is important to note that all of the selected working fluids are considered dry fluids.

Table 1: Properties and classification of the working fluids studied.

Working fluid	Type	M (g/mol)	T_b (K)	T_c (K)	p_c (MPa)	GWP
R245fa ($C_3H_3F_5$)	Dry	152.9	300.99	427.20	3.65	950
n-Butane (C_4H_{10})	Dry	58.12	272.65	425.15	3.80	4.0
i-Butane (C_4H_{10})	Dry	58.12	261.45	407.85	3.63	3.0
n-Pentane (C_5H_{12})	Dry	72.15	309.07	469.70	3.36	<3.0
i-Pentane (C_5H_{12})	Dry	72.15	301.06	460.40	3.37	<3.0
Toluene (C_7H_8)	Dry	92.14	383.75	591.75	4.13	~3.3

Source: Authors.

2.3. Thermodynamic modeling.

The thermodynamic models employed in this study were established based on the following assumptions:

- All systems analyzed operate under steady-state conditions.
- Variations in kinetic and potential energy of the working fluid are disregarded.
- Pressure and heat losses are not taken into consideration.
- The performance of turbines and pumps is determined using isentropic efficiencies.

To develop the models, each component of the system is treated as a control volume, and mass, and energy balance equations are applied. With the aforementioned assumptions in mind, the mass and energy balance equations are formulated as follows:

$$\sum \dot{m}_{in} = \sum \dot{m}_{out} \tag{1}$$

$$\sum \dot{m}_{in}h_{in} + \sum \dot{Q} = \sum \dot{m}_{out}h_{in} + \sum \dot{W} \tag{2}$$

where, $\dot{m}$ denote for the mass flow rate, h the enthalpy, $\dot{Q}$the heat transfer and $\dot{W}$is the mechanical power transfer. The subscripts *in* and *out* refer to the inlet and outlet of the control volume respectively.

Final expressions for mass and energy balance equations for each component of the systems are listed in Table 2.

Table 2: Energy balance equations.

	Component	Energy balance equation
ORC	Pump	$\dot{W}_p = \dot{m}_f(h_2 - h_1)$
	Evaporator	$\dot{Q}_{evap} = \dot{m}_f(h_3 - h_2)$
	Expander	$\dot{W}_{exp} = \dot{m}_f(h_3 - h_4)$
	Condenser	$\dot{Q}_{cond} = \dot{m}_f(h_4 - h_1)$
	System	$\dot{W}_{net} = \dot{W}_{exp} - \dot{W}_p$
		$\eta_{th} = \dot{W}_{net}/\dot{Q}_b$
TFC	Pump	$\dot{W}_p = \dot{m}_f(h_2 - h_1)$
	Heater	$\dot{Q}_{evap} = \dot{m}_f(h_3 - h_2)$
	Expander	$\dot{W}_{exp} = \dot{m}_f(h_3 - h_{4s})\eta_{nozzle}\eta_{rotor}$
		$\eta_{nozzle} = 0.865 + 0.00175 \cdot \rho_{4v}$
		$\eta_{rotor} = 0.575 + 0.325 \cdot x_4$
	Condenser	$\dot{Q}_{cond} = \dot{m}_f(h_4 - h_1)$
	System	$\dot{W}_{net} = \dot{W}_{exp} - \dot{W}_p$
		$\eta_{th} = \dot{W}_{net}/\dot{Q}_b$
OFC	Pump	$\dot{W}_p = \dot{m}_f(h_2 - h_1)$
	Heater	$\dot{Q}_{evap} = \dot{m}_f(h_3 - h_2)$
	Expander	$\dot{W}_{exp} = \dot{m}_f(h_3 - h_{4s})$
	Condenser	$\dot{Q}_{cond} = \dot{m}_f(h_4 - h_1)$
	System	$\dot{W}_{net} = \dot{W}_{exp} - \dot{W}_p$
		$\eta_{th} = \dot{W}_{net}/\dot{Q}_b$

Source: Author.

where ρ_{4v} is the vapor density at the condensation pressure and x_4 is the vapor quality at the nozzle exit.

The nozzle and rotor efficiencies have been developed taking into account the main influencing parameters for different working fluids (Welch and Boyle, 2009; Hays, 2010).

3. Results and Discussions.

This section focuses on comparing the performance of three power cycles: the basic organic Rankine cycle (ORC), the trilateral flash power cycle (TFC), and the organic flash power cycle (OFC). Simulations were conducted under predetermined operating conditions, which are presented in Table 3. To facilitate the analysis, a program was developed using Engineering Equation Solver (EES) (Klein and Nellis, 2012), taking into account the established model and assumptions described above.

The performances of the three systems are graphically presented in Figure 3, considering different working fluids. The comparisons are made based on three key factors: mechanical

Table 3: Operating conditions.

Heat source working fluid	PG
Heat source mass flow rate, kg/s	50
Heat source temperature, °C	80
ORC, TFC, OFC working fluid	R245fa, R600, R00a, R601, R601a, Toluene
Evaporator (Heater) temperature, °C	75
Condenser temperature, °C	30
Flash temperature, °C	(75+30)/2
Turbine isentropic efficiency, %	80
Pump isentropic efficiency, %	70

Source: Authors.

power generated, mass flow rate of the working fluid, and thermal efficiency.

The ORC system demonstrates the highest heat input to the system due to the heating, vaporization, and superheating of the working fluid. However, within the specified operating parameters, the ORC system achieves the highest power output ranging from 80.55 kW to 89.30 kW.

Following that, the TFC system yields a power output ranging from 30.21 kW to 35.01 kW, and the OFC system produces power ranging from 27.09 kW to 27.95 kW, as depicted in Figure 3(a).

Consequently, in terms of thermal efficiency, the ORC system outperforms both the TFC and OFC systems, as illustrated in Figure 3(c).

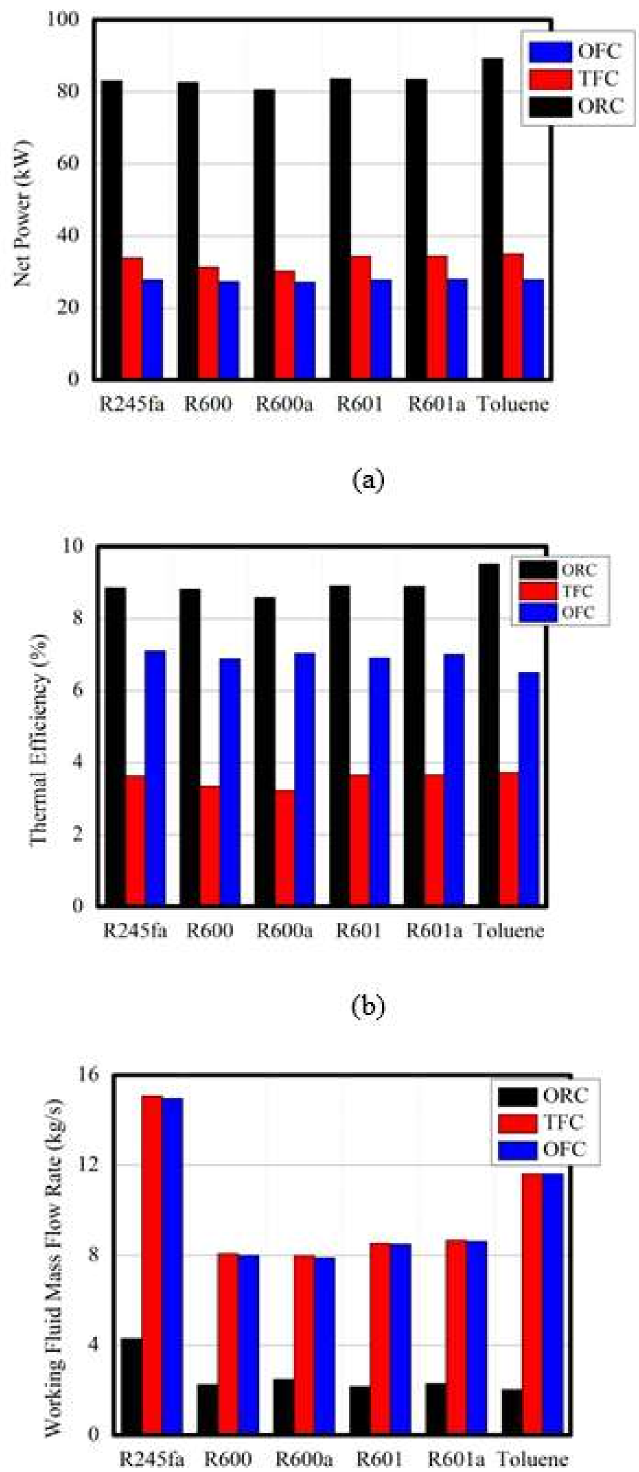
Notably, in the case of the ORC system, all of the selected working fluids result in higher power output compared to R245fa. However, for the TFC and OFC systems, only R601, R601a, and toluene surpass the performance of R245fa.

Within the considered operating conditions of this study, the ORC system exhibits lower mass flow rates of the working fluid compared to the TFC and OFC systems. Conversely, the TFC and OFC systems demonstrate similar mass flow rates across all the considered working fluids.

The TFC system, with its working fluid remaining in a liquid state, results in a lower specific volume at the end of the heat addition process (expander inlet). On the other hand, the OFC system, with its working fluid undergoing flashing to an intermediate pressure and separation into saturated liquid and vapor, exhibits a significantly higher volume of working fluid flowing through the expander.

Consequently, the TFC systems require smaller-sized expanders compared to the OFC systems. This reduced system size holds significant importance for marine applications. Aside from the space-saving benefits onboard ships, a smaller-sized system substantially decreases material costs.

Figure 3: Performance comparison among systems: (a) Power output; (b) Mass flow rate; (c) Thermal efficiency.



Source: Authors.

Conclusions.

A comparative analysis of three waste heat recovery technologies, namely ORC, TFC, and OFC, was conducted in terms of power output, thermal efficiency, and volumetric mass flow rate supplied to the expander. Simulations were carried out using different working fluids, including R245fa, butane, isobutane, pentane, isopentane, and toluene. The main conclusions drawn from this study are summarized as follows:

- The ORC system demonstrates superior performance compared to both the TFC and OFC systems.
- With the exception of butane and isobutane, which exhibit slightly lower performance than R245fa, the other working fluids (pentane, isopentane, and toluene) consistently deliver better performance across all systems.
- Due to the TFC system's working fluid remaining in a liquid state, there is a reduced specific volume at the end of the heat addition process (expander inlet). As a result, TFC systems require smaller-sized expanders in comparison to OFC systems. This characteristic makes TFC systems particularly advantageous for marine applications.

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Linking Personality Traits with Entrepreneurial Attitude with Mediation of Entrepreneurial Alertness: An Explorative Study on Indian Marine Engineers

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ABSTRACT

On the discourse of virtues of entrepreneurship to economic development, a spate of scientific evidence illuminates the mediation effect of entrepreneurial alertness on the linkage between personality traits, and entrepreneurial attitude carried out among university students, and many of the studies are Western-oriented. Also, the scanty nature of such studies on the Indian maritime sector calls for an explorative intervention to identify such mediation effects. Using standard questionnaires for measuring personality traits, entrepreneurial attitude and alertness, this study uses convenience sampling to gather evidence from active Indian marine engineers to establish linkages among such attributes. The basis of research anxiety is due to a lack of formal ways to channelise the entrepreneurial attitude among Indian marine engineers. This study calls for arenas of re-conceptualising policy interventions to formalise investment opportunities for marine engineers and thus contribute to higher growth rates of the blue economy of India.

1. Theoretical Backdrop.

The linkages between entrepreneurship and economic development have been commonplace in the literature on entrepreneurship. In this context, research illuminates that entrepreneurs generate employment opportunities, thus creating purchasing power and contributing to economic development. This is one of the major reasons that most countries encourage entrepreneurship intentions. However, such an environment would bring results only if backed by an entrepreneurial attitude. Most of these entrepreneurship initiatives failed due to a lack of awareness and attitude among the younger generation towards self-employment, as self-employment is seen as a measure of entrepreneurship (Ayalew and Zeleke, 2018). The attitude towards self-employment is influenced significantly by various factors like attractive opportunities, attitude toward innovation, family background, education qualification, etc. (Corden*et al.*, 1997; Moulton and Scott, 2016; Dillon and Stanton, 2017). This, in turn, affects entrepreneurial attitude in line with the predictions of the theory of planned behaviour. Such attitude plays a significant role as entrepreneurial attitude and behaviour are positively linked, which *inter alia* means that entrepreneurial attitude results in entrepreneurial intentions (Abun*et al.*, 2018, Ngan and Khoi, 2020). This makes scientific research on entrepreneurial attitude a need of the hour for developing economies like India, where unemployment rates have been escalating in recent times. In this context, an interrelated array of literature focuses on the effect of personality on entrepreneurial attitude, as personality is one of the significant factors affecting entrepreneurial attitude (Jaho and Seibert,2006; Zaho*et al.*, 2010, Çolakoğlua and Gözükara, 2016, Kerr *et al.,* 2017, Biswas and Verma, 2021).

Similarly, a spate of literature illuminates the significance of entrepreneurial alertness in the process of entrepreneurship. Kirzner (1973) defines entrepreneurial alertness as a 'return to knowledge' on imperfections in the market that an entrepreneur could capture. In this context, Kirzner (1973) describes alert-

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ness as the cognitive ability of a person to capture unnoticed / unexploited opportunities with an element of risk that brings returns and, thus, market equilibrium. Such an ability of an entrepreneur to perceive opportunities brings returns. This is the initial phase of decision-making, which affects entrepreneurial intentions. Such alertness facilitates an entrepreneurial attitude and thus results in entrepreneurial intentions (Samo and Hashim, 2016; Li *et al.*, 2020; Biswas and Verma, 2021).

Further, a few studies consider mediation analysis between personality, entrepreneur intention and entrepreneur alertness. In this regard, with the help of mediation analysis which predicts the relationship between a dependent and an independent variable by the intervention of a mediator (variable), the works of Awwad and Al-Asser (2021) and Hu *et al.* (2018) recognise the mediation effects of entrepreneurial alertness on the linkage between personality and entrepreneurial intentions.

Given the above backdrop, mediation studies measuring linkages between personality traits and an entrepreneurial attitude with the mediation of entrepreneurial alertness of an individual are scanty and consider such attributes majorly among students, thus increasing the potential risk of staking the realisation of such entrepreneurial intentions into the practice of entrepreneurship. Also, many of the existing studies are Western country oriented. In this context, only a few attempts are made in the Indian context, and studies are even fewer involving working professionals and that too in the Indian marine engineering sector.

In this context, in the present study, we consider in line with Sharma 2022 that entrepreneurial attitude and not the intention (as intentions are realised only if there is an entrepreneur attitude) is affected by an individual's personality traits. Also, the present study considers examining the linkage between personality traits and an entrepreneurial attitude with the mediation of entrepreneurial alertness, considering working marine engineers as subjects of the study. Most of the available studies on mediation effects are done among university students.

The contribution of such a study is also important in view of the escalated realisation of India towards the contribution of the Blue Economy. The comparative advantage of the present study is that it considers working marine engineering professionals, presumably increasing the realisation of entrepreneurship attitude to intentions. Further, entrepreneurial studies in the field of Indian marine engineering domain are very few. This study also attempts to fill such gaps in entrepreneurial research in the marine engineering domain with a specific focus on India.

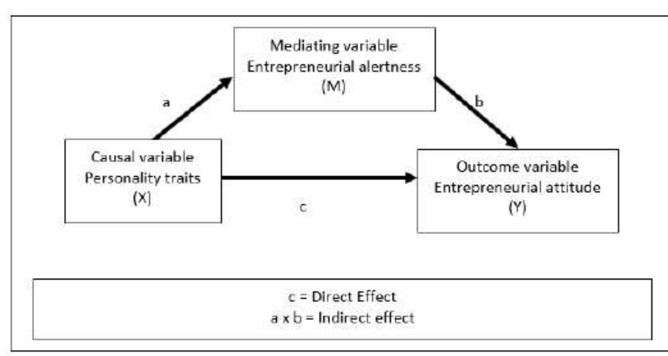
Moreover, studies of such nature are important in the current Indian economic context, as India's ranking in Global Entrepreneurship Index (GEI) is the highest among South Asian countries, with a ranking of 68. The Global Entrepreneur Monitor Report 2019-2020 illuminates that India has the highest adult population perceived availability of opportunity and ease of starting a business (Bosma*et al.*, 2020). In view of this, the current study is important because to increase India's GEI along the lines of another Asian counterpart like China, India's market environment has to provide incentives to understand entrepreneur attitude, personality and entrepreneur alertness and their linkages. Given the foregoing discussion, the objective of the present study is to explore an understanding of the linkages between personality traits, entrepreneurial attitude and alertness in the context of the Indian marine engineering domain. Specifically, the paper attempts to explore whether the personality traits of Indian marine engineers impact their entrepreneurial attitude and identify if the entrepreneurial alertness of the Indian marine engineers acts as a mediator between their personality traits and entrepreneurial attitude.

2. Analytical Framework: Mediation Analysis.

The present study is based on a well-structured statistical procedure named the 'Mediation model'. Mediation is a causal model to express how an independent variable influences a dependent variable when a third variable is added in between. Such a third variable is known as the 'mediator' or 'mediating variable', and it is inferred that there is a causal relationship between the independent variable to the mediating variable and mediating variable to the dependent variable. Mediation analysis reveals whether the existence of a mediator is responsible for a decrease or increase in the relationship between the causal variable and outcome variable. It can even be possible that the relationship between the causal variable and outcome variable be reversed by including mediating variable, which is a distorter variable (Rosenberg, 1968), i.e., a variable that, if included, would change the nature of the relationship between the independent variable(s) and dependent variable(s).

The mediation analysis reveals two different effects: direct effect and indirect effect. The concept of direct and indirect effects is shown in figure1 below. The direct effect explores the relationships between independent variables and dependent variables. On the other hand, indirect effects are those structural model paths that involve a sequence of relationships with at least one intervening mediator.

Figure 1: Direct Effect and Indirect Effect in Mediation Analysis.



Source: Authors.

Mediation can either be complete or partial. In the scenario when the independent variable doesn't have a significant impact on the dependent variable but a significant impact exists through the mediator, such mediation is known as full or complete mediation. On the contrary, a significant effect between the independent and dependent variables and through the mediator is called partial mediation.

3. Methodology.

The study essentially attempts to link personality with entrepreneurial attitude with the mediation effect of entrepreneurial alertness. For this exercise, the present study considers the marine sector with a specific focus on marine engineers.

With a coastline of 7,500kms, 12 major ports and 205 notified non-major ports facilitating almost 95 per cent of the merchandised trade (MIV 2030), the basis of Indian economic development has been facilitated by its water tributaries to a significant level. With the emergence of the realisation of the blue economy of India, the government of India has taken initiatives in the domain of coastal shipping, inland waterways, green shipping, etc. In this context, the role of shipping in contributing to Indian economic development is well-illuminated. India also supplies 10-12 per cent of seafarers to the world market(MIV 2030).

In this context, the maritime sector, specifically, is characterised by temporary sojourns of seafarers under different temporary contracts. As Talmor (2021) points out that although seafarers take up careers at sea for reasons in the likes as monetary benefits from such careers, pressure from family, and learning new skills, however, reasons like the contractual nature of the job, no long terms career progression with the current employer, and away from family, etc. make seafarers to have a dynamic career in the maritime industry. In a similar line, Ljung and Widell (2014) and Albert *et al.*(2016) illuminate career changing dynamics of seafarers and point out that seafarers have no boundaries in choosing a career that is working on shore after working a few years on board a ship in the sea. This is because of the opportunity cost of staying away from family, the constrained work environment on board ship, and the stressful work that prompts seafarers to look for career opportunities onshore, resulting in a dynamic career path for seafarers.

At this juncture, it is worth noting that majority of the marine engineers start their sailing careers in their 20s. After sailing for a few years, a good number of mariners keep looking for onshore opportunities. One such good option among many seafarers is starting their own companies or exploring new business ideas[2]. However, research on entrepreneurship among marine engineers is inadequate and rigorous scientific attempts are limited exclusively in the Indian scenario. With escalated recognition of India towards the blue economic development, research in the domain of entrepreneurship in the marine industry is the need of the hour, as with suitable policy interventions, such entrepreneurial attitude would be realised. This makes the marine engineering domain a very useful candidate for the current study. In this regard, the current study is an endeavour to fill gaps in research on entrepreneurship in the marine engineering domain, apart from contributing towards studies on linking personality and an entrepreneurial attitude with entrepreneurial alertness as mediating factors among working professionals.

For the current study, a non-random sampling method known as the convenience sampling technique is used to collect data from Indian marine engineers. Convenience sampling is a non-random sampling method which does not take a representative sample but a subset of the population collected based on the convenience of the researchers (Baxter *et al.*, 2015). Convenience sampling is used for the present study due to the lack of accessibility to a sample frame on the number of Indian marine engineers working on board ships. Therefore, samples drawn with known probabilities could not be employed. Thus, the researchers had to search for Indian marine engineers on LinkedIn and contact marine engineers at competency training sessions, etc. Although the data collection was tired sum, the researchers were able to receive responses from a heterogeneous group of Indian marine engineers. This subtly reduced biases in data collection. However, in the absence of any sample frame, convenience sampling at least helped gather samples and collect data. The absence of a sample frame could also be a tentative reason for the lack of entrepreneurial studies on working professionals in the Indian marine engineering domain. A total of 94 responses were collected and analysed for the present study.

A structured questionnaire is used for the study, which consists of four parts, viz., (i) demographic profile of the respondents; (ii) Personality traits; (iii) Entrepreneurial attitude and (iv) Entrepreneurial alertness.

Part One: Demographic profile.

This section collects information from Indian marine engineers on their demographic characteristics, e.g., name, age, sailing experience, gender, etc.

Part Two: The personality traits.

The personality traits are being identified using the ‘Big Five Inventory’ scale developed by Goldberg (1993). The Big Five Inventory is a widely used five-point Likert types personality test in recent years. The instrument is a five-point Likert-type scale consisting of 44 items and identifies personality traits in the following dimensions (as provided in Figure 2). The use of the BFI scale has been acknowledged for measuring personality in studies on entrepreneurship in the likes of Sharma (2022), Mamat*et al.* (2021), and Kerr *et al.* (2017).

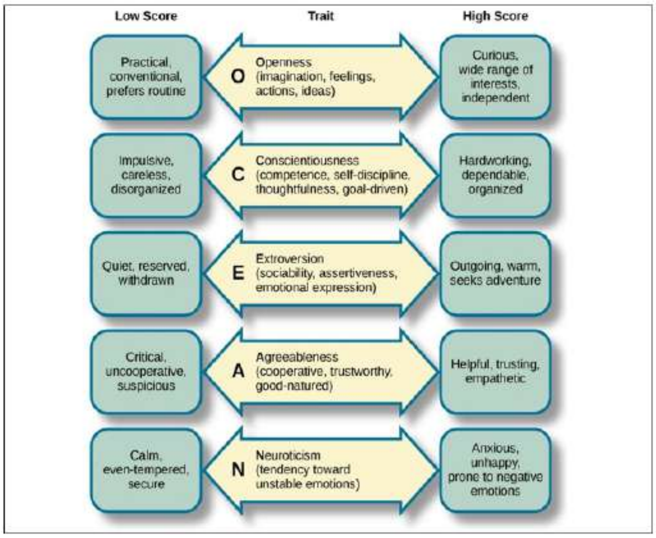
Part Three: Entrepreneurial Attitude.

The Entrepreneurial Attitude Orientation (EAO) Scale, developed by Robinson, Stimpson, Huefner and Hunt in 1991, is used to collect data from Indian marine engineers on their entrepreneurial attitude. This consists of 75 statements and is a 10-point Likert scale. This scale measures entrepreneurial attitude in the following dimensions, viz.,

1. “*achievement in business: refers to concrete results in connection with new business or growth of an existing business;*
2. *innovation in business: refers to using innovative methods in business activities;*

[2]Source: https://www.marineinsight.com/careers-2/best-online-entrepreneurship-courses/ accessed on 29.11.2022

Figure 2: Big Five Inventory Scale.



Source: https://sites.psu.edu/leadership/2017/09/02/the-importance-of-personality-trait-screening-for-todays-organizations-application-of-the-five-factor-model-ffm/ accessed on 29.11.2022.

3. *perceived personal control of business outcomes: refers to the owner's control or influence in his/her own business, and*
4. *perceived self-esteem in business: refers to the self - confidence and perceived competency of an individual in connection with his/her business activities*" (Robinson *et al.*, 1991).

Part Four: Entrepreneurial Alertness.

The entrepreneurial alertness scale developed by Tang, Kacmar and Busenitz (2010) consists of 13 items and is a seven-point Likert scale. This scale is used to measure entrepreneurial alertness (as acknowledged by Tang *et al.* (2010). In this study, this scale is used to measure entrepreneurial alertness among Indian marine engineers in the following areas;

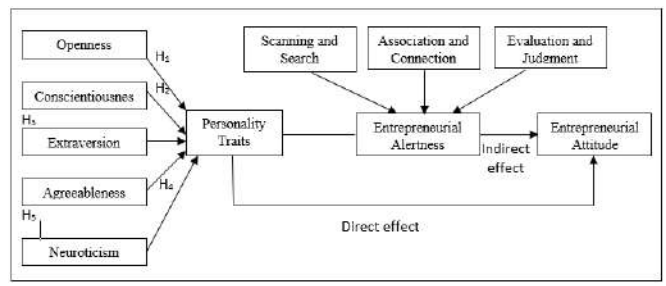
- *Scanning and search: It refers to the acumen of an entrepreneur to be unconventional towards investigating new ideas. Entrepreneurs with more extensive scanning and search will have a wider range of knowledge and information, which can benefit them in attaining expert performance (Ericsson et al., 1993) in enhanced alertness to business opportunities.*
- *Association and connection: This refers to acumen towards receiving new information, creativity, and extending an idea in logic. It also allows an individual to consider multiple options and also enables him/her to connect them logically.*
- *Evaluation and judgment: This is another dimension through which an entrepreneur can evaluate different options, alternatives etc., and finally takes an informed judgment.*

Based on the above discussion in theoretical framework, analytical framework and methodology as discussed, the following hypotheses are developed to be tested for significance on the data collected from Indian marine engineering working on board ship.

H_1: The openness personality trait has a positive impact on entrepreneurial alertness, which in turn affects entrepreneurial attitude positively among active Indian marine engineers.

H_2: The conscientiousness personality trait has a positive impact on entrepreneurial alertness, which in turn positively affects entrepreneurial attitude among active Indian marine engineers.

Figure 3: Model Estimation.



Source: Author?s own depiction of the estimation model.

H_3: The extraversion personality trait has a positive impact on entrepreneurial alertness, which in turn positively affects entrepreneurial attitude among active Indian marine engineers.

H_4: The agreeableness personality trait positively affects entrepreneurial alertness, which in turn affects entrepreneurial attitude among active Indian marine engineers.

H_5: The neuroticism personality trait affects entrepreneurial alertness in a positive way, which in turn has a positive relationship with the entrepreneurial attitude among active Indian marine engineers.

The current study uses structural equation modelling (SEM), which has gained interest among researchers and is currently considered one of the most popular methodologies in quantitative social sciences. Structural Equation Modelling (SEM) is a multivariate statistical technique used to analyse the relationship between variables (Kaplan 2000). The SEM with Unweighted Least Square (used in the case of data collected using a non-random sampling method) is carried out using the 'R' language. The path model, along with SEM, reveals the;

i. direct effects, i.e., effects of the personality traits on the entrepreneurial attitude of the Indian marine engineers, and
ii. indirect effects, i.e., effects of personality traits on entrepreneurial attitude, when such relationships flow (get mediated) through the entrepreneurial alertness of Indian marine engineers.

4. Results.

4.1. Descriptive Statistics on Sample.

As discussed in the previous section, a survey was carried out among active Indian marine engineers who are still continuing to work on board ships. Among the respondents, 100 per cent are male, majority of them (around 90.43 per cent) comprises of marine engineers aged 21 to 40 years. Of the 94 respondents from whom data was collected through a questionnaire, around 67 per cent are married, and 38.30 per cent of respondents have work experience of 6 to 10 years. Adding to this, around 36.17 per cent of our samples have work experience of more than 10 years. Our survey shows that 55.32 per cent of the respondents are working in the ranks of second engineer and chief engineer, which are managerial roles on board ship. Thus these samples are already in team management roles. Nearly 57.45 per cent of respondents know someone who is a successful entrepreneur, and this could affect entrepreneurial alertness for the sample respondents. The above discussion shows the richness of the sample as the majority are young marine professionals with considerable work experience in the managerial ranks of second and chief engineers and are alert of entrepreneurship opportunities.

4.2. Internal Consistency of the Constructs.

Cronbach's Alpha is a measure of the internal consistency of constructs. Such measures for the instrument used in the present study are shown in Table 1 below, which shows Cronbach's Alpha value of 0.70 or more for almost all constructs which are acceptable.

Table 1: Cronbach's Alpha Values of the Constructs.

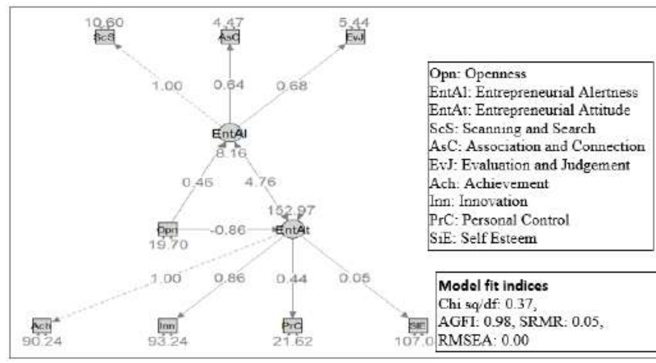
Variables	Cronbach's Alpha
Openness	0.71
Conscientiousness	0.78
Extraversion	0.75
Agreeableness	0.65
Neuroticism	0.86
Scanning and Search	0.77
Association and Connection	0.82
Evaluation and Judgement	0.78
Achievement	0.88
Self Esteem	0.70
Personal Control	0.71
Innovation	0.76

Source: Author's own estimation.

H_1: OPENNESS PERSONALITY TRAIT → ENTREPRENEURIAL ALERTNESS → ENTREPRENEURIAL ATTITUDE.

The impact of the openness personality trait on entrepreneurial attitude can be observed through the direct effect shown in the path diagram provided in Figure 4. The same also indicates an indirect effect among these two when mediated through entrepreneurial alertness among Indian marine engineers. The effects are consolidated in Table 2 below. Path diagram and table showing direct and indirect effects of openness personality traits on entrepreneurial attitude.

Figure 4: Path diagram.



Source: Author's own estimation.

Path diagram showing direct and indirect effects of openness personality traits on entrepreneurial attitude.

Table 2: Direct, Indirect and Total Effect.

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
Indirect	2.185	0.925	2.361	0.018	0.113	0.502
Direct	-3.045	1.861	-1.636	0.102	-0.158	-0.700
Total	-0.860	0.979	-0.878	0.380	-0.045	-0.198

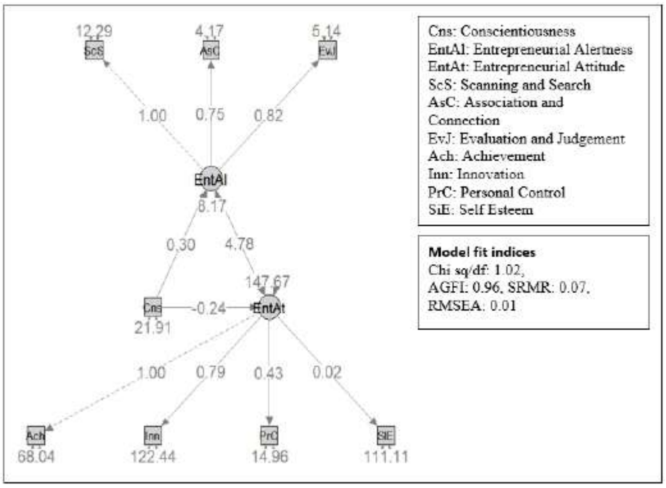
Source: Author's own estimation.

The above diagram and table indicate the presence of a mediation effect when the relationship between the openness personality trait and entrepreneurial attitude is mediated through entrepreneurship alertness. While the direct effect is non - significant, the presence of entrepreneurial alertness significantly improves the relationship and boosts the Indian marine engineer's entrepreneurial attitude. Hence, entrepreneurial alertness fully mediates the relationship between openness traits and entrepreneurial attitude.

H_2: CONSCIENTIOUSNESS PERSONALITY TRAIT → ENTREPRENEURIAL ALERTNESS → ENTREPRENEURIAL ATTITUDE.

The question of the impact of conscientiousness personality trait on entrepreneurial attitudes among Indian marine engineers can be examined through the direct effect. On the other hand, such a relationship, if mediated through entrepreneurial alertness, can be seen through indirect effect. The direct and indirect effects are shown in the path diagram as provided in Figure 5 and Table 3.

Figure 5: Path diagram.



Source: Author's own estimation.

Path diagram showing direct and indirect effects of openness personality traits on entrepreneurial attitude.

Table 3: Direct, Indirect and Total Effect.

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
Indirect	1.446	0.509	2.840	0.005	0.076	0.354
Direct	-1.685	1.028	-1.639	0.101	-0.088	-0.412
Total	-0.239	0.574	-0.417	0.677	-0.012	-0.059

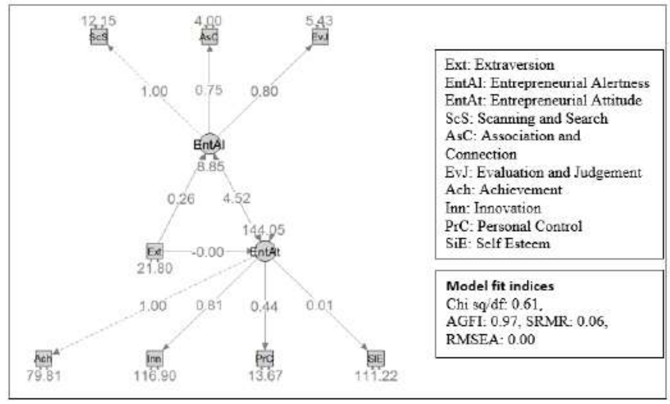
Source: Author's own estimation.

The above path diagram and table indicate a non-significant direct effect of conscientiousness personality trait on entrepreneurial attitude among Indian marine engineers. It also transpires that entrepreneurial alertness as a mediator significantly mediates the relationship, i.e., due to entrepreneurial alertness among Indian marine engineers with dominant conscientiousness personality traits; the attitude towards entrepreneurship further augments.

H_3: EXTRAVERSION PERSONALITY TRAIT → ENTREPRENEURIAL ALERTNESS → ENTREPRENEURIAL ATTITUDE.

The impact of persons with higher levels of extraversion on their higher levels of entrepreneurial attitude and vice versa is tested, and results are provided herewith. The direct effect examines the direct impact of extraversion on entrepreneurial attitude. Again the indirect effect exhibits the presence or absence of a mediation effect between these two via entrepreneurial alertness. Such direct and indirect effects are shown in Figure 6 and Table 4 below.

Figure 6: Path diagram.



Source: Author's own estimation.

Path diagram showing direct and indirect effects of openness personality traits on entrepreneurial attitude.

Table 4: Direct, Indirect and Total Effect.

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
Indirect	1.166	0.472	2.471	0.013	0.062	0.289
Direct	-1.169	0.936	-1.248	0.212	-0.062	-0.290
Total	-0.003	0.534	-0.005	0.996	-0.000	-0.001

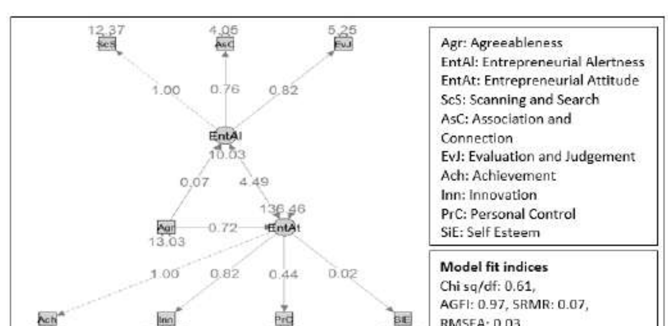
Source: Author's own estimation.

As per the above path diagram and table, it is clearly established that though the direct effect of extraversion on entrepreneurial attitude is absent, the mediation effect through entrepreneurial alertness is visible, i.e., for extraversion personality trait, the alertness about entrepreneurship encourages Indian marine engineers to have a positive attitude towards entrepreneurship.

H_4: AGREEABLENESS PERSONALITY TRAIT → ENTREPRENEURIAL ALERTNESS → ENTREPRENEURIAL ATTITUDE.

The direct effect of the agreeableness trait on entrepreneurial attitude as well as the indirect effect through entrepreneurial alertness as a mediator can be seen in Figure 7 and Table 5 below.

Figure 7: Path diagram.



Source: Author's own estimation.

Path diagram showing direct and indirect effects of openness personality traits on entrepreneurial attitude.

Table 5: Direct, Indirect and Total Effect.

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
Indirect	0.300	0.317	0.947	0.344	0.016	0.058
Direct	0.415	0.713	0.582	0.560	0.022	0.080
Total	0.715	0.467	1.533	0.125	0.038	0.138

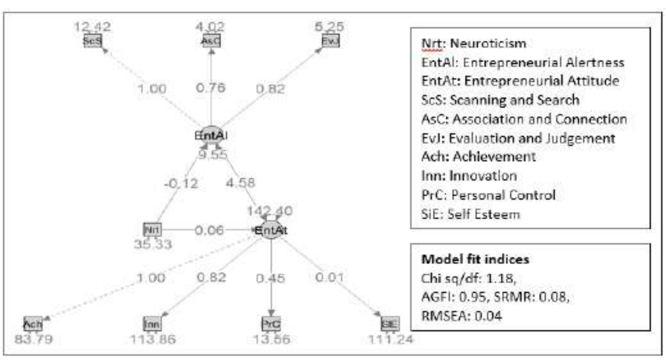
Source: Author's own estimation.

The above table indicates the absence of any significant effect, either direct or indirect, among Indian marine engineers with a dominant agreeableness personality trait, towards entrepreneurial attitude.

H_5: NEUROTICISM PERSONALITY TRAIT → ENTREPRENEURIAL ALERTNESS → ENTREPRENEURIAL ATTITUDE.

Whether the relationship between neuroticism and entrepreneurial attitude gets influenced by entrepreneurial alertness can be examined through direct and indirect effects, as shown in Figure 8 and Table 6 below.

Figure 8: Path diagram.



Source: Author's own estimation.

Path diagram showing direct and indirect effects of openness personality traits on entrepreneurial attitude.

Table 6: Direct, Indirect and Total Effect.

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
Indirect	-0.536	0.270	-1.984	0.047	-0.029	-0.170
Direct	0.600	0.571	1.051	0.293	0.032	0.191
Total	0.065	0.346	0.187	0.852	0.003	0.021

Source: Author's own estimation.

The above path diagram and the table don't exhibit any direct impact of neuroticism trait on entrepreneurial attitude among Indian marine engineers. On the other hand, the neuroticism trait has a negative and significant indirect effect on entrepreneurial attitude. Hence, it can be concluded that entrepreneurial alertness among Indian marine engineers with dominant neuroticism traits impacts their entrepreneurial attitude adversely.

Concluding Remarks.

The study is an attempt to explore measuring the mediation effect of entrepreneurial alertness on the linkage between personality and entrepreneurial attitude among Indian marine engineers who are active in their careers. The data was collected using convenient sampling from a sample of 94 marine engineers. SEM is used to estimate the impact of different personality traits on entrepreneurial attitude with mediation effects of entrepreneurial alertness. The results depict that openness, conscientiousness and extraversion personality impact entrepreneurial attitude through the mediation of entrepreneurial alertness. The results are found to be significant. This shows that such personality traits affect entrepreneurial attitude among Indian marine engineers if mediated through entrepreneurial alertness. The more knowledge of entrepreneurial opportunities makes these personalities potentially have entrepreneurial attitude fostered among Indian Marine engineers. However, the agreeableness personality trait has no direct or indirect significant effect on entrepreneurial attitude among Indian marine engineers. This shows that such personality has no potential linkage with an entrepreneurial attitude, and such a relationship is insignificant even though mediated through entrepreneurial alertness for Indian marine engineers. Also, it is found that for Indian marine engineers, in the case of neuroticism personality, a significant negative indirect effect exists between personality and entrepreneurial attitude mediated through entrepreneurial alertness. This illuminates that a higher level of neuroticism personality trait would lead to a lower possibility of such person having an entrepreneurial attitude even though such person has entrepreneurial alertness in terms of knowledge of various entrepreneurial opportunities. Although studies in line with Li *et al.*(2022) and Wooten *et al.* (1999) confirm the direct effect of personality on entrepreneurial intention, however, scientific shreds of evidence on the mediating effect of entrepreneurial alertness on the linkage between personality and entrepreneurial attitude in the case Indian marine engineers are scanty. Such limited scientific understanding results in no exclusive development of entrepreneurship ecosystem for marine engineers of India. In this context, noteworthy to mention here is that marine engineers follow a dynamic career and search for shore jobs after a professional sojourn on board ship. As confirmed by Talmor (2021), Ljung and Widell (2014), and Albert *et al.*(2016) confirm dynamic careers for marine engineers in terms of onshore jobs. As marine engineers return from sea jobs with savings, some of them start their own businesses. The same is pointed out in a study by Southampton Solent University in 2005 that in some countries, cases returned marine engineers from the sea who do not take up employment on board ships involved in carrying small businesses or taking up family businesses. This tendency is affected by entrepreneurial alertness. However, the unorganised nature of the

Indian marine industry and lack of scientific studies acknowledging such entrepreneurship trends in this sector have resulted in no formalised channelling of savings by marine engineers towards specific investment opportunities at the policy level. This calls for exclusive Entrepreneurial Development Programmes, formal investment plans prescribed by the government, particularly for and in the Indian marine industry and exploring avenues of collaboration between government and sea-returned marine engineers in line with Public Private Partnership programmes in order to contribute to the development of Blue Indian Economy in an escalated speed.

The limitation of this study is the use of convenient sampling, which comes with a caveat of non-generalisation of the study's results beyond the considered samples. Also, the study acknowledges the limitation of the Big Five Personality Scale (McAdams, 1992) in terms of personality being changing over time, people respond in terms of socially acceptable behaviour, which may hide their true personality, and there could be more than just five types of personalities existing which this scale does not consider.

Future research in this domain may focus on comparing group two groups of officers from the deck and engine side of a ship in terms of measuring the mediation effect. Comparison between different ranks of officers in the engineering department of a ship would also provide deeper insights. In this regard, a scientific exercise may also include comparing entrepreneurial attitude and personality with the mediation of entrepreneurial alertness among female marine engineering students and female marine engineers.

Data Availability Statement.

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

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The Impact of The Marine Ecosystem Sustainability on Marine Transportation in Malaysia

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ABSTRACT

Malaysia's success depends on the marine sector. Malaysia counts on the seas for transportation, communication, and security, but its maritime sector has yet to reach its full potential. The maritime industry growth will enhance water transport. Thus, as ships move and navigate actively, marine life is affected. This literature review is based on comprehensive search and data analysis from studies published form 2018 until 2022. Methodology is used with quantitative analysis about impact of marine ecosystem on marine transportation. This study's findings provide the impact factor and solution of the marine ecosystem on marine transportations. While they have the importance of the marine ecosystem on marine transportation in Malaysia. In conclusion, protecting biodiversity, reducing climate change, sustaining ecosystem services, and guaranteeing the industry's continued existence are all impacted by marine ecosystem sustainability. By implementing sustainable practices, we can save marine species, reduce pollution, and create a future that is both sustainable for the marine ecology and the transportation industry.

1. Introduction.

1.1. Background and Content.

One of the important economic areas that will move Malaysia toward prosperity is the marine industry. Malaysia is heavily dependent on the seas for many of its economic and resource-exploitation processes as well as its transportation, communication, and security requirements, but it has not yet fully used the potential of its marine industry. As the use of this marine industry increases every year, it will also increase the movement of water transport. Therefore, when the activities of movement and navigation of said ships are carried out actively, this will also cause effects on marine life in particular.

More than 70% of the earth's surface is covered by marine environments. The marine environment provides a variety of habitats for flora and fauna in marine aquatic systems, from the coast to the deep seabed. Millions of species call this aquatic environment home. Therefore, the marine environment is a great mix of biotic and abiotic components that work together to ensure existence. Marine ecosystems are characterised by different biotic (living) and abiotic (non-living) components. Plants, animals and bacteria are examples of biotic variables; Key abiotic factors include the amount of sunlight in the environment, the volume of dissolved oxygen and minerals in the water, distance to land, depth, and temperature. Marine ecosystems play an important role in the preservation of the environment. For example, water plants help reduce carbon levels in the atmosphere in the same way that land plants do. Aquatic plants take carbon dioxide from the atmosphere and release oxygen back into it. Furthermore, the plants and animals in this maritime ecosystem are intimately connected. Where life, such as fish and other living creatures, are interdependent with flora, such as trees, seaweed, coral reefs, from which fauna seek food to eat, defend themselves from enemies, breeding grounds, and habitats.

Over 3 billion people, or 39% of the world's population, contribute to the funding of marine and coastal biodiversity

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(UN, 2021). As a result, if there are numerous activities and uses that may be done by exploiting the resource, the usage of marine resources is high. Activities that can be completed include fishing, tourism and recreation, shipping commodities by sea, and using water transportation to reach a place. When such actions are active in a certain region and location, it indicates that there is a probability that there may be impacts as a result of such activities one day. As a result, in order to safeguard and preserve the environment, particularly marine life, various efforts and actions to protect them are required. To safeguard marine life, one option is to practice marine conservation. Among the marine conservation goals is SDG 14: Conserve and sustainably utilise the oceans, seas, and marine resources for sustainable development.

Marine transportation provides for 80-90% of worldwide trade, transporting about 10 billion tonnes of containers, solid and liquid bulk goods yearly across the world's oceans (Walker et al., 2019). People and products have travelled by sea across continents and across seas throughout history. Although marine transportation can convey practically any item effectively and efficiently, the advent of air travel is a great accomplishment for perishable and high-value goods. The industrial revolution boosted ship transportation even more by leveraging on the possibilities of internal combustion engine-power, and the following adoption of containerization significantly revolutionised marine transportation once again in the name of efficiency. Next, marine transportation supports global trade, transporting about 10 billion tonnes of containers, solid and liquid bulk goods yearly across the world's oceans. Historically, shipping businesses and ports were subject to little environmental regulation; however, unintentional oil spills in the 1960s caused significant coastal pollution and seabird mortality, prompting the International Convention for the Prevention of Pollution from Ships to be established (MARPOL). MARPOL is the primary international treaty for preventing maritime pollution caused by ships, whether intentional or unintentional. Furthermore, the International Maritime Organization (IMO) employs a variety of tools to safeguard the maritime environment from shipping activity. Nonetheless, marine transportation has a negative impact on the marine environment, including air pollution, greenhouse gas emissions, ballast water releases containing aquatic invasive species, historical use of antifoulants, oil and chemical spills, dry bulk cargo releases, garbage, underwater noise pollution; ship strikes on marine megafauna, risk of ship grounding or sinking, and widespread sediment contamination of ports during transhipment or ship operations. This chapter covers the environmental effects of maritime transportation and analyses the existing mitigation, legal, and environmental performance methods available to enhance global issue management by Tony et al. in 2019.

Malaysia is a country that has land and sea. Because the ocean region has the greatest surface area in comparison to the land area, Malaysia is known as a maritime nation. Malaysia's marine border position is extremely crucial in industry, particularly trade.Furthermore, because this area of Malaysian seas is strategically important, it provides for a wide range of operations and activities that may be carried out in Malaysian waters. For example, trade, tourism, industry, and fishing. These things can benefit the country's economy and well-being. Malaysian waterways are thus the busiest and most active route for marine activity. According to historical trends, it is known as the Malay land and is the focal point of traders from all over the world due to its strategic location and is a route that facilitates or shortens the trader's voyage.

Industrial maritime transport is another contributor to marine ecosystems. This is because they are the main users of sea water throughout their activities such as navigation, shipping and so on. Therefore, various things involving pollution will happen if they are not responsible for inappropriate actions.

1.2. Problem Statement.

The problem found in my research is that sea transport is the main cause of marine pollution. among the problems affecting the sea fishing equipment. Fishing equipment such as trawlers, fishing nets and so on. This is because it will cause small fish to be caught once, so the immune system and the life cycle of marine life there will be stunted. Moreover, it will involve the destruction of the coral reefs if the trawl is left under the bottom for so long. This will cause the habitat of marine life to be affected according Walker (2019).

That is according to Walker (2019) they say about end-of-life disposal by releasing the harmful chemicals, lubricants, or oils used in shipbuilding, shipbreaking has a detrimental influence on the environment. Old ships are sunk to build artificial reefs, which increase protection against coastal erosion and fish habitat, but careful planning is required since badly built structures can harm natural reefs.

Next, spills from ships at the sea are also the sources of the water pollution that leads to destruction to marine life ecosystems. The oil spill was caused while refuelling at sea, a leak in the oil tank, and irresponsible people releasing the waste oil into the sea. When this oil spill occurs, this will cause the water surface to be covered by oil and will cause the fish not to receive oxygen properly. This will cause the fish to die for not receiving sufficient oxygen content according to Walker (2019).

Further remnants from the ships are also a source of the impact on marine life. According to Walker (2019) he and a friend say the waste from the ships in question is sewage waste from the ships, solid waste that should not be discharged into the sea such as plastic. This will cause disturbing the ecosystem of marine life, this will also cause the fish to die due to ingestion of waste that should not have happened. Fish, turtles which are often said by the press media where there is this living thing that dies due to ingestion of plastic where it assumes the plastic is their food. Therefore, continuous research in the field nowadays is essential to make it a matter of attention from the players in the marine transport industry.

1.3. Research Objective.

The specific objectives of this research are:

1. To study the importance of marine ecosystem sustainability on marine transportation in Malaysia.

2. To determine the impact factors of marine ecosystem sustainability on marine transportation in Malaysia.
3. To purpose the solution factors of marine ecosystem sustainability on marine transportation.

1.4. Research Questions.

The research questions include the following:

1. What is the importance of marine ecosystem sustainability on marine transportation in Malaysia?
2. What are the impact factors of marine ecosystem sustainability on marine transportation in Malaysia?
3. How are the solution factors of marine ecosystem sustainability on marine transportation?

1.5. Relevance and Importance of the Research.

With the existence of a vast marine ecosystem that needs to be cared for and preserved. In addition, the things that cause environmental pollution are those that occur from marine transport, which needs to be dammed so that pollution does not occur. Therefore, this research study helps to improve and create new policies, legal frameworks, and effective strategic plans to care for, preserve, and conserve the national environment. The findings of this study will directly benefit Malaysians on the importance of taking care of the environment, especially in matters related to the marine ecosystem. The study also helps in collecting data and responses from seafarers and surrounding people related to pollution caused by marine transport to safeguard the rights and sustainability of marine ecosystems.

1.6. Conclusion.

In this chapter, the authors provide an increased overview of the research. A study's goals and questions should be designed to produce the most relevant and useful findings for that goal. This chapter also explains about marine ecosystem, marine transportation, Malaysia has maritime countries. Lastly about the development of problem statements and then relevance and importance of this research.

2. Literature Review.

This literature review on the impact of Marine ecosystem sustainability on marine transportation in Malaysian waters was conducted based on a comprehensive search and data analysis from studies published in the last 5 years on information related to the impact of marine ecosystems caused by marine transport. To carry out this research, a systematic strategy for reviewing the literature was created. The literature was then analyzed using content analysis methods to obtain relevant data for the research.

2.1. Key Concepts, Theories and Studies.

2.1.1. Marine Ecosystem.

The marine ecosystem is the largest body of water covering 71% of the earth's surface compared to the land surface. However, the global ocean system is divided into five main oceans and several oceans based on historical, cultural, geographical, scientific and size differences, namely the Atlantic, Pacific, Indian, Arctic and Antarctic Ocean basins are the most famous living marine systems according to the author G.G.N. Thushari in 2020. In other words, the marine ecosystem is an aquatic habitat with a high level of dissolved salt. These include open ocean, deep sea, and coastal marine habitats, each with its own set of physical and biological characteristics according to the National Geographic Society (2022). However, according to Huiping (2019) they related by marine resources include substances, energy, and marine space that exist in the marine environment and may be mined and utilized by humans. These resources include marine biological resources, seawater resources, seabed mineral resources, marine renewable energy, and marine space resources. Malaysia's coastlines and oceans are rich in marine biodiversity, ecosystems, habitats, and other natural resources. Together, they provide the population's economic and social requirements, act as coastal protection systems, and produce cash through tourism. The government has made the sustainable development of our coastlines, oceans, and related resources a top priority. Through policy research, timely and suitable inputs into policy-making and ocean coastal zone management, and marine-related educational activities, the Centre for Coastal and Marine Environment (CMER) hopes to contribute to ecologically sustainable ocean management according to the Maritime Institute of Malaysia in 2020.

2.1.2. Marine Transportation.

Daily basis, marine transportation transports billions of dollars in products, accounting for more than 90% (by weight) of worldwide trade. Cargo-carrying commercial shipping for example merchant marine and non-cargo commercial shipping are both types of marine transportation; it is ferries, cruise ships, this statement from Walker (2019). According to Riley in 2019 the marine transportation accounts for 80-90% of worldwide trade, transporting about 10 billion tonnes of containers, solid and liquid bulk goods across the world's oceans each year. Although marine transportation can successfully and efficiently convey practically any item, the advent of air travel proved advantageous for perishable and high-value goods. Maritime transport, an important mode of transport in international trade, is moving towards digitalization and digital transformation at different speeds in the different domains. So, shipping as part of the logistics chain, is a volatile business that is in a chaotic state owing to energy price volatility, technical immaturity, and future regulatory hikes this statement from Edvard in 2021.

2.1.3. Sustainability of Marine.

The International Maritime Organization (IMO) has considerable power, both directly and indirectly, because the IMO Convention defines its main objective as the conservation and

”sustainable” use of seas and their resources according to Lee in 2019. Following that, the International Maritime Organization (IMO) established the International Convention for the Prevention of Pollution from Ships (MARPOL) to prevent tanker accidents and minimize their consequences, including pollution prevention of routine operations such as cargo tank cleaning and disposal of oily engine room wastes. MARPOL also addresses chemical pollution, packaged goods pollution, sewage pollution, waste pollution, and air pollution (IMO, 2015a). The United Nations Convention on the Law of the Sea (UNCLOS), approved in 1994, is another example of international regulation to limit the environmental implications of marine transportation (Gulas, Downton, D'Souza, Hayden, & Walker, 2017; UNCLOS, 1982). Next, according to Hiroshige in 2019 an underside strategy should be used to build sustainable systems of marine ecology and civilization. Sustainable systems should improve communication and cooperation with many stakeholders, as well as efficiently manage marine ecology risks. Sustainable development and ecological protection have to be taken as the primary premise in the exploitation and utilization of marine resources, so as to ensure the sustainable development of mankind that statement from Huiping (2019). As a result of the conference, nations around the world presented their plans to develop marine spatial planning, sustainably manage marine ecosystems, conserve at least 10% of the world's marine habitats, end overfishing, provide access for small-scale fishers, reduce marine pollution and ocean acidification, and achieve other ambitious goals, the majority of which are expected to be met by 2020 with statement from Pinheiro (2019).

2.2. *Key Debates and Controversies.*

2.2.1. *The importance of marine ecosystem sustainability on marine transportation.*

It is important to tackle the predicted increase with a view toward both economic and environmental sustainability. Key elements of environmental sustainability are the efforts made by the International Maritime Organization (IMO) and its different instruments to address issues including oil pollution, solid waste disposal at sea, maritime safety, and invasive species, as stated by David Jean-Marie. According to Zhong, 2019 they say that in order to safeguard the environment and develop marine resources, many experts have conducted extensive study. This is because uncontrolled development has resulted in a number of catastrophic events that cannot be understated. The conservation of the marine ecosystem should be emphasised with the promotion of the ocean's sustainable development since doing so will also benefit humans. Lastly, according to Laffoley et.al. They may bring social advantages for the appreciation and involvement with the environment, they can improve marine ecology by conserving and restoring biological diversity, and they can provide significant economic benefits by encouraging sustainable fisheries, tourism, and recreational use of our oceans. Fundamentally, they can support the operation of the ocean's ecosystem, which serves as the world's principal regulating system, and develop resistance to the effects of climate change.

2.2.2. *The impact factors of marine ecosystem sustainability on marine transportation.*

The International Maritime Organization (IMO) employs a variety of tools to safeguard the maritime environment from the effects of shipping. Although the IMO is responsible for global shipping safety and security, it has also acknowledged that maritime transportation and port operations have unexpected environmental consequences from Walker (2019). According to Ukpong in 2019 they say the causes of these environmental and social problems, referred to as 'disturbances' in this report, range from oil pollution, acid rain, floods, deforestation, and erosion to sea level rise and tidal activities. Some of the unsettling features are natural, while others are the result of the oil company's exploitation of technology. Next according to the statement from Choong in 2021 the maritime environment is polluted by massive plastic trash and garbage, as well as microplastics, which are created from primary and secondary sources, endangering the aquatic ecosystem's well-being and preservation. To be the significant environmental effect of maritime transportation and record mitigating techniques, legislative mechanisms, or environmental performance indicator systems that are available to solve this worldwide issue. The environmental implications of sea transportation have been covered in greater length in previous chapters, but an overview is provided here. Air pollution, ballast water release containing aquatic invasive species (AIS), cargo waste release, oil spills from ships, waste management and marine-based sources of plastic debris, underwater noise, ship strikes on marine megafauna, grounding or ship sinking, and widespread sediment pollution in ports and harbours during ship transfer or shipwreck activities are all environmental impacts this statement for Tony R. Walker,etc. in 2019.

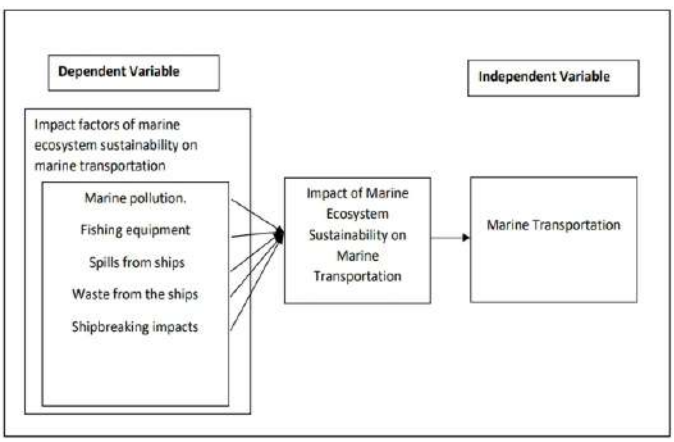
2.2.3. *The solution factors of marine ecosystem sustainability on marine transportation.*

One of the most important management methods in use across the world to mitigate the environmental impacts of maritime transportation is legal regulation of the shipping sector. Port operations and maritime transit providers are connected with environmental protection laws. Beginning with MARPOL four decades ago, the International Maritime Organization (IMO) has enforced international regulations on the shipping sector. The Convention on Marine Pollution Control (MARPOL) 73/78 is still the key legal instrument for preventing pollution from ships. The only countries affected are those that have signed MARPOL. There have been additional recent legislative instruments established to curb shipping's contribution to maritime pollution. This statement from Walker (2019), another critical management strategy, is increasing public understanding of maritime environmental regulations, clean technologies, best environmental management practices, and modern shipping problems on a global scale. The shipping industry as a whole need to be better educated on the importance of anticipating potential problems and taking preventative measures to safeguard the marine environment. In light of this importance, in 2010 the IMO updated the STCW code from 1978 to include new requirements for marine environmental awareness training. According to the new STCW code, maritime workers on some vessels will need additional education and/or certification.

2.3. *The Thematic Framework of Study.*

The most appropriate theories from the collected literature review on the previous chapter were analysed in order to answer all the research questions in chapter 1. For this study impact factors of marine ecosystem sustainability with marine pollution, fishing equipment, spills from ships, waste from the ship, shipbreaking impact is the dependent variable while independent variable is the model of the relationship between the impact factors of marine ecosystem with to marine transportation.

Figure 1: Framework for impact factors of marine ecosystem sustainability on marine transportation.



Source: Authors.

2.4. *Conclusion.*

In conclusion, this chapter described the keyword, theory and studies of literature review. The key debates and controversies from previous research, and it is matched for use in this study. There are independent and dependent variables for the next step to provide the theoretical framework.

3. Methodology.

3.1. *Introduction.*

In this chapter they will describe the methods undertaken during the field observation work through the study based on the impact of marine ecosystem sustainability on marine transportation in Malaysia.

3.2. *Study area.*

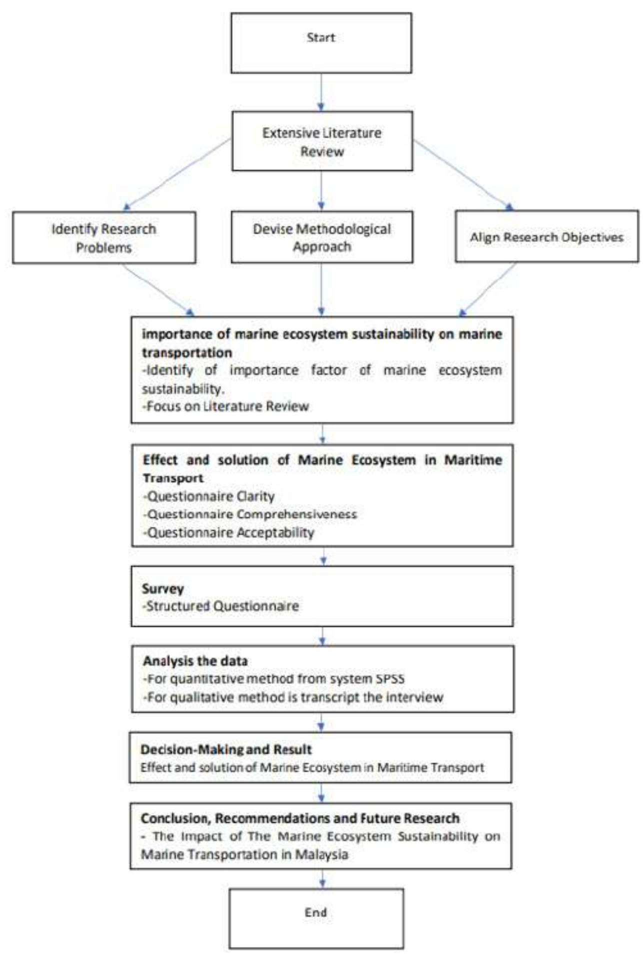
Malaysia water in the south china sea is my choice of research for this case. Especially about the Terengganu water area. This area is the strategic place because they have any economic activity to develop the state of the water area. For example, oil and gas, supply base, tourism, fishing marine and all activities of marine transportation at Terengganu.

Figure 2: Maps of Malaysia Waters.

Source: Authors.

3.3. *Research design and framework.*

Figure 3: Research Framework.



Source: Author.

Research frameworks start from the title, introduction and then they move to literature review. They come up with a research problem that they identify, devise a methodological approach, and align research objectives before they move to the next step. Next step about the data collection, identify the importance factor of marine ecosystem sustainability for the objective first then they must focus on literature review. For the effect and solution of marine ecosystem on marine transport they use data to get a questionnaire then they move to survey to get a respondent. For analysis data for quantitative they use SPSS system after use questionnaire the data come up from Microsoft excel while the qualitative method transcript the interview. Next step is decision making and the resulting effect and solution of the marine ecosystem on maritime transport. Lastly about conclusion, recommendation and future research about the impact of the marine ecosystem on marine transportation.

3.4. Type of Data.

Qualitative research is conducted to collect and examine information that cannot be reduced to numbers in order to get a deeper understanding of concepts, viewpoints, or experiences (such as text, video, or audio). It may be used for both gaining a broad comprehension of a topic and for generating novel ideas for further investigation. Qualitative methods are widely used in the humanities and social sciences, particularly in disciplines like anthropology, sociology, education, health sciences, history, etc. So on this method identify the importance factor of marine ecosystem sustainability for the first objective then they must focus on literature review.

In quantitative studies, numbers are gathered and analysed to draw conclusions. It may be used for the purposes of averaging out data, spotting trends, investigating correlations, and extrapolating findings to workgroups. Quantitative methods will be used regarding impact factors and solutions of marine ecosystem sustainability on marine transportation. In this study, stratified sampling will be used. In order to achieve more exact results, stratified sampling divides the population into many, non-overlapping groups (strata). This sampling technique is typically employed when one or more population sections have a low incidence when compared to the other sections.

3.5. Data collection.

3.5.1. Quantitative.

In addition, a questionnaire will be sent out to the relevant participants in this research in order to gather information on the impacts of the marine ecosystem on maritime transportation. The study's objectives (three of those) will be listed on the survey questionnaire that will be made available to participants. Predictions may be produced from the collected, reviewed, and assessed data with the help of data inference.

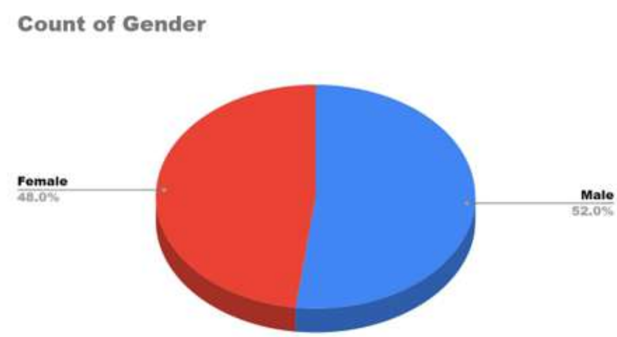
For the purpose of showing how to manage a questionnaire, we will first establish the goals and objectives of the study, then release a set of questions, select reliable respondents, collect all responses and data through appropriate analysis, and finally construct convincing findings to back up the research. One hundred respondents at the Transportation Company were surveyed online using Google Forms.

In addition, the data will be analysed using Microsoft Excel and the Statistical Package for the Social Sciences (SPSS), saving time since Google forms may be distributed online through email, WhatsApp, and similar platforms, and even when respondents are not in the office. In addition to these benefits, doing a survey online makes it possible to reach a wider audience, extend the response window beyond normal business hours, and expand the geographical scope of the research. However, it seems that only a small percentage of people really fill out survey questionnaires.

4. Data Analysis and Discussion.

4.1. Demographics Respondent.

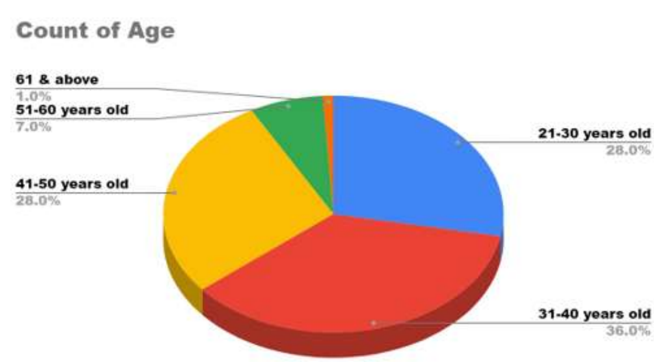
Figure 4: Demographics respondent of gender.



Source: Authors.

This Figure 4 shows the percentage of gender information at Malaysia experts on marine transportation. The observation totally from the worker at Malaysia expert on that marine transportation. Based on the result, 52.0% were answered by a population of male which is 52 respondents, it is the highest count of gender on the survey and 48.0% were answered by a population of female which is 48 respondents.

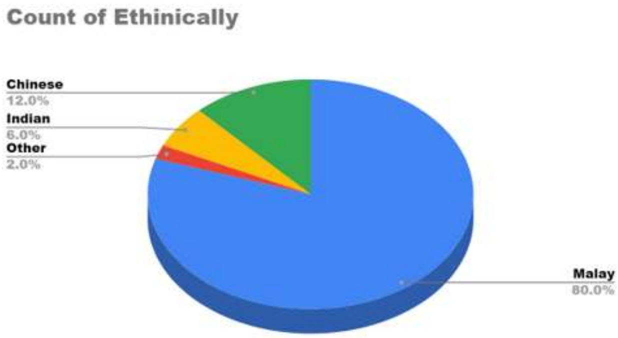
Figure 5: Demographics respondent of age.



Source: Authors.

Figure 5 as the result of a survey above shows people aged 31 to 40 are the highest percentage with 36.0% consisting of 36 respondents in this survey. Other than that, the same percentage of age was found 21 to 30 and 41-50 years old which is 28.0% which is 28 respondents. Otherwise, the percentage of 51 to 60 is the third highest with 7.0% consisting of 7 respondents and the last age is 61 and above which is 1.0% that is 1 respondent of the survey.

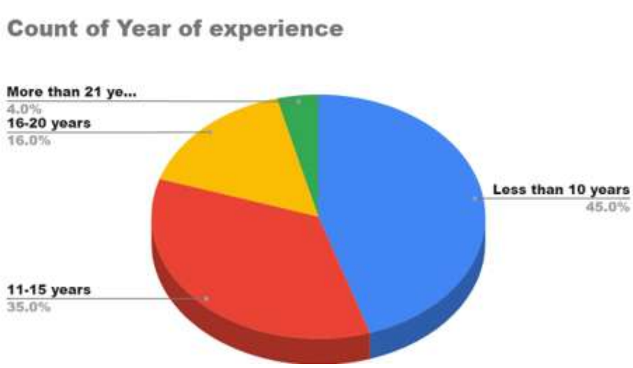
Figure 6: Demographics respondent of ethinically.



Source: Authors.

Furthermore, the Figure 6 shows the ethnically of response which has four categories Malay, Chinese, Indian and Others. Through this observation, the highest of respondents ethnically is Malay with 80.0% answered the survey which is 80 respondents. Next, Chinese is a second higher score 12.0% which is 12 respondents. Moreover, Indian was found to be about 6.0% which is 6 respondent and the low score that is other selected it is about Bumiputera Sabah 2.0% which is 2 respondents.

Figure 7: Demographics respondent of year of experience.

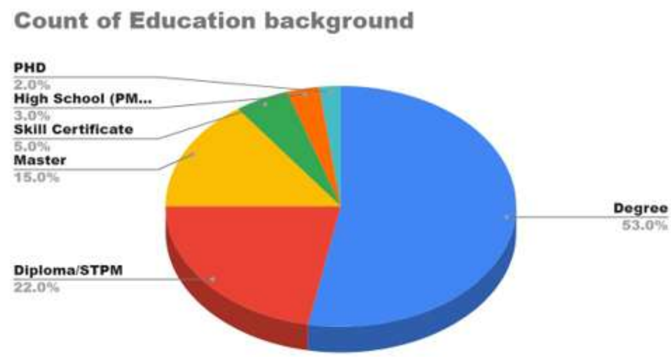


Source: Authors.

This Figure 7 shows the result of years of experience of respondents and there were several inputs on this part which is less than 10 years to more than 20 years. The highest score on that survey answer is less than 10 years with 45 respondents and 45.0% percentage on that survey. Next, 11 to 15 years with a percentage which is 35.0% was scored by 35 respondents. Moreover, 16 to 20 years were found of 16 respondents with 16.0 percent and the lowest on that part is more than 21 years' experience which is 4.0% percent response in that survey.

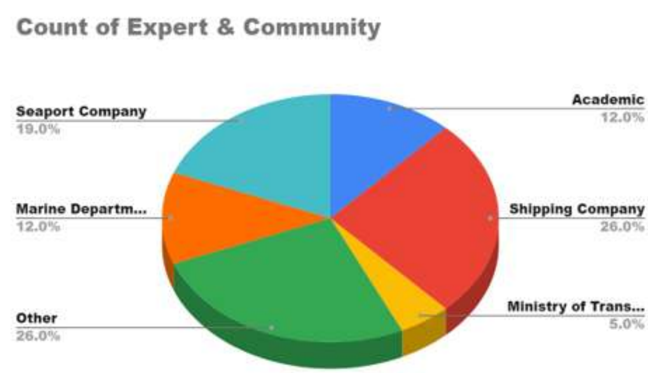
The Figure 8 shows the result of education background respondent and there were several inputs on this part which is Degree is the highest score is 53.0% was found 53 respondents. Next, the Diploma/STPM, which is 22.0% then 48 respondents. Moreover, the Master about the education background they found 15.0% which is 15 responses of respondents. Next, 5.0% is about the Skill Certificate with 5 respondents on that education background. Besides, the High School (PMR/SPM) is 3.0% with 3 respondents about this survey. Lastly about the education background is PHD they with 2.0% on they have 2 respondents only.

Figure 8: Demographics respondent of education background.



Source: Authors.

Figure 9: Demographics respondent of expert and community.



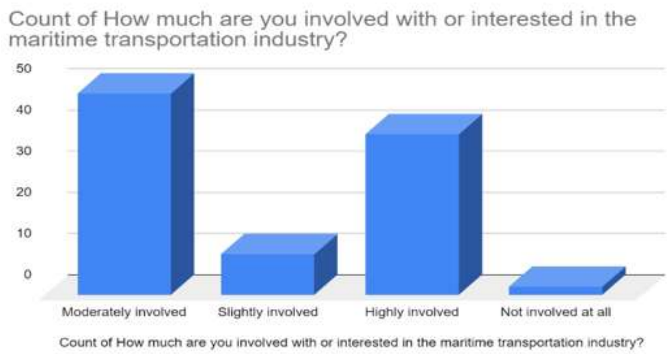
Source: Authors.

Figure 9 as the result of a survey about the expert and community with the position or the workers of the survey. They have academic backgrounds, ministry of transportation, marine department, seaport company, shipping company and others. The highest result on that survey is about 26.0%. They have the same result as the shipping company and the other backgrounds with 26 respondents. Moreover, the seaport company expert has 19.0% responses with 19 respondents on that survey. Next, the same result of that survey is 12.0% with the marine department and academics found 12 responses on that survey. Besides the ministry of transportation, it is the lowest result on that expert and community background they have 5 respondents while the percentage of 5.0% on that survey.

4.2. First Objectives.

First Objectives: To study the importance of marine ecosystem sustainability on marine transportation in Malaysia.

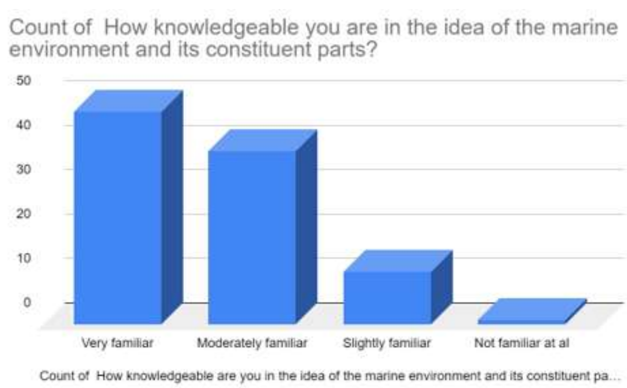
Figure 10: Graft of question number one.



Source: Authors.

On that result Figure 10 this is a question of objective one, it is about how much are you involved with or interested in the maritime transportation industry. The highest percentage on that question is the first answer about the moderately involved with 49 responses on that respondent. The second on that answer is the highly involved 39.0 percent of respondents. Next, the answer about the slightly involved there has 10 percent on that survey area of the answer. Lastly about the respondent's choice it is about the not involved at all they were the lowest of the respondents with 2% of the respondents.

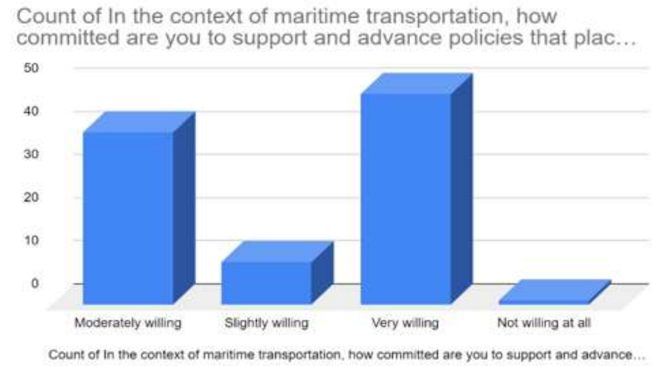
Figure 11: Graft of question number two.



Source: Authors.

The result of Figure 11 is about how knowledgeable you are in the idea of the marine environment and its constituent parts. So, the highest result on that respondent choice of this answer is very familiar with 48.0 percent of the respondents. About the lowest of the chosen on that respondent it is not familiar at all with 1 respondent only on that survey. The second highest of this question is about the answer moderately familiar and knowledgeable in the idea of the marine environment and its constituent parts with 39 respondents on that survey. The last result on that question is from answers slightly familiar with 12.0 percent on that respondent.

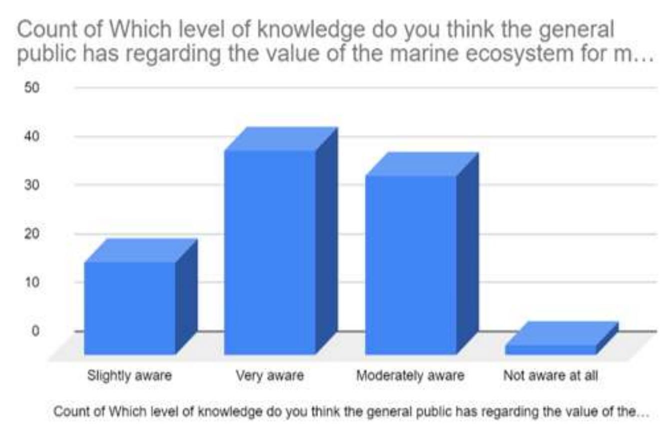
Figure 12: Graft of question number three.



Source: Authors.

Next, figure graft at Figure 12 it is about question numbers three on the first objective. The question is: In the context of maritime transportation, how committed are you to support and advance policies that place a high priority on the preservation and conservation of the marine ecosystem. So, the highest of the survey respondents is the answers of the very willing with 49 percent of the respondents. for the lowest result on that survey is the answer of not willing at all the response with 1 respondent only. The second highest percentage on that survey is moderately willing of the responses on that answer of the respondent. The last part of the percentage on that question is about the answer of slightly willing with 10 respondents.

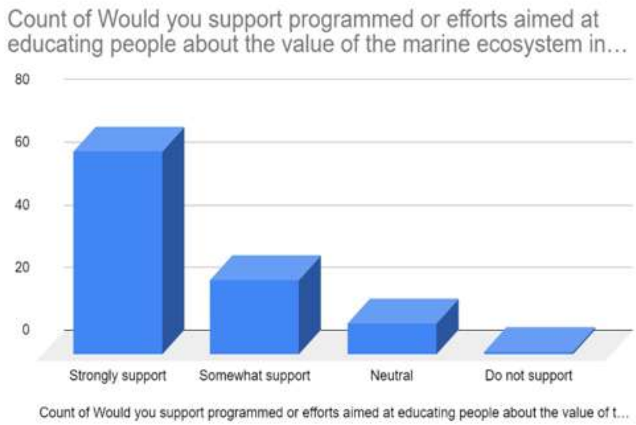
Figure 13: Graft of question number four.



Source: Authors.

On that result of Figure 13 this is question four of objective one, which level of knowledge do you think the general public has regarding the value of the marine ecosystem for maritime transportation. The highest percentage on that question is the first answer about the very aware with 42 responses on that respondent. The second on that answer is the moderately aware 38.0 percent of respondents. Next, the answer about the slightly aware there is 19 percent on that survey area of the answer. Lastly about the respondent's choice it is about the not aware at all they were the lowest of the respondents with 2% of the respondents.

Figure 14: Graft of question number five.



Source: Authors.

Furthermore, figure graft above 14 is about the last question on the first objective. The question is: Would you support programs or efforts aimed at educating people about the value of the marine ecosystem in relation to maritime transportation. So, the highest of the survey respondents is the answers that strongly support 65 percent of the respondents. for the lowest result on that survey is the answer of do not support the response with 1 respondent only. The second highest percentage on that survey is moderately willing of the responses on that answer of the respondent. The last part of the percentage on that question is about the slightly willing with 10 respondents.

Frequency.

Table 1: Frequency of the objective one.

Question / Total Respondents	Interested in the maritime transportation		Knowledgeable of the marine environment		Committed to support advance policies		The general public regarding the value of marine ecosystem		Support programmed or educating people	
	N	%	N	%	N	%	N	%	N	%
Answer 1	49	49.0	48	48.0	49	49.0	42	42.0	48	48.0
Answer 2	39	39.0	39	39.0	40	40.0	37	37.0	39	39.0
Answer 3	10	10.0	12	12.0	10	10.0	19	19.0	12	12.0
Answer 4	2	2.0	1	1.0	1	1.0	2	2.0	1	1.0

Source: Authors.

On that figure of the Table 1 there is the frequency of the objective one, to study the importance of marine ecosystem sustainability on marine transportation in Malaysia. The result of the highest frequency is 49.0%. It is about question number one the most interested in maritime transportation and the answer number one is moderately involved that the highest chosen of the respondents. The lowest on that chosen of the respondents is about questions knowledgeable of the marine environment, committed to support advance policies, support programmed or educating people, they have 1.0% respondent on those answers responses.

Mean, Mod, Median, Standard Deviation, Variance.

Next, about the explanation on that mean, mod, median and standard deviation and variance. The highest about the mean is question number four is the general public regarding the value of the marine ecosystem. They have 1.81 for the result of mean.

Table 2: Mean, mod, median, standard deviation, variance of the objective one.

Question / Total Respondent	Interested in the maritime transportation	Knowledgeable of the marine environment	Committed to support advance policies	The general public regarding the value of marine ecosystem	Support programmed or educating people
Mean	1.75	1.66	1.63	1.81	1.47
Median	2.00	2.00	2.00	2.00	1.00
Mod	2	1	1	1	1
Std. Deviation	.716	.728	.706	.813	.717
Variance	.513	.530	.498	.661	.514

Source: Authors.

The lowest mean about this objective is question number five: it is about the support programmed or educating people with 1.47 only. Furthermore, they have the median of the objective one for the lowest of the median is question number five. It is about support programmed or educating people with only 1.00 for this part. Overall, on that median on that the objective one is the same with 2.00 about the part. Next, for the mod the highest of this part of the question is question number one it is about interest in maritime transport they have 2 while the overall on that question is the same it has got only 1 of the mods on that part. The lowest of the standard deviation, question number three is committed to support advance policies with 0.706. About the highest on that part is question number four, the general public regarding the value of marine ecosystem with 0.813. Last but not least about the variance, the highest on that situation is the count of question number four is the general public regarding the value of marine ecosystem with 0.661. The lowest of the variance is the committed to support advance policies with 0.498.

4.3. Second Objectives.

Objectives: To determine the impact factors of marine ecosystem sustainability on marine transportation in Malaysia.

Frequency.

Table 3: Frequency of the objective two.

Question Total Respondents	Oils spills		Ships drop their anchors to the seabed		Ballast water		Noise in water from marine transport		Plastic waste	
	N	%	N	%	N	%	N	%	N	%
Strongly Disagree	3	3.0	3	3.0	1	1.0	1	1.0	1	1.0
Disagree	5	5.0	8	8.0	6	6.0	8	8.0	3	3.0
Neutral	24	24.0	21	21.0	24	24.0	24	24.0	14	14.0
Agree	36	36.0	36	36.0	26	26.0	32	32.0	29	29.0
Strongly Agree	32	32.0	32	32.0	43	43.0	35	35.0	53	53.0

Source: Authors.

On that 4.3 about this table, they refer to the frequency about the second objective it is to determine the impact factors of marine ecosystem sustainability on marine transportation in Malaysia. On that table, they have five questions. For the first question the keyword of impact factor is oil spill. Next, they have ships drop their anchors to the seabed; it is the keyword for question number two. The keyword of question number three is they have the ballast water to prevent the impact factor. The next part is the noise in water from marine transport that is the keyword on that question. The last key question is the plastic waste about the impact factor of the marine ecosystem.

The result of the highest frequency is 53.0%. It is about question number four about the plastic waste, the answer is strongly agree that the highest chosen of the respondents. The lowest on that chosen of the respondents is about questions of ships dropping their anchors to the seabed, ballast water, noise in water from marine transport and the plastic waste. they have 1.0% respondents that strongly disagree.

Mean, Mod, Median, Standard Deviation, Variance.

Table 4: Mean, mod, median, standard deviation, variance of the objective one.

Question Total Respondent	Oils spills	Ships drop their anchors to the seabed	Ballast water	Noise in water from marine transport	Plastic waste
Mean	3.89	3.86	4.04	3.92	4.30
Median	4.00	4.00	4.00	4.00	5.00
Mod	4	4	5	5	5
Std. Deviation	1.014	1.054	1.004	1.002	.893
Variance	1.028	1.112	1.008	1.004	.798

Source: Authors.

Next, about the explanation on that mean, mod, median and standard deviation and variance. The highest about the mean is a question about the impact factor from the plastic waste. They have 4.30 for the result of mean. The lowest count mean of this objective is the question of ships drop their anchors to the seabed. They have 3.86 for the count of mean. Furthermore, they have the median of the objective two for the highest of the median is question number five is the plastic waste. They have the highest count of the median is 5.00. Overall, on that median on that the objective two is the same with 4.00 about the part. Next, for the mod the highest of this part of the question is question number one it is about interest in maritime transport they have 2 while the overall on that question is the same it has got only 1 of the mods on that part. For the next part, the lowest of the standard deviation, question number five is plastic waste with 0.893. About the highest on that part is question number two, ships drop their anchors to the seabed with 1.054. Last but not least about the variance, the highest on that situation is the count of question number two is ships drop their anchors to the seabed with 0.863. The lowest of the variance is the plastic waste with 0.798.

About the elaboration on that objective with the previous study it is to attract the differentiation of that discussion. For the previous study they according from Zhong (2019) Accidental leaks of petroleum and its derivatives during the extraction, refinement, and transportation processes in the ocean will result in an oil film that will block sunlight from reaching the seabed and severely impair photosynthesis in aquatic animals and plants, preventing them from feeding, growing, and reproducing normally. So, the differentiation from my study is that ship-related oil spills and leaks can have serious repercussions for marine life, including fish, animals, and coral reefs. Pollutants such as chemicals and garbage that are released into the environment may also deteriorate water quality and endanger marine creatures.

Next, about the explanation, the fishermen who make a living from fishing are more concerned with their real advantages than with whether their overfishing will harm the sustainable development of marine resources. The only certainty they have is that the more fish they capture, the more economic rewards they will receive. Or simply because of life's pressures. People will be more dishonest if resources are scarce. Given that the complete number of marine resources is known, the more severely harmed the marine resources, the more harmful the marine environment will be according to Zhong (2019) while for my study is the ships anchoring can cause harm to coral reefs and marine habitats, especially if the anchors are dropped directly onto these fragile ecosystems. Anchors may crush and damage coral formations when they are lowered onto the seafloor, disturbing their fragile structure. Because coral reefs develop slowly, this damage can take years or even decades to repair. Anchor chains may cause physical harm as well as drag along the bottom, killing coral and other marine life along their path. The chain's dragging motion can uproot or destroy seagrass beds, which provide critical habitat for many marine animals.

4.4. Third Objectives.

Objectives: To purpose the solution factors of marine ecosystem sustainability on marine transportation.

Frequency.

Table 5: Frequency of the objective three.

Question Total Respondents	Enforcing stronger rules and regulations		Creating and putting into practice sustainable shipping practices		Collaboration with key parties		Incentives such as tax breaks or subsidies to shipping companies		Improving international collaboration and implementing international frameworks and agreements	
	N	%	N	%	N	%	N	%	N	%
Strongly Disagree	1	1.0	-	-	-	-	1	1.0	2	2.0
Disagree	4	4.0	1	1.0	3	3.0	3	3.0	1	1.0
Neutral	12	12.0	17	17.0	18	18.0	21	21.0	10	10.0
Agree	38	38.0	37	37.0	25	25.0	29	29.0	34	34.0
Strongly Agree	45	45.0	45	45.0	54	54.0	46	46.0	53	53.0

Source: Authors.

On that 4.4 about this table, they refer to the frequency about the third objective it is to purpose the solution factors of marine ecosystem sustainability on marine transportation. On that table, they have five questions. For the first question the keyword of solution factor is Enforcing stronger rules and regulations. Next, creating and putting into practice sustainable shipping practices; it is the keyword for question number two. The keyword of question number three is they have collaboration with key parties. The next part is incentives such as tax breaks or subsidies to shipping companies that is the keyword on that question. The last key question is improving international collaboration and implementing international frameworks and agreements. The result of the highest frequency is 54.0%. It is about question number three about the collaboration with key parties, the answer is strongly agree that the highest chosen of the respondents. The lowest on that chosen of the respondents is about questions one and four, which is Enforcing stronger rules and regulations, incentives such as tax breaks or subsidies to shipping companies. They have 1.0% respondents that strongly disagree about that.

Mean, Mod, Median, Standard Deviation, Variance.

Next, about the explanation on that mean, mod, median and standard deviation and variance. The highest about the mean

Table 6: Mean, mod, median, standard deviation, variance of the objective three.

Question Total Respondent	Enforcing stronger rules and regulations	Creating and putting into practice sustainable shipping practices	Collaboration with key parties	Incentives such as tax breaks or subsidies to shipping companies	Improving international collaboration and implementing international frameworks and agreements
Mean	4.22	4.26	4.30	4.16	4.35
Median	4.00	5.00	4.00	4.00	5.00
Mod	5	5	5	5	5
Std. Deviation	.883	.774	.870	.929	.857
Variance	.779	.598	.758	.863	.735

Source: Authors.

is a question about the solution factor from improving international collaboration and implementing international frameworks and agreements. They have 4.35 for the result of mean. The lowest mean about this objective is the incentives such as tax breaks or subsidies to shipping companies. They have 4.16 for the count of mean. Furthermore, they have the median of the third objective for the highest of the median is question number two and five is the creating and putting into practise sustainable shipping practices and improving international collaboration and implementing international frameworks and agreements. They have the highest count of the median is 5.00. Overall, on that median on that the objective two is the same with 4.00 about the part. Next, for the mod the overall count on that mod is the same as the question it is about the 5 mod. Besides the lowest of the standard deviation, question number two is creating and putting into practise sustainable shipping practices with 0.774. About the highest on that part is question number four, incentives such as tax breaks or subsidies to shipping companies with 0.929. Last but not least about the variance, the highest on that situation is the count of question number four is incentives such as tax breaks or subsidies to shipping companies with 0.863. The lowest of the variance is the creating and putting into practise sustainable shipping practices with 0.598.

Furthermore, it is the discussion about the previous study in which the shipowners will be able to analyse their repair and maintenance expenditures in order to avoid detention using this data analysis. Government and policymakers should take into account these high impact risk factors and areas of detainable deficiency that may result in ship detention when improving inspections and governance strategies to optimise maritime safety operations and marine pollution prevention. Following the findings of this study, shipping firms should maintain ISM compliance, fire safety, prompt self-inspection, and crew education to reduce the possibility of ship detention, which might result in economic loss as well as environmental issues according from Chuah et. al (2022) while for my study the collaboration among key parties is crucial to address the impact of marine transport operations on marine ecosystems in Malaysia. By working together, the government, industry, and environmental organizations can pool their resources, expertise, and influence to develop effective strategies and initiatives to mitigate the negative effects and promote sustainable practices.

Next, according to Zhong (2019) the preservation of the maritime ecological environment is the most important link in protecting the global ecological environment, since the status of ecological environment maintenance has a direct influence on human life and development. Aside from plentiful marine animals, there are also a big number of oil, gas, and mineral resources in the vast marine resources, which are strongly tied to human production and living. The degradation of marine resources will not only harm marine species' living environments, but will also have major consequences for human existence while for my studies improving international collaboration and implementing international frameworks and agreements are crucial steps to protect the marine ecosystem from the effects of maritime transportation in Malaysia. International frameworks and agreements provide countries with a common platform for developing and enforcing policies addressing the environmental implications of marine transportation. The use of international standards guarantees uniformity and harmonisation in the approach of reducing the impacts of maritime traffic on the marine ecosystem. It also contributes to avoiding a race to the bottom in which nations compete with low environmental standards. These frameworks frequently include regular evaluations and revisions that take into account scientific advances and growing environmental issues. This flexible approach means that effective solutions may be implemented when new difficulties arise.

Conclusions.

In conclusion, Malaysia may get various advantages by prioritising marine environment sustainability in maritime transportation. For starters, it assures the conservation of the country's rich maritime biodiversity, including endangered species and unique ecosystems. This preservation is critical for preserving ecological balance and sustaining the long-term health of the marine ecosystem. Maritime ecosystem sustainability in maritime transportation helps to preserve essential ecosystem functions. The coastal areas of Malaysia provide a variety of functions, including nutrient cycling, water filtering, and storm protection. Malaysia can assure the continuous provision of these ecosystem services by reducing pollution, avoiding habitat degradation, and establishing responsible shipping practises, which will benefit both the environment and local residents.

Finally, Malaysia must ensure marine ecosystem sustainability in maritime transportation. Malaysia may protect its rich marine life, preserve coastal ecosystems, fight climate change, and support the economy by implementing sustainable practises. Sustainable maritime transportation practises will contribute to the long-term health and resilience of Malaysia's marine ecosystems, ensuring the country's long-term viability.

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Are we all in the same boat: An Evaluation of the Female Perception on the Maritime Industry

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ABSTRACT

Ever since the pirating days there has been an inherent bias about women being onboard ships. It originally stemmed from the sailors' lore about women being bad luck on ships because they were distracting and brought uncooperative weather. The bias has stemmed into modern day seafaring. There is a problem regarding the bias against women in maritime culture. Despite the many efforts made to better support females in maritime there is still inherent bias, which has led to the marginalization of women. Through an ethnographic study a series of interviews will be conducted to better understand the personal effects of this bias on the women. The interviews will then be coded by common themes that arise. What was found was that many of the women had as equally positive experience as negative experience. There seemed to be more of an issue with female on female support aside from gender bias.

1. Introduction.

Throughout maritime history there is an embedded bias against female seafarers. This bias has traveled into current day seafaring. For the purpose of this research maritime will be defined as "an industry revolving around shipping that is highly male dominated" (Wu 2017). Male dominated being defined as an "infrastructures ability to uphold hegemonic masculinities which produce masculine privilege" (Galea 2022). Similar to all other work forces the maritime industry originated as a male only occupation. It was no until 1988 that the fight for female workforce equality really started to take off, the fight for female equality has been going on for over 34 years.

The maritime industry has been around as a source of economic and commercial prosperity for many years. Despite the economic and commercial prosperity, the culture of the industry is very biased. This is due to the infrastructure being created by men, because similarly to many other occupations it was originally allowed for men only. This means that there was a lack of female perspective on the culture. This has resulted in the industry having an abundance of "gender related work issues" (Lares M.C.R 2017) along with a hierarchical and patriarchal structure. Gender related work issues can span anywhere from "uncooperativeness from colleagues, inability to fully complete the task and even sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature that is considered sexual harassment" (Lares M.C.R 2017). This has created a serious problem for the women in the industry.

This bias has created a major issue for female mariners and results in them being impacted negatively. There is an obvious problem in the maritime industry regarding the perception of females being bad luck and ineffective on ships. Despite the amount of females in maritime job posters and academy advertisements there is still inherent bias. Through an ethnographic study I will be able to fully analyze the impacts of this bias on current and past female seafarers and their perception of their role in maritime in 2022-2023.

2. Literature Review.

2.1. Historical Perspective.

Similar to all other work forces the maritime industry originated as a male only occupation. It was not until 1988 that

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the fight for female workforce equality really started to take off. According to Lares M.C.R, an Associate Professor at the World Maritime University claims that "the fight for female equality has been going on for over 34 years" (Lares 2017).

This shows that the fight for female mariner equality is fairly new. What must be established is a historical context on maritime infrastructure. An example of how bias is present in the maritime industry has been prevalent through the US Navy. Kate Pike, a professor at Tulane University School of Law explains that the US Navy has been developed through a "long-established strongly hierarchical and patriarchal structure" (Pike 2022). This is in agreement with Lares claims because her stance is that the fight for female equality in maritime has been a rather newer development due to Pike claim that any maritime infrastructures have been developed on a "hierarchical and patriarchal structure"(Pike 2022). This presents the idea that if there is to be major infrastructure and cultural change to the maritime industry then what must be fought is implementing policy and perspective change in the industry to make it more inclusive and equal for all workers.

This problem of the maritime culture being built on is not only an issue in the United States of America. Due to the widespread international relations the culture has affected many other ports. Kate Pike, professor at Cambridge University, claims that "reflect failures of leadership in developing and promoting a safe and inclusive onboard culture" (Pike 21). Which agrees with previous authors because it states that due to the culture there has been major failure on behalf of females. There is proof behind this because in the same excerpt it provides that "research suggests that all women seafarers will experience some form of harassment during their careers" (Pike 2021). That proves that bias is prevalent as previously stated by many other authors, which is due to McCarthy's claim about a hierarchical and patriarchal structure and Romeros claim about the fight for equality being fairly new.

Building off the idea of the structure of the maritime culture being created through hierarchical and patriarchal bias. Similar thoughts are being portrayed through the International Maritime Organization (IMO). IMO conducted a study that proved that throughout maritime history there is "almost no women present, and others where we can see some minimal elements of parity and equal representation" (IMO 2022). This is in agreement with all other sources that claim that due to the nature of maritime culture has created a disconnect between representation and equality. There is a common agreement between authors saying that due to the nature of the industry's culture it was made to not benefit females however what has yet to be established is how females feel about this phenomena.

All sources do prove that there is a historical bias woven into the culture of seafaring.

Contrary to the abundance of research proving the prevalence of the bias; there is minimal research that responds to the personal effects of females in the industry. Research proves that there is victimization and circumstances that lead to the lack of women as proven through University of Cambridge and the World Maritime University. There is also proof that internationally there is an issue involving the historical effects of the bias as proven through the International Maritime Organization. Despite all this research proving that there are historical bias issues throughout the maritime industry, there is a lack of research in the findings of the personal effects.

2.2. Female perspective on the Maritime Industry.

Now that the historical context of bias against females and the research conducted proves there are efforts being made to support men, a review of the female perspective on the maritime industry must be evaluated. There is significant research regarding the obstacles faced by female seafarers. Zbigniew Szozoda a professor at the Maritime University conducted a study regarding the primary source of female struggle in maritime. His findings found proof that "almost 25% said that they were afraid about psychological predisposition" (Szozoda 2014), meaning that a quarter of the females in maritime have a fear about the psychological impacts that the industry leaves on their workers. Another statement was made during the study about an example of females being directly impacted by the bias they claimed that they were "denied the planned apprenticeship because the cabins were double and [they] would have been the only woman on the vessel so it simply was not cost-effective for the ship owner" (Szozoda 2014). That proves that there is bias that previous authors have also made claims about regarding the reasoning behind denying women onboard.

Many other studies about females on ships have been taken to provide primary source statements. One more notable study taken was by flyfishing.org, the nation's number one shipping magazine. This source offers some insight into some of the coping mechanisms and other tactics used to keep motivation and morale high while working as a seafarer. The demographic studied was the female SuperYacht deckhands. They claimed that "despite the hardships faced by female deckhands it is important to foster positive mental health strategies" (FlyFishing 2012). This agrees with Szozodas study by building off the idea of the physiological impacts of the culture of maritime.

There is commonality amongst all the sources, they all claim that there are many obstacles faced by females in maritime. There are psychological impacts on them especially.

Despite all the research that proves that there are no primary source studies that prove that there are personal effects. The research shows that women are impacted by this, without regard to how they are impacted.

2.3. Women in other Workforces Fight for Equality.

Now that historical context has been provided, an evaluation of men in maritime, and a female perspective of the obstacles faced by female seafarers. Conclusively what has yet to be evaluated is the female struggle in the other workforces. There is a prevalent bias throughout all workforces but there is much research supporting equality issues in other transects of transportation industries.

Recently a study was taken to evaluate the underrepresentation of females in management positions. According to the U.S Government Accountability Organization (which we be referred to as USGAO) there is a very obvious financial disconnect in regards to female managers, "in 2019, women remained underrepresented in management positions in the U.S. workforce and continued to earn less than male managers" (USGAO 2022). They continue to build on this idea of the underrepresentation of females by claiming that, "women make up nearly half of the U.S. workforce, yet they face disparities in pay and challenges in advancing their careers" (USGAO 2022). There are similar ideas portrayed in the sources describing the hardships of women in maritime primary source statements. In regards to the underrepresentation of women in the workforce a similar study was taken about women in overall male dominated careers.

Elizabeth Hall Dorrence, a professor in communications at the University of Michigan, conducted a study regarding the impacts of marginalization (or treatment of a certain group) of females in workforces. She explains that the marginalization was built through "micro - aggression" (Dorrence 2020). That means that a bias already embedded against women results in marginalization of females. That proves many other sources theories about the bias against women and the impacts of them. She also provides the information that most of that micro-aggression builds from "societal factors, job contexts and personal factors" (Dorrence 2020). This gives context to Pikes theory about the inequality regarding women in maritime.

Finally Rosa Delauro, a Politician in Connecticut, provides some final thoughts about the hardships of women in politics. She explains that many issues from women are overlooked because "perception" of women's issues are viewed as ""soft" women issues" (Delauro 2010). This provides some causation behind the theories and ideas brought up by the other sources. She also builds on this idea of the perception of women by men being persuaded in the workplace she claims that into order to reach full quality "the vast majority of men must see them as equal, coworkers, and bosses" (Delauro 2010), because this is not happening there is prevalent disconnect between women and men in male dominated industries which proves many ideas that other females are thinking.

Overall there is a common theme throughout the female perspective in other workforces, concluding that they are overlooked, especially in regards to male dominated workforces.

However this overall does not cover the personal effects on females. There is a similar lack of research in the maritime industry.

2.4. *Efforts Made for Men in Maritime.*

Although there is a multitude of research proving the problems for women in maritime there is an abundance of research proving the efforts made to support men in maritime. There is a rich body of literature that addresses the relationship between gender and labor. According to Adrienne Mannov, a professor of social anthropology of land and sea, states that "the overwhelming majority of merchant seafarers are men" (Mannov 2021) but then he builds on the changes made for the betterment of men. For example there is "they were worried, but their fears had to do with providing financial security for their families" (Mannov 2021), so in return they were paid more and their hours were changed. This proves that many of the issues involving men in maritime have been faced head on to change.

Now despite the changes made to improve the working conditions of men there is bias against men as well. Despite the bias is being fought head on to create change, Mannov explains that "very traditional and stereotype definitions of masculinity" among straight, white men from Western countries, including "the relentless repudiation of the feminine . . . emotional impermeability, inexpressiveness . . . daring, risk taking" (Mannov 2021), which means that due to the nature of a females emotions it is believed that they are not fit for this certain type of job as much as men are. That proves a bias because that is thoroughly believed throughout the entire maritime culture. This is in agreement with previous sources such as the ideas presented in the University of Cambridge that there is inherent bias in maritime however the issue is not only regarding women. Despite the bias being affecting maritime gender inequality across the board both The University of Cambridge agrees with Adrienne Mannov that "changes need to be made" (Mannov 2021). Which proves that the changes being made for men greatly outweigh the changes being made for women.

It was important to evaluate the male experience in the maritime industry because in order to establish a gap all perspectives must be evaluated. The given literature proved that despite minimal microaggression against male mariners their experience is vastly different from the female mariners. What the literature also proved was that there is already research of the male perception, however no literature analyzing the female perception.

2.5. *Gap.*

As proven throughout the large amount of research provided there is an obvious lack regarding the personal effects of female seafarers. This bias has directly impacted gender equality and the work environment for current day seafaring. That lack of research has created a necessary perspective needed. This issue can be rectified through a series of interviews from a wide variety of females in the maritime industry. Throughout the course of this paper an ethnographic study will be taken to evaluate the personal effects of the bias on females perception of the maritime industry. Those directly impacted by these aspects of the industry will be thoroughly evaluated throughout the course of this paper.

As heavily stated there is a very obvious lack of research but the posing question is why is this research important? Due to the gap in research there has been no space for females to share their stories on how this bias has impacted them or how they feel about their occupation. Through the conducted research there will be a source that provides the perspective that has been missed through alternative research on maritime.

This paper will focus on the personal effects of the bias in the maritime culture on current female mariners. Through a series of interviews the personal aspects of the bias on female mariners and their perception of their occupation will be evaluated. This paper will provide a coded evaluation of the statements given by the female mariners to emphasize any common themes that have shown present throughout the interviews. The goal is to answer the question: how does the bias embedded in maritime culture personally impact female mariners perception of their occupation in 2022-2023?

3. Method.

Through an Ethnographic study I was able to analyze the perception of female mariners roles in 2022-2023 seafaring. An Ethnographic study allowed for a study to be taken of the impact of a culture on a certain demographic. That is in alignment with my question because I was analyzing the bias in maritime cultures impacts on the female mariners demographic. In order to collect the data a series of open ended interview questions (shown in Appendix A) was performed and then the interview responses were coded through a thematic analysis. These questions pertain to filling my perspective gap of a lack of literature with a female perspective.

That is because by definition I was studying the lived experience of a culture on a certain demographic. I was studying the impact of the maritime cultures gender bias on female mariners.

An Ethnographic study has produced the correct results as opposed to other methods because the alignment will allowed me to collect the correct data. This research called for the exploration of the female perception as opposed to explain or create. That narrows down many of the research methods. A survey seemed viable however it did not allow for responses to cover a wide perspective, which is why my data collection is open ended interviews in order for there to be an opportunity for a wide perspective coverage.

In order to fully grasp the female perception of their role the interview questions are logically ordered to analyze their perception. It begins with an analysis of their familiarity of the historical context behind the bias, then begins to cover all aspects of the gender bias in company culture. Finally I concluded with the conclusion of actual analysis of the female perception of the maritime industry. At the end of each interview there was an opportunity for some open discussion for any other interviewees to share any thoughts they felt fit to better analyze their perception of the maritime industry.

In order to produce any finding a thematic analysis was necessary to analyze the findings from these interviews. A thematic analysis is a form of semantic coding, that means that as common themes throughout the interviews become more prevalent they were recorded and then compared to other responses. This will be done by finding common themes throughout the interviews. Once common themes begin to become prevalent they were recorded in order to draw conclusions. Through coding a thematic analysis that was how my research question was answered.

In order to properly conduct this research the tools that were needed were the open ended interview questions, those will allow me to stay within the guidelines of an ethnographic study.

Open-ended interviews also make it so the people I am interviewing feel as though they have space to verbally share their responses without a limit. Also I needed a recording device in order to make sure that I have the responses in their entirety. Finally notes were taken on the interviews in order to emphasize any common findings and to continuously analyze the data as was provided.

There were a few limitations regarding this method. An ethnography study has a very strict definition of study of the lived experience of a culture on a certain demographic. This means that any responses regarding any future direction or thoughts about the future of the industry may not be used as a response because it did not happen in the past. Another aspect of the ethnographic study that must be addressed is that it is qualitative research which means the usage of formulas and arithmetic is not used to prove the point, it is words which may yield less impactful results.

4. Findings.

Based off of the commonality between interview questions I created a code, shown in table 1.

Table 1

Code	Relative Questions
CoDP (+)(-)	- What companies have you worked for do you believe have been treated with respect and as a quality member of the company? (+) - What companies do you feel have treated you as unequal to your male colleagues and not a quality member of the company? (-) - Is there any company you worked for that originally started treating you as unequal but now does treat you with respect? (±) - Have you ever had to leave a company based on inequality? (-)
MDP (+)(-)	- Do you feel that your management or authority allows for this inequality? - Have you ever been mistreated by management or authority?
CwDP (+)(-)	- Do you feel that your coworkers and those at an under or equal position as you allow for this inequality? - Have you ever been mistreated by coworkers or people under an equal position as you? - Have you ever had any of your fellow coworkers stand up for your rights or your experience in the company?
MaDP (+)(-)	- Have you ever considered leaving the maritime industry based on inequality? - Has any coworker ever treated you unfairly before they even got a chance to know you? - What were your original ideas/ perception of going into the maritime industry (either post education or switching careers) - Do you think that you have changed your ideas about your job based on what you experience? - Do you know what the bias in maritime is/ are you familiar with the sailors' lore about women being bad luck on ships? - Do you feel that you have been treated with respect in your occupation or do you think that people have treated you unfairly? - Open ended conversation

Source: Author.

The code is based on what parts of the industry are being affected taken from four different perspectives (company, coworker, management and maritime), then through the interviews it seemed to be that there was equally as much positive perception as there was negative as shown through these two symbols: (+)(-). From the findings there were three sections of results (findings, keywords and quote) as shown in table 2.

Table 2

Code	Findings	Key Words	Quote
CoDP (+)(-)	(+) As far as companiesgot here is no bias that affects their perception because respect was shown. (-) Broken down into situational/ circumstantial that didhave an effect	- Circumstantial - off/on - Work harder - Frustrating - Overall - Yes	"You have a magnifying glass onyou which proves you to work harder"
MDP(+)(-)	(+) onshore companies: More people stayed with onshore because management was supportive (-) offshore companies: More movement between offshore companies because offshore management was unsupportive	- Yes - Expectation - Frustrating - No support - SASH - Good mentors - No tolerance	"Quite dependent on the expectation of the company"
CwDP(+)(-)	(+) many women feel more supported with female coworkers and superiors (-) more negative experience with male coworkers and an uneven female to male ratio	- Position - Misunderstanding - Male supports - Male unsupported - Unequal culture - Expectation blurred lines - Female superior support	"You don't have torespect the person you have to respect the position"
MaDP (+)(-)	(+) Despite the negative experience minimal regrets would not trade the experience (-) There is a bigger issue with female on female rivalry	- Naive - Passion - Female on female rivalry - Slow but sure change	"Passion outweighsthe hardships"

Source: Author.

5. Coded Thematic Analysis.

5.1. CoDP(+)(-):

This code analyzes the perception that was affected by overall company experience. This, similar to many of the other codes, proved there was equally as much positive experience as there was negative. A positive perception of their job was shown through overall company experience. This was found when key words such as "overall, yes, work harder". On the other hand when broken down into situational and circumstantial issues there was a negative perception regarding the company. This was shown when key words such as "off/on, frustrating, and circumstantial" were shown. The quote that emphasized that finding was "you have a magnifying glass on you which proves you to work harder" (anonymous). This emphasized my finding because there is not as much of a "magnifying glass" on you when you are just a member of the company, however when broken down into interpersonal interactions there is a more surveillance on you which results in a negetive perception.

5.2. MDP(+)(-):

This code analyzed the perception that was affected by management and authoritative figures. The interviews showed that there was, again, a positive and negative experience regarding both; what made this theme different from the CoDP(+)(-) is that the difference is based on onshore company management compared to offshore company management. What was found was that many offshore companies had more supportive and attentive management and less female employees left the companies. This was shown in key words "no tolerance, SASH (sexual assault and sexual harassment), yes, good mentors and expectation". The negative perception was emphasized by the majority of offshore companies because the management was not as supportive. This was shown in the keywords "frustrating and no support". This quote that emphasized this code was, "quite dependent on the expectation of the company" (anonymous). That emphasized my finding because it shows that the negative perception was shown with unsupportive management and positive perception was shown with supportive expectations.

5.3. CwDP(+)(-):

This code analyzes the perception that was dependent on coworker and colleague relationship. Many showed positive interactions with fellow female coworkers and a negative experience with male coworkers. The female coworkers provided a more positive experience because the environment was more supportive. The male coworkers fostered a more negative experience because many of the interview participants said that there was more competition.The prevalent key words regarding positive experience with females were "female superior support and unequal culture". The emphasized keywords to prove negative experience with male coworker interaction was "Position, misunderstanding, male unsupported, Expectation blurred lines". The quote that emphasized my finding was "you don't have to respect the person you have to respect the position" (anonymous). This emphasized my finding because the negative perception was shown when that ideology was not shown and the positive perception was shown when it was.

5.4. MaDP(+)(-):

The final code that was analyzed was the perception that was dependent on overall maritime culture. The interviews showed that despite all hardships and bias they have undergone, the passion much outweighed any negative experience. Many agreed that they would trade their experience. However there was an unexpected element that the culture overall negatively promotes female comradery and instead fosters more female on female rivalry. The keywords that portrayed positive perception were "short but slow change and passion" the key words that portrayed negative perception "female on female rivalry and naive". The quote that emphasized my finding was "passion outweighs the hardships" (anonymous). This emphasized my findings because a more prominent positive perception was shown following that quote being a response with that however that positive perception was contradicted when the topic of female on female rivalry was presented.

Conclusions.

What the data showed was that contrary to my hypothesis there was equally as much positive experience as there was negative experience. Many of the interviews showed that when presented with a negative experience it was always contradicted with something positive.

Therefore, their perception did change from their original ideas of the maritime industry. They knew originally that it was male dominated and the journey would be difficult but they also are seeing a lot of female success in the industry. Which conclusively created a neutral regard for the female perception of the maritime industry.

What the interviews also showed is even though there have been many strides in female success the culture has changed from being strictly male dominated to an even bigger issue of females competing to be "trail blazers" in their industry. This has created a change in the demographic where many companies have only 1 to 2 females on board because of this competition that was created. This is reasonable because it is difficult to become a face for equality when there are multiple people advocating for the same thing.

Another situation that needs to be addressed as a result of the interviews is that there seems to be less problems regarding bias dependent perception when there were female authority figures. This is because the females in charge have made a very distinct line of expectations to provide a "no tolerance" aspect minimizing the bias that happens in the company. This makes sense because the culture directly stems from how the management reacts to conflict.

So how does the bias embedded in maritime culture personally impact female mariners perception of their occupation in 2022-2023? The results show that their perception of the occupations is split in half to think about it positively and negatively. The bias has impacted them in the sense that they will from time to time feel "frustrated" or "misunderstood" however it is more a tale of a journey of overcoming hardship, ultimately resulting in an overall sense of pride about their occupation.

Limitations of Research.

As the female perception of their role in the industry has both a positive and a negative side, What has yet to be addressed is the limitation of this research. There were two limitations that had a direct impact on this research. The first one was the location availability of people to interview. The second one was that I forgot to ask how this issue makes you feel.

One limitation that had a direct impact on my research was the availability of women to interview. Due to the networking there was o a limited number of women that were available to interview, and based off of location there was only a very few women available to interview in person which may have led to a limited response due to the situation. Phone calls are not as comfortable as in person interviews to this may have led to answers that had misinterpreted responses. This is due to the environment regarding interviewing on the phone.

Another aspect that would have been conducted differently was the wording of the interview questions. Analyzing perception yields questions regarding people's personal lives. In order to ask the questions to answer the research question while being respectful of inquiring about the interviewees personal lives the questions may have been misinterpreted. Asking them how they felt may have resulted in a response that was not honest simply because it would be difficult to recall or the people being interviewed did not want to share their honest opinion. This led to more work in the end of having to grasp how they felt based on how they responded to questions. If the questions asked had words to signify a response with honest feelings the conclusion may be different.

Implication.

Due to the gap in the research there is a lack of female perspective on this issue. This is an issue because the problem directly affects females. The gap was that there is a lack of female perspective for a problem that directly affected females. This paper in the future will accomplish multiple things, there will be a source that admits the problem had an effect on the population, fills in a necessary perspective to increase the fight for change and it will allow women to share their experience which will create a more connected culture around the industry.

The problem was that women are affected by the gender bias, as shown it impacted them negatively and positively, despite all the sources that admitted that the gender bias existed and was a problem. This paper admitted that the gender bias impacted many women. However now that the data has been analyzed a conclusion has been made there is a source that admits there is an impact. This proven impact can impact the culture positively in the future. This means that the target demographic; women in maritime, will have a source that speaks out for their experience in the culture.

Now that there is a source that admits an impact of the demographic this can spark positive change. Admitting that the bias impacts women does not inspire companies to enact change or policy in their industry. However now that the victims of the bias have shared there experience that is reason to inspire change or policy in the industry. This can result in a positive culture shift for the maritime industry.

Not only does the implications of this research inspire change for male on female bias it also can provide a future direction for the issue regarding female on female rivalry that was prevelent through this research. This was an unexpected result from the research but equally as necessary in the future of this research.

Finally due to the widespread bias and the fact that women are a minority it has created an isolating environment for the women in the industry. This is due to the fact that many women are working on ships or in companies as one singular woman; they do not visibly see other women being impacted by the gender bias. However a major implication of this research is that there are multiple sources admitting that they have experienced the gender bias. This will in turn prove to women that they are not alone and will start to limit the isolating environment around the culture.

Future Direction.

As previously mentioned this issue was only evaluated through a small number of females. This is because of a vague definition of female. This made it available for any women who indentified as female and worked in the maritime industry eligible for an interview. This meant there was no hyperfixation on a stricter definition of female. Looking into evaluating the same issue through a more narrow definition may yield a different conclusion. There are many definitions to look at such as, how does it affect females of color or how does it affect married women and even the impact on women who identify as LGBTQ.

The time frame also resulted in a limited number of women available to interview. So for the future of this research there could be an opening for a larger group of women being interviewed. This may yield a response that is geared either more negatively or positively. This could similarly be done using a narrower definition regarding aspects such as location or national versus international industry culture.

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Appendix A.

Interview questions

1. Do you know what the bias in maritime is/ are you familiar with the sailors' lore about women being bad luck on ships?
2. Do you feel that you have been treated with respect in your occupation or do you think that people have treated you unfairly?
3. What companies have you worked for do you believe have been treated with respect and as a quality member of the company?
4. What companies do you feel have treated you as unequal to your male colleagues and not a quality member of the company?
5. Is there any company you worked for that originally started treating you as unequal but now does treat you with respect?
6. Do you feel that your management or authority allows for this inequality?
7. Have you ever been mistreated by management or authority?
8. Do you feel that your coworkers and those at an under or equal position as you allow for this inequality?
9. Have you ever been mistreated by coworkers or people under an equal position as you?
10. Have you ever had any of your fellow coworkers stand up for your rights or your experience in the company?
11. Have you ever had to leave a company based on inequality?
12. Have you ever considered leaving the maritime industry based on inequality?
13. Has any coworker ever treated you unfairly before they even got a chance to know you?

14. What were your original ideas/ perception of going into the maritime industry (either post education or switching careers).
15. Do you think that you have changed your ideas about your job based on what you experience?

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Effectiveness of Training on Collision Regulations of Boat Captain: Modified Basic Safety Training Course with Typhoon Awareness with Maritime Industry Authority Region V1

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ABSTRACT

Safety of life at sea is very important aspect in terms of navigation. The purpose of the study is to determine the level of awareness of the Boat Captains in terms of sounds and lights signal and lights and shapes on Collision Regulations by using the validated questionnaires that the author was provided based on the International Collision Regulations for Preventing Collision at Sea. The study was conducted to the different areas of Region V1 namely: Boracay Island Malay, Aklan, Estancia, Roxas City Capiz and Guimaras Province. The study was conducted last November 2018 to November 2019. Participants of the Modified Basic Safety Training Course with Typhoon Awareness and Collision Regulations conducted by the Maritime Industry Authority, Region VI Iloilo City and Iloilo State College of Fisheries, were utilized as respondents of the study. The respondents were composed of One Hundred Eighty boat captains through stratified sampling using the Slovin's formula. A quali-quanti research design was employed in the study. Open ended validated questionnaires were administered to the selected respondent. Focus group discussion was conducted to get reliable data from their personal experiences at sea. Answered questionnaires were gathered, tabulated, and analyzed using appropriate statistical tool. The results of the study in the sounds and lights signals the mean of pretest is 3.05 it is knowledgeable while on posttest is 4.41 it means more knowledgeable and level of awareness in terms of lights and shapes the mean of pretest is 5.86 it is knowledgeable and the mean of posttest is 7.88 more knowledgeable. The significant value of the level of awareness in terms of sounds and lights signals is 0 .437 while in terms of lights and shapes the significant value is 0.953. There is a significant difference between the level of awareness of boat captains in term of sounds and lights signal and lights and shapes before and after the Modified Basic Safety Training with Typhoon Awareness and Collision Regulations was conducted. The Collision Regulations training is really need of the boat captain in their profession. The MARINA must provide a Memorandum Circular pertaining to the Boat Captains that they must have a Certificate on the "International Collision Regulations Course" so that they are aware about the Rules of the Road and they can apply on their profession and can minimize or prevent whatever accident happen onboard.

1. Introduction or Problem.

Basic safety training offered maritime students' as well as professionals the different trainings on personal survival technique, disaster management and others while disaster preparedness is a process of ensuring that an organization has complied with the prevention measures. It is assumed as a state of readiness to contain the effects of a forecasted disastrous event to

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minimize loss of life, injury and damage property. It is extensively defined as a way to provide rescue, relief, rehabilitation and other services in the aftermath of the disaster. It entails the capability and resources to continue to sustain its essential functions without being overwhelmed by the demand placed on them, first and immediate response – emergency preparedness. Training is not a "recreational" luxury to be implemented when times are good, but a continuous effort that is even more valuable when times are rough. Proper planning of disaster awareness and disaster preparedness activities in isolation from people's daily lives and everyday concerns will rarely succeed. This is because people's interest in disaster preparedness fades if it has been a long time between disaster events. Typhoon affect the natural environment and cause harm to trees and other vegetation, including crops that communities may rely on for sustenance or trade or both. In addition, these typhoons do not only destroy the agricultural and industrial properties but also killed thousands of lives. Equally, the Philippines is a nation surrounded by water. In so much so, the nation sees many water-related accidents and disasters on a yearly basis. Literally, thousands of people have been killed by ferry and boating accidents in the Philippines. Due to the fact our nation consists of 7,563 islands, and many are not able to afford air travel or they are located too remote to an airport facility, ferry boats are the predominant mode for national travel. Likewise, bad weather, especially during typhoon season, poor maintenance, overloading of vessels – especially during the Christmas season as families return to their villages for reunions – and lax enforcement of regulations has brought many tragedies. Natural disaster caused by eliminate change are among the greatest threats faced by the world, especially the developing countries.

COLREGS were adopted as a convention of the International Maritime Organisation in 1972 but they have been amended several times since. The Rules are divided into five parts A-E covering: General Rules (A) Steering and Sailing (B). One of the most important innovations in the 1972 COLREG was the recognition given to traffic separation schemes - Rule 10 gives guidance in determining safe speed, the risk of collision and the conduct of vessels operating in or near traffic separation schemes.

Basic safety training offered maritime students' as well as professionals the different trainings on personal survival technique, disaster management and others while disaster preparedness is a process of ensuring that an organization has complied with the prevention measures. It is assumed as a state of readiness to contain the effects of a forecasted disastrous event to minimize loss of life, injury and damage property. It is extensively defined as a way to provide rescue, relief, rehabilitation and other services in the aftermath of the disaster. It entails the capability and resources to continue to sustain its essential functions without being overwhelmed by the demand placed on them, first and immediate response – emergency preparedness. Training is not a "recreational" luxury to be implemented when times are good, but a continuous effort that is even more valuable when times are rough. Proper planning of disaster awareness and disaster preparedness activities in isolation from people's daily lives and everyday concerns will rarely succeed. This is because people's interest in disaster preparedness fades if it has been a long time between disaster events. Therefore, disaster awareness activities will have the greatest impact when they are integrated into broader program strategies that seek to alleviate everyday community problems and hazards such as basic health care water scarcity and potability, sanitation concerns such as garbage collection, employment and community based first aid. While it is a fact that a community may be exposed to various natural and technological hazards, oftentimes, the reality of the situation is that people may not see the practicality of disaster preparedness suggestions and messages when they are trying to provide for themselves and their families in difficult and harsh economic environments. Study suggested approaches to disaster emergency relief, such as empowering the communities to prepare for natural disasters. Typhoon affect the natural environment and cause harm to trees and other vegetation, including crops that communities may rely on for sustenance or trade or both. In addition, these typhoons do not only destroy the agricultural and industrial properties but also killed thousands of lives [8]. Equally, the Philippines is a nation surrounded by water. In so much so, the nation sees many water-related accidents and disasters on a yearly basis. Literally, thousands of people have been killed by ferry and boating accidents in the Philippines. Due to the fact our nation consists of 7100 islands, and many are not able to afford air travel or they are located too remote to an airport facility, ferry boats are the predominant mode for national travel. Likewise, bad weather, especially during typhoon season, poor maintenance, overloading of vessels – especially during the Christmas season as families return to their villages for reunions – and lax enforcement of regulations has brought many tragedies. Natural disaster caused by eliminate change are among the greatest threats faced by the world, especially the developing countries. She furthered mentioned that climate change and disaster risks are the defining issues of our time, their increasing trend driven by economic growth brings to fore a human development issue and a human security concern that calls for urgent action. Over the last couple decades, the number of ferry accidents has reached catastrophic levels. December 1987: In the world's worst peacetime shipping disaster, The Dona Paz ferry collides with an oil tanker off Mindoro island near Manila, leaving more than 4,000 dead; October 1988: The Dona Marilyn ferry sinks off the central island of Leyte, leaving more than 250 dead; December 1994: A Singaporean freighter hits the ferry Cebu City in Manila Bay, leaving about people 140 dead; September 1998: The Princess of the Orient ferry sinks off Batangas City south of Manila. About 150 die; April 2000: The cargo vessel Anahanda, overloaded with passengers, sinks off the southern island of Jolo. Approximately 100 people die; February 2004: Islamist militants firebomb the Superferry 14 near Manila Bay, leaving 116 dead; June 2008: The Princess of the Stars ferry sails into a typhoon and tips over near the coast of Sibuyan island. close to 800 people are killed; November 2008: Don Dexter Kathleen, small wooden-hulled ferry, capsizes in freak winds off the central island of Masbate, leaving 42 dead; December 2008: The ferry Maejan capsizes off the northern Philippines, leaving 30 dead; May 2009: The Wooden-hulled

Commander 6 cracks open and sinks just south of Manila, leaving 12 dead; September 6, 2009: Nine people killed after the Superferry 9 tilts sharply and sinks near the city of Zamboanga and last December 24, 2009: Twenty seven people are missing as the Catalyn B with 73 people on board collides with a fishing vessel at the opening of Manila Bay. Academy and the LPU Maritime Training Center. The researcher was prompted to conduct the study so that community may understand about the hazards and risks to which they are exposed. This will improve preparedness and help citizens respond to local early warnings.

2. Objectives.

1. What is the training's effectiveness on the Boat Captains in sound and light signals and light and shape in Collision Regulations before the training conducted?
2. What is the training's effectiveness on the Boat Captains in sound and light signals and light and shape in Collision Regulations after the training conducted?
3. Is there a significant difference in the Boat Captains' effectiveness in sound and light signals and light and shape before and after the training conducted?

3. Theoretical Framework.

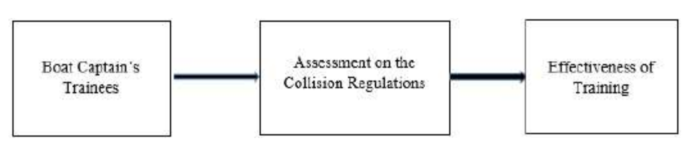
When it comes to safe behavior, Zohar and Luria (2003) identify a paradox in that individuals indulge in careless behavior even though they know that it might have adverse consequences. They explain this by advocating that human behavior is guided by the principle of maximizing expected utility. The perception of this utility is in turn distorted by a melioration bias, meaning that people tend to overestimate benefits of short-term results, and a rare-event bias which means that people generally underestimate the assessed likelihood of being adversely affected by rare events. As a result of these cognitive mechanisms, Zohar and Luria (2003) argue that individuals overestimate the short term costs of acting safely, such as time loss, increased efforts and personal discomfort, to an extent where it outweighs the likelihood of being struck by the negative consequences that risky behavior might have. Consequently the perceived equilibrium of maximized utility is placed at a position that, at a first glance, facilitates the procedures that the individual takes part in. Unfortunately the same equilibrium will, from a broader perspective, lead to an increased rate of injuries, accidents and ultimately disasters. To make matters worse, Zohar and Luria state that the above mentioned phenomenon is augmented by the fact that safe behavior leads to non-events while unsafe behavior gives immediate feedback in the form of tangible benefits. This, in turn, results in a reinforcement based learning that leads the individual towards unsafe behavior patterns. One example of such a theory, frequently applied to shipping (Stenmark, 2000), is that of Perrow's (1999) normal accidents. Perrow sees a problem with highly complex organizations as a great number of interconnected components has a tendency to create unforeseeable chains of events. He goes on to subdivide complexity into two dimensions.

Another theory that deals with catastrophic breakdowns in organizational activities refers to such occurrences as man-made disasters (Pidgeon & O´Leary, 2000). Just as in the theory of Perrow's normal accidents the unpredictable nature of complex socio-technical systems is acknowledged but this model uses sociological concepts in order to explain how this leads to undesired events. According to Pidgeon and O´Leary, organizational members share perceptions and assumptions of the system they are a part of, the hazards it may be subjected to and the appropriate actions to deal with such hazards. These perceptions and assumptions may over time be deflected away from reality to an extent where the organization is no longer capable of managing the situations in which it might find itself. Financial risk (Miu *et al*., 2010;Terzic *et a*l., 2015), health risk (Vellojin, 2011), toxic substance risk (Aschberger *et al*., 2010;Tong et al., 2002), natural disaster risk (Apel *et al*., 2004), underground storage risk (Deel *et al*., 2007), air transport safety risk (Harkleroad et al., 2013), marine transport safety risk (Goerlandt, 2015), food safety risk (Stirling *et al.,* 2006), emerging technology safety risk (Som *et a*l., 2012), drinking water safety (Roser *et al*., 2015), buildings safety (Bukowski, 2006) and major industrial accident risk (Ale *et al*., 2014;Grote, 2012), are among the many subjects, mentioned in scientific literature about risk assessment.

4. Conceptual Framework.

The paradigm of the study shows the independent variable which are the Boat Captain's Trainees, the intervening variable which is the assessment on the collision regulations and the dependent variable is the effectiveness of training.

Independent Variable	Intervening Variable	Dependent Variable



Safety of life at sea is very important in terms of navigation. Navigation is transferring a passengers and cargoes from one place to another in a safest and shortest distance. Now a days with the changing of our environmental climate. Many accident/incident happened at sea due to strong current, big waves even theirs no signal that our navigators must be always prepared for that. That's why the purpose of conducting this study is to determine the level of awareness of our boat captains in terms of sound and light signal and light and shapes in Region VI and Guimaras Province participants and to give knowledge, enhanced and trained on how to prevent accident/incident happen onboard. Life is so very important for everything else in this world. That's why we give importance about the training on collision regulations for the safety of the crew, passengers and cargoes onboard.

5. Methods.

Research Design.

Descriptive a qualitative/quantitative research design.

Locale/Study Site.

Selected areas in Region VI namely: Boracay Island Malay, Aklan, Estancia, Roxas City Capiz and Guimaras Province.

Respondents.

Boat Captains in selected areas in Region VI namely: Boracay Island Malay, Aklan, Estancia, Roxas City Capiz and Guimaras Province.

Sampling Techniques.

Stratified sampling using Slovin's formula.

Research Instrument.

Validated Survey Questionnaires in sounds and light signals and light and shapes based on international collision regulations 1972.

Data Gathering Procedure.

Make a proposal regarding the MBSTC training with Typhoon Awareness to be approved by the President of the Administration then after the approval sending an invitation letter to the MARINA for the resource speaker and after the approval make a courtesy call to the Mayor of every selected areas to inform about the training to be conducted after the approval of the Mayor coordinate with the president of the organization and met the boat owners to inform the training to be conducted by the MARINA and ISCOF so that they will inform their crew to participate in that said training.

Data Analysis.

Data gathered will be recorded and subject to statistical analysis.

The Level of awareness in sounds and lights signals result was presented using the following:

Scale		Description
5	5.00 - 4.21	Very Much Knowledgeable
4	4.20 - 3.41	Much Knowledgeable
3	3.40 - 2.61	Knowledgeable
2	2.60 - 1.81	Less Knowledgeable
1	1.80 - 1.00	Very Less Knowledgeable

The Level of awareness in lights and shapes result was presented using the following:

Scale		Description
5	8 - 10	Very Much Knowledgeable
4	6 - 7.99	Much Knowledgeable
3	4 - 5.99	Knowledgeable
2	2 - 3.99	Less Knowledgeable
1	0 - 1.99	Very Less Knowledgeable

6. Development (application and results).

Findings with analysis and interpretation

The study aimed to know the effectiveness of Boat Captains in Region V1. It also assessed the experiences of the Boat Captains in manuevering and handling the ship in terms of bad weather. The response for each questions and its findings are presented in the succeeding table.

Table 1 result of the pretest and posttest on sound and light signals:

Mean		Descriptive
Pre-Test	3.0	Knowledgeable
Post-Test	4.4	Very Knowledgeable

Table 2 result of the pretest and posttest on lights and shapes:

Mean		Descriptive
Pre-Test	5.9	Knowledgeable
Post-Test	8.0	Very Much Knowledgeable

Table 3 significant result of pretest and posttest on sound and light signals and pretest and posttest on light and shapes based on the paired sample correlation.

	Correlation	Sig.
Pair 1 Pre-Test and Post-Test	-.058	.437
Pair 2 Pre-Test and Post-Test	-.004	.953

Conclusions.

- In terms of sound and light signals in the pretest result the highest score is item number one. One short blast to mean (isa ka utod nga pag busina) got a 124 respondent answered correct out of 182 respondents and the lowest item is number 5 two flashes to mean (duha ka pag igpat sang suga) 94 respondent answered correct out of 182 respondents. While on post test result the number got a highest score of 180 is item number one and the lowest item is number 5 got a score of 142. We can see that same number 1 and 5 in terms of sounds and light signals in pretest and posttest results of the highest and lowest score.

- In terms of light and shapes the pretest result the highest item is number three got a 124 respondents answered correct and the lowest item is number 10. The respondent answered 82 correct while on the post-test the highest item is number 1 got a 162 correct and the lowest item is number 6 got a 135 correct. We can see that in terms of light and shapes the result of pretest and posttest has a bigger difference.

- Based on the Paired Samples Statistics the result of sound and lights signals in pretest is 3.0495 it means that it is knowledgeable base on the scale I was presented and the post test result is 4.4121 it mean that more knowledgeable while on the light and shapes the result of pre-test is 5.8571 it means that it is knowledgeable base on the scale that I was presented and the result of posttest is 7.8791 it means that it is more knowledgeable.

- Based on the paired sample correlation the result of pretest and posttest on sound and light signals is 0.437 and paired 2 on pretest and posttest on light and shapes is 0.953. It means that both of them has a significant effectiveness on the training.
- Modified Basic Safety Training with Typhoon Awareness and Collision Regulations is very important to the Boat Captains and Motormen in Region V1.
- Many Participants thankful to the Marina and ISCOF for conducting a training because it is a big help for them to give ideas and improve their knowledge regarding the safety of life at sea.
- Some boats are not equip with the lifesaving appliances for their safety.

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Investigation of SEPS electric power quality indicators based on mathematical simulation models

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ABSTRACT

The analysis of the electric power quality indicators for electrical power system on board ship is made. Electric power quality refers to the various properties of electric power, which together ensure the normal operation of ship consumers. Any ship electrical power system (SEPS) is characterized by limited capacity and the presence of a full cycle of generation, transmission, distribution and consumption of electric power. The consequences of deviations in the quality of electric power indicators are determined. Ways to improve the quality of electricity on board the ship are considered. A simulation model of the ship's electric power system has been developed to analyze the harmonic components of the voltage and current of the busbars of the main switchboard. A carried-out simulation showed the presence of interharmonic current components during the operation of reciprocating compressors' powerful electric drives. Methods for eliminating distortion by using boosters and active current filtering systems are proposed.

1. Introduction.

Improving the quality of electricity on a ship is a very urgent task due to the requirements of the Russian Maritime Register of Shipping (RMRS) and the International Association of Classification Societies (IACS) regarding the indicators of the sinusoidal current and voltage of SEPS in any operating modes. Various methods are being taken and new methods and devices are being created to solve this problem.

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2. Problem formulation.

The quality of electricity for operation in different modes is one of the most important characteristics on which the efficiency of SEPS operation depends [1-2].

Electric power quality refers to the various properties of electric power which together ensure the normal operation of ship consumers. The widespread use of various devices with non-linear and asymmetric loads significantly reduces the electric power quality indicators on ships. Therefore, it is necessary to perform a parametric analysis of the causes of current and voltage sinusoidal distortions in ship electric power systems. Indicators of the quality of electric power will be the deviations of certain parameters from the nominal

Any SEPS is characterized by limited capacity and the presence of a full cycle of generation, transmission, distribution and consumption of electric power. Requirements for the operation of ship electrical equipment are defined by the Russian Maritime Register of Shipping (RSRS) in the Rules for the Classification and Construction of Sea Vessels.

Table 1: Permissible deviations of power supply parameters.

Parameters	Deviations of parameters from the nominal		
	Long	*Short-term*	
	%	%	*Time, s*
Voltage (AC)	+6…-10	±20	1,5
Frequency (frequency range of a power plant with a variable frequency of the main source of electric power)	±5	±10	5
Voltage (DC)	±10	5 10	Cyclic ripple deviations

Source: Authors.

3. Consequences of deviations in power quality indicators.

Deviations in the values of certain indicators can affect the operation mode of electric power consumers. For example, if the grid's voltage is reduced by 5%, this will lead to a decrease in the induction motor (IM) torque by 10%, at the same time, the consumed current will increase by 11%. Such oscillations can cause false operation of protective devices that are designed to operate at rated voltage [3,4,5].

As for oscillations in the current frequency, they almost proportionally affect changes in the rotational speed of a three-phase induction motor that also has a negative effect on other joined mechanisms.

Ways to improve the quality of electric power on board. Various devices and schemes can be used to improve electric power quality on ships. One of these devices is the regulator of excitation current, which, in turn, stabilizes the voltage at the generator terminals. The generator voltage decreases when the stator current increases with an active-inductive load in normal mode. A compounding device is used to restore the voltage at the generator stator terminals. This device automatically increases the excitation current, and as a result, the generator rotor current.

One of the most effective means to ensure voltage stabilization can be boosters. Such devices are effectively used both for the groups of consumers that are particularly critical of supply voltage oscillations, and for voltage stabilization in the entire ship grid as a whole [6].

Energy storage devices can be used to significantly reduce the power of boosters. Among them are high-capacity capacitors, or small-capacity batteries, but for high voltages of 300 V and above.

The normal operation of large power electrical equipment and other ship receivers is adversely affected by the voltage unbalance of the three-phase system. For example, induction motors are subjected to additional heat, increase in vibrations, which leads to significant reduction in speed and other losses. Synchronous generators also experience increased rotor heating, stator heating and increased generator vibration. For single-phase receivers, unbalance manifests itself in an increase or decrease in the voltage level. Voltage unbalance in three-phase rectifiers leads to low-frequency ripples in the output voltage.

4. Simulation model design.

The model was designed in the Simulink environment (Fig. 1). Since the main source of electricity on the ship is a synchronous generator, the model uses a block of a synchronous machine.

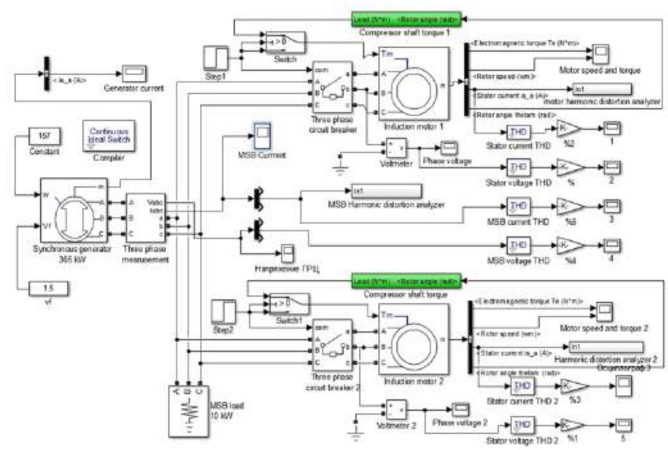
The rated active power of the generator is 375 kW. The rated power of the IM compressor is 11 kW, the constant load on the busbars of the main switchboard (MSB) is 10 kW.

The block of the synchronous machine can operate in the modes of the generator or the engine. The operating mode is determined by the sign of the mechanical power (positive for generator mode, negative for motor mode).

The electrical part of the synchronous generator unit is represented by a model based on the Park-Gorev differential equations [7]. Fig.2. shows the electrical circuit of the synchronous machine block in the axes d, q.

The model takes into account the dynamics of the stator windings, excitation windings and damper ones. The equivalent circuit of the model is represented in the rotor reference frame (d,q). All rotor parameters and electrical values are normalized to the stator windings.

Figure 1: Simulation model of SEPS with electric drives of high power compressors.



Source: Authors.

5. Results of mathematical and simulation modeling.

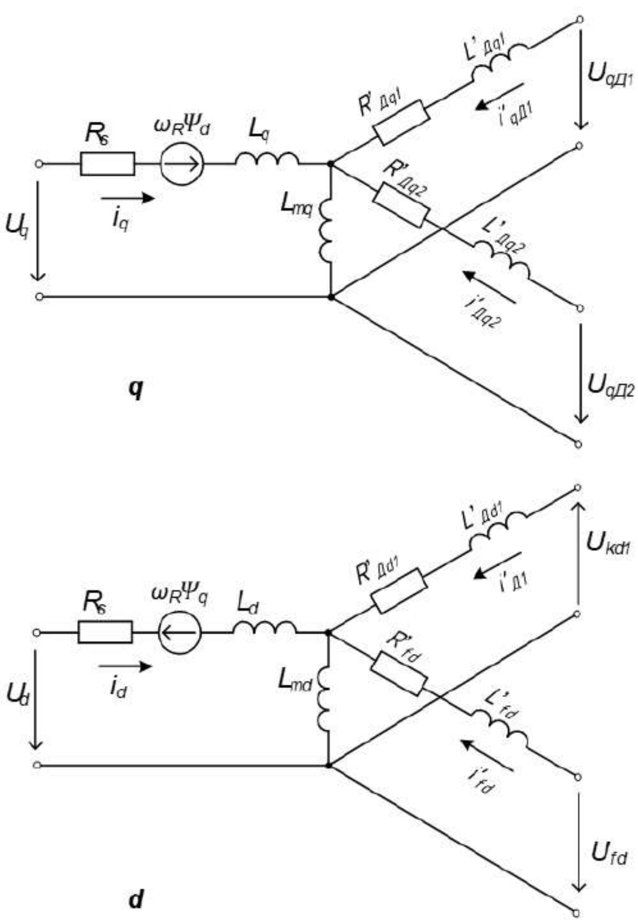
Modeling was carried out for three stages - start-up of the synchronous generator, connection of the first and second IM. The dip of the voltage sinusoid when the first IM is connected is shown in Figure 3.

The voltage dip was 13.7%, which meets the requirements of RMRS. However, according to [2], the compressor is an unbalanced load on the IM shaft, which makes interharmonic components of the stator current. Therefore, a voltage dip provides insufficient information about meeting the power quality requirements for the nonce. Figure 4 and figure 5 show an analysis of the selected interharmonic current components of the MSB busbars [8-10].

The amplitudes of the IC current of the busbars of the main switchboard when operating two reciprocating compressors are about 1.5 A, and THDi is 15%, which significantly affects the distortion of the voltage sinusoid. Thus, the THDu of the busbar voltage in the main switchboard rises up to 1.5%.

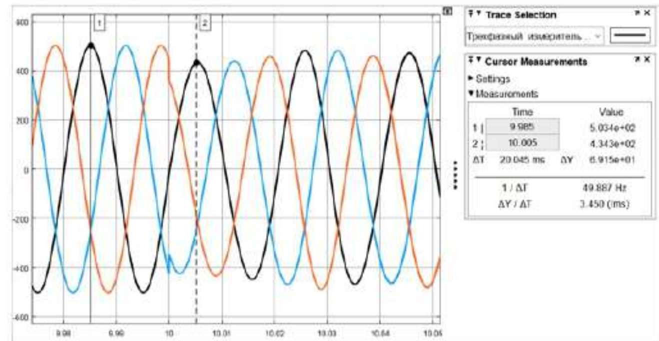
Therefore, there is a need for a systematic study of the problem of voltage distortion during the operation of powerful electrical appliances of reciprocating compressors as part of a SEPS of limited power.

Figure 2: The equivalent circuit of the electrical model of a synchronous machine in the axes d, q.



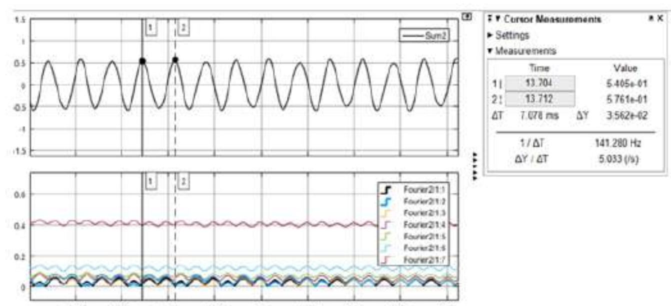
Source: Authors.

Figure 3: MSB voltage when connecting the first IM.



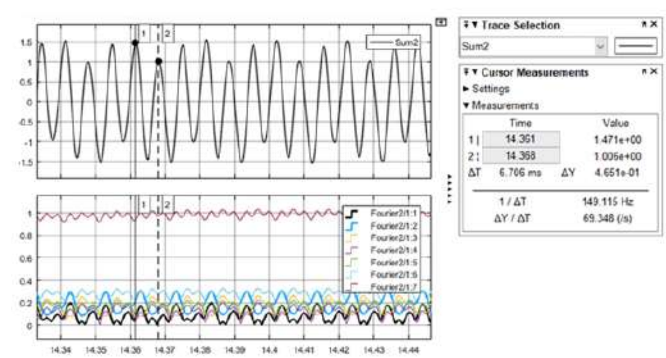
Source: Authors.

Figure 4: Analysis of the interharmonic components (IC) of the main switchboard current during the operation of one IM.



Source: Authors.

Figure 5: Analysis of the IC of the current during the operation of two IM.



Source: Authors.

Based on this, it is necessary to use devices that allow compensating for asymmetry and distortion, automatically adjusting the changing parameters [11-13]. In order to realize this, they use a system based on the principle of voltage boost which in its action is similar to the voltage stabilization system in the ship's network during its drawdowns and jumps.

Conclusions.

As a result of the research and modeling, it was revealed that the current sinusoid of the main switchboard is distorted and the IC occurs when operating a powerful electric drive of a reciprocating compressor as part of the SEPS. The voltage dip during the start of the IM does not violate the requirements of the RMRS, however, the harmonic distortions determined by THDi, THDu, and the IC amplitudes show a significant effect of the variable load of the IM on the voltage sinusoidality and current sinusoidality of the MBS.

In the course of the analysis, a solution to the problem of the presence of current IC was proposed through the use of filter-compensating devices in the circuits of compressor electric drives.

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A review of Ethical Considerations within Autonomous Maritime Cybersecurity Research

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ABSTRACT

The paper covers some of the ethical considerations and principles that researchers need to consider while conducting research within the field of autonomous maritime cyber security. It starts with a brief introduction to the research area and the cyber security risks associated with this. Then moves on to address the ethical considerations that researchers must consider. Basic research principles such as honesty, transparency, objectivity, independence, accountability, and fairness are emphasised. Additionally, the paper briefly explores an important socio-technical consideration, industry-sponsored research, and the potential conflicts of interest that arise when conducting such research. The conclusion highlights the importance of conducting ethical research with a high level of transparency.

1. Introduction.

Autonomous configurations are defined by the ability to make decisions without interacting with humans (Brodsky, 2016; Collingwood, 2017; Suchman & Weber, 2016). In their present form autonomous maritime vessels, land-based vehicles, and industry-related units, which are considered autonomous, still depend on humans as the operators (Ramos et al., 2018). It is difficult to predict with certainty what the future will demand from humans in terms of operational routines (Komianos, 2018; Mallam et al., 2020). From the maritime angle cyber security risks onboard vessels are commonly discussed by dividing digital environments into two categories: operational technology (OT) and information technology (IT) (Lagouvardou, 2018; Larsen & Lund, 2021). Within the maritime sector three major categories of research have been identified. (1) Detailed documentation of policies and important know-how relating to maritime cybersecurity, (2) cybersecurity related to ports, and (3) vulnerabilities of OT (Awan & Al Ghamdi, 2019).

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2. Background.

Contemporary research is subject to a public image of being conducted by individuals which shows heightened levels of ethics, often including being reliable, accurate, transparent, and always working in the best interest of society (Oliver, 2010). Still, even though researchers can assume that they will be accountable for their publications and that this involves being as unbiased as possible (Bos, 2020), there has been an increasing amount of Questionable Research Practices (QRPs) over the last 20 years (Bruton et al., 2020; Gopalakrishna et al., 2022; Isbell et al., 2022). For the context of this document, it is important to understand that maritime cybersecurity research is still very much in its infancy and there are a small number of researchers active within the industry (Oruc, 2022).

3. Method.

To be able to collect relevant data the following approach has been embraced for this unstructured literature review. The scope of the research has been defined using terminology such as ethical research, maritime research and autonomous maritime research. Furthermore a list of what is to be considered important keywords within this field has been compiled and used to search academic databases, search engines, and other sources for gathering literature, including university libraries and search engines such as Google Scholar. Selection has been made from relevance, publication date and quality.

4. Considerations.

Ethics is used as an individual compass for determining what is acceptable, it is based on personal moral conviction, society enforced rules and regulations together with both social and cultural heritage (Hamburg & Grosch, 2017). Not surprisingly there are increased demands within the academical profession when it comes to experience and the knowledge within different methodologies for conducting research in a manner which can be considered ethical (Navalta et al., 2019).

There is a consensus that we should develop and enhance technology and social behaviour in conjunction with each other to advance both aspects at the same time (Taxén, 2020). In this regard, cybersecurity can be defined as a function of the interactions between various technological and social factors that make up complex, adaptive socio-technical systems (Kowalski, 1994). As a result, researchers within any area of cyber security will likely at one point or another come across information during their research which could be considered private (Macnish & Van der Ham, 2020). In all such cases it is important for the researcher to abide by the laws and regulations to determine which information can be processed and how (Loi & Christen, 2020). This should be applied both in the context of following international as well as local legislations, something that could possibly interfere with experiments and data collection (Burstein, 2008). It all comes down to the key ingredient of consent when conducting research which involves individuals, something which has been emphasised since the Nurmberg trials and the Helsinki declaration (Association et al., 2001; Code, 1949; Weindling, 2001). This is or should be a human right by default and its fundamental value was established already by Brandeis and Warren (1890) with their conclusion of every individuals right to be let alone.

5. Principles.

There are ethical principles presented within the research community which serve as guidelines for researchers to conduct their work with integrity and accountability (Kretser et al., 2019). These principals emphasise importance of honesty, transparency, objectivity, independence, accountability, and fairness in research practices (ALLEA, 2017; Drenth, 2012; Vetenskapsrådet, 2017). It should be acknowledged that the field of research ethics within cybersecurity has been subject to numerous attempts to standardise ethical principles (Bailey et al., 2012; Loi & Christen, 2020; Morgan et al., 2020; van de Poel, 2020; Weber & Kleine, 2020).

Industry sponsored research raises several ethical considerations that researchers should be aware of (Stahl et al., 2019). Several studies states that industry sponsored research might be designed to generate results that support the sponsor's interests (Djulbegovic et al., 2000; Fabbri et al., 2018). Researchers need to be aware that potential conflicts of interest can arise when conducting industry sponsored research, not surprisingly this might be conflicts of a financial kind (Fabbri et al., 2018; Smith, 2006). In fact, there is a growing opinion that such financial conflicts of interest might jeopardise the reputation of the whole research field (Resnik, 2000).

Conclusions.

Ethical research is of utmost importance for researchers across all fields. It can be concluded that in many cases it is the researcher who must choose to conduct research in an ethical manner (Fujii, 2012). This should include disclosing any financial or personal interests that could affect the objectivity of their research carried out. Furthermore, researchers must respect privacy laws such as General Data Protection Regulation 2016/679 (GDPR) (European Parliament and the European Council (EP/EC), 2016) and of course any other international and/or local regulations which might be applicable. In all cases within the field of autonomous maritime cybersecurity research, principals of how to conduct ethical research should be taken into consideration and that the results of any industry sponsored research are reported both accurately and fully transparently. In conclusion, researchers which are conducting industry sponsored research shall remain vigilant to potential ethical concerns and make sure that the research carried out is conducted with the highest standards of ethical conduct regarding design, execution, and that all reporting is made in a manner which is independent, transparent, and scientifically valid.

As a researcher it should be the ambition to abide to the laws and regulations which apply for any specific field and for research in general, but also to follow existing ethical guidelines such as those described within The European Code of Conduct for Research Integrity (ALLEA, 2017), always striving to conduct ethically sound research with as high level of transparency as is possible and by doing so helping in maintaining the public's trust in the research enterprise.

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The Use of Hybrid Learning in Improving Academic Achievement

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ABSTRACT

This research was performed to evaluate the effectiveness of hybrid learning to improve the learning of Material Technology Courses at the Politeknik Ilmu Pelayaran Semarang. The respondents used in this study were six classes with 143 students. The test is carried out with multiple choices in the amount of 54 questions, then validity and reliability tests are carried out. Validity is set with a number of 0.6 while reliability is set at 0.8. The results of the Pretest and Postest are to determine the effectiveness of the hybrid learning approach to learning material technology courses at the Politeknik Ilmu Pelayaran Semarang. The results of the study can be seen that the postest score is higher than that of the pretest. Based on the results of the effectiveness test, the N Gain score obtained a figure of 0.821 and is included in the high category. These results show that hybrid learning shows significant results when compared to traditional learning. The COVID-19 pandemic has taught Educational Institutions to be creative in learning and come up with new methods in teaching and learning activities.

1. Introduction.

Pendeavouring is a fairly complicated matter and concerns human survival. Education is inseparable from the life of the family, society as well as the nation and state.

The government has established the law of the Republic of Indonesia of 2003, that countrywide schooling functions to expand abilties and shape a dignified country wide disposition and civilization so one can teach the state's lifestyles, aiming to expand the capacity of college students to turn out to be humans who've religion and piety in God Almighty, have a noble man or woman, wholesome, informed, succesful, innovative, impartial and end up democratic residents and responsible.

Education in Indonesia is expected which will shape the mindset, behavior and characterof a real individual. Man as the center of scientific progress, human resource development plays an important role. Development of human resources that are equitable, quality and equitable.

Politeknik Ilmu Pelayaran Semarang is an Educational Institution under the Ministry of Transportation that carries out vocational education in a boarding school. It is one of the official educational institutions that prepares students to become skilled workers on ships in the field of navigation and machinery. Learning is theoretical and practical, as well as courses according to the field. The school is expected to be able to develop the potential that exists in all students to the maximum, (Maslihah, n.d.).

The educational objectives can be achieved well if high enthusiasm is embedded, to achieve high achievements, as well as for the Teknika program which is one of the study programs at the Politeknik Ilmu Pelayaran Semarang, to achieve practical learning achievements, studentsare required to have a high spirit of practice as well, so that their achievements are good.

One of the practical courses is the practice of Material Technology. The author wants to know How much knowledge can be absorbed by studentsabout the practical knowledge of Materials Technology. The amount of knowledge will affect the strong enthusiasm of studentsto excel. Student achievement needs to be supported by high discipline from students in carrying out Material Technology practice, besides that student practice achievement can also be influenced by the state of a good or supportive practice environment, in this case it is a supportive practice place situation, for example, how the floor is stated, ventilation, room size, air circulation, and so on.

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Politeknik Ilmu Pelayaran Semarang has laboratories and simulators to foster positive student perceptions of practical equipment so that it will affect students' enthusiasm for high achievement in the practice of material technology. Because to carry out the practice of material technology, it is necessary to support complete equipment and meet the requirements, considering that the purpose of vocational schools is to train skills or competencies. The completeness of adequate practical tools allows achievements to be achieved, the completeness of adequate practical equipment will facilitate the implementation of practice, make it easier for students to master the practice, and will increase psychomotor abilities to students. after the COVID-19 pandemic hit Indonesia began to shrink, learning was diverted using hybrid learning, which is a combination of conventional and virtual learning, (R.R. Germo, 2022).

According to (Horton, 2011), hybrid learning by utilizing technology can improve the learning experience. In Indonesia, the hybrid learning approach is synonymous with online learning, (Trend 10.1.1.983.1634, n.d.). In order for the experience of a hybrid learning method to be powerful,_It should observe the four foremost strategies mentioned, (Ruth Colvin Clark, 2021). In_the_further, additionally_they introduced architectures_of blended studying procedures Receptive, directive, and guided discoveries. but, there are fewer article for every character architecture which in turn serves as a gap for more research to be undertaken. To fill in some thrilling portions,-(Hrastinski, 2008)- states that there are kinds of blended learning approaches, particularly: asynchronous, (Hyder et al., 2007). In addition, Horton (Horton, 2011),-also-stated-his-various- types-of-blended-learning approaches-which-include:-social-learning-, virtual classroom courses, self-paced courses, learning games and simulations.

Teaching in the country, especially higher education is slowly for a hybrid learning approach. More complicated challenges include mastery of technology, curriculum, motivation, and student behavior, (Acosta, 2016).

The rapid growth of Information, Communication, and Technology (ICT) as an extraordinary medium in transforming education. ICT has been proven to create a paradigm shift in academic coaching strategies and for that reason a hybrid mastering approach has been embraced as a way to offer green and low price great training, (Bhuasiri et al., 2012).- ICT and hybrid mastering approaches were proven toaddress academic improvement efficaciously as saidwith the aid of Button, Harrington, and Belan, (Button et al., 2014).

2. Material and Methods.

2.1. Definition of Hybrid Learning.

Hybrid learning according to the author is the combination of online and conventional learning. While according to some experts are as follows.

Hybrid learning is combines of online learning with conventional learning with face to face regularly and effectively. Hybrid learning integrated with learning outside the classroom with use electronic facilities as tutorials, study groups, or information from the library, (Garnham & Kaleta, n.d.). Hybrid Learning is combining electronic learning with face-to-face learning methods or conventional methods, (Jeffrey et al., 2014).

Hybrid learning combines two or more learning methods and approaches to achieve learning objectives, (Sutisna, 2016). Hybrid Learning is a combination of various learning media (technology, activities, types of events) for learning programs that combine the power of traditional face-to-face learning with electronic learning formats, Bersin (2004). Hybrid learning is a blend of conventional (synchronous) learning with combining internet-based learning, (Massoud et al., n.d.).

2.2. Academic achievement.

According to the author, academic achievement is an achievement of formal education. Academic achievement according to Bloom (in Azwar, 2005) is to reveal a person's success in learning. Academic achievement is all the results that have been achieved (achievement) obtained through the academic learning process, according to the author of the term which can be concluded that all the results that have been obtained through the academic learning process can be used as a measure to find out the extent to which students master the subject matter taught and studied. Academic achievement is the result of learning activities to know to what extent a person masters the subject matter taught as well as express the successes achieved by that person. Factors affecting academic achievement. Wahyuni (in Gunarsa, 2000) explains that academic achievement can be influenced by internal and external factors. Things that are included in internal factors are intellectual ability or intelligence, interests, special talents, motivation to excel, attitudes, physical and mental conditions, academic self-esteem, and independence. Then it was also stated that things are included in external factors, namely the school environment, family, and situational factors, Suryabrata (2002).

2.3. Material Technology.

Material technology is a course in engineering at the Politeknik Ilmu Pelayaran Semarang which is taught to 7th semester students. This course consists of 3 chapters taken from the IMO Model course 7.02 STCW 2010 Amendment. This course is used because the author teaches in this course after students carry out marine practice. This study intends to explore and compare hybrid learning which is then analyzed to see how effective it is for future learning.

This study used a literature study. Peneliti conducted a literature search for the research framework and utilized the educational resources on the campus of the Politeknik Ilmu Pelayaran Semarang. A literature study and evaluation of students in the odd semester of 2021 was carried out. The types of data used are primary data and skunder data, then processed with pre-tests and post-tests to measure how much effectiveness it is.

3. Results and Discussion.

Respondents used in this study were six classes with 143 students. The test is carried out with multiple choices in the amount of 54 questions, then validity and reliability tests are carried out. Validity is set with a number of 0.6 while reliability is set at 0.8. The results of the Pretest and Postest are to determine the effectiveness of the hybrid learning approach to learning material technology courses at the Politeknik Ilmu Pelayaran Semarang.

To discover the extent of effectiveness of the version that has been applied in this observe, it is able to be calculated with the benefit Index above, that is as follows:

The calculation of the gain index is done to see how much the use of Hybrid Learning has increased. The Gain Test is used to determine the effectiveness of a treatment on the expected results. The Gain index formula is calculated by the formula:

$$\text{Gain Index} = \frac{(\text{Postest Score} - \text{Pretest Score})}{(\text{Max Score} - \text{Pretest Score})}$$

The N-Gain yield criteria are presented in Table 1.

Table 1: Gain Index Criteria.

No	Index	Information
1	g ≤ 0,3	Low
2	0,3 > g > 0,7	Tall
3	g ≤ 0,7	Keep

Source: Meltzer (2002).

The criteria used to interpret the value of Gain are: Gain means $\geq 0,7$ high; 0.3 0.7 means medium; and Gain means low $\leq\ll 0,3$ (Hake, 1999: 1; Melzer dalam Sulistiyono, 2014).

$$Index\ Gains = \frac{(78{,}9704 - 52{,}6984)}{(84 - 52)}$$
$$Index\ Gains = \frac{(26{,}272)}{(32)} = 0,821$$

The COVID-19 pandemic was not predicted in advance. In fact, there are various viruses that threaten this world, but never before has it been as deadly as COVID-19 with the ability to transmit the virus which is also very fast. After the COVID-19 pandemic was officially announced by the Indonesian government, not only economic activities stopped, but educational activities were also affected by, (Khan, 2020). The whole world of education is worried and enters into an event full of uncertainty.

Apandemic was the most difficult time not only for students, education staff, educators, but also parents. Sistem which is standard in supervising students and lecturers in carrying out the learning process through distance has not been found, (Purwanto et al., n.d.). Curriculumadjustments have not been fully implemented for distance learning. However, the concept of "Distance Learning" is also interpreted in various ways by many people.

Ayear after the enactment of Large-Scale Social Restrictions, the government decided to allow the re-implementation of limited face-to-face schools. During the transition period, schools in Indonesia have been allowed again to carry out face-to-face learning activities in schools even with a limited number of students and with strict health protocols after the Covid-19 pandemic that began to decline in Indonesia. This situation is an exciting opportunity for the world of education, especially maritime education. Likethe implementation of online learning at the peak of the pandemic, Limited Face-to-Face Learning has perfect guidelines, especially on what strategies and methods need to be used to be able to accommodate various learning possibilities in the midst of this still uncertain pandemic situation. Various schools tried several approaches and one of them was with a Hybrid Learning approach, (Ganovia et al., n.d.).

The Hybrid learning approach is carried out as a solution that accommodates students with limited Distance Learning but have a strong desire to be able to enter school. For students who are worried about the COVID-19 pandemic situation, they are still given the opportunity to continue to be able to take part in learning from home. The idea of this learning approach must be recognized as good, but in its implementation it still needs to be reviewed and has many shortcomings, especially in the effectiveness of learning and the ability of lecturers to adjust their teaching methods.

Face-to-face learning will form teacher-student interactions that develop cognitive, psychomotor and affective potential, (Rahim Mansyur, 2020). Therefore, the existence of limited face-to-face learning opportunities is addressed with high enthusiasm by lecturers, educators, students and parents.

Students' enthusiasm for participating in face-to-face learning tends to fade. For them, offline learning is not an option because they feel comfortable with distance learning. This condition illustrates how students' study habits have changed significantly without realizing it. This learning habit is the impact of online learning. Finally, excessive use of online learning actually causes problems in the learning process, ranging from decreased concentration, difficulty in communication, lack of response when people invite to speak and lack of active students in participating in teaching and learning activities, (Cai et al., 2022).

Hybrid Learning has similarities with the Blended Learning learning method, where through the Hybrid Learning approach we can see efforts to integrate technology in learning activities. With Hybrid Learning, according to (Tian et al., 2020), it is necessary to have active interactions even if it is carried out in a virtual scope. On the other hand, the main idea in Blended Learning is to carry out a combination of various learning strategies ranging from web-based technology, e-learning technology, multimedia utilization, online learning to face-to-face learning at the same time, (Bordoloi et al., 2021)

Hasil analysis of the effectiveness of the use of the Hybrid Learning learning model in upper-level schools which states that this method is declared ineffective, (Guruh Triyono & Arwin Dermawan, 2021). In line with (Hendrayati & Pamungkas, n.d.) where the results of the study showed that the application of the Hybrid Learning method was not suitable to be applied to lectures in certain courses.

However, Hybrid Learning is one of the sensible choices today, but it takes a great willingness from all parties to be willing to change and adapt again to this new thing. All parties are required to be able to adjust as soon as possible so that the adverse impact of ”Learning Loss” experienced by students so far does not further aggravate the situation in the world of education in general, (Wilson et al., 2011). One of our biggest challenges together today is how this can be used by stakeholders to refocus learners' focus on their learning objectives. Educators need to think about and also consider how the technical implementation of learning can accommodate betweenstudents who are present at school and who are at home (Mulyadi & Mardiko, 2022).

Conclusions.

This research concludes that, although the Covid-19 pandemic is over, in the world of learning it has meaning and takes the wisdom that the combination of traditional and online learning (hybrid) is more profitable. Students who are not able to join in person can receive lecture materials online without compromising the core of learning. Of course, mechanisms like this can be seen as beneficial or detrimental. It needs a more in-depth, structured and systematic study to formulate policies, regulations and technicalities of using this hybrid method.

By building good collaboration from various parties, it is hoped that Hybrid Learning learning can be even more effective. Although the implementation of Hybrid Learning is far from perfect, this choice is one of the choices of learning methods that we can take today. A policy is needed by the government and schools as key stakeholders on how the future of education will be built after this pandemic.

Hybrid learning can be formed effectively if it involves the active and collaborative role of schools, families, and communities, (Sibuea, 2018). In the family sector, parents accompany, provide moral support, provide motivation, and haveactive interactionwith schools. Mbecame the first pillar of education to shape the character of children.

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Safe Manning: Workload Assessment of Deck Officers

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ABSTRACT

The determination of Minimum safe manning levels ,their evaluation and approval have been particularly questioned. The research findings indicate that the detailed principles listed in International Maritime Organization Resolution A.1047(27) (IMO, 2011) for establishing minimum safe manning are not adhered to in most instances.
The purpose of this paper is to highlight the issues related to the workload assessment procedure for determining minimum safe manning in the context of deck officer's. Presently, the framework for determining the minimum Safe manning by the administration and companies mainly focuses on the size , engine power of the vessel and route of the vessel. Workload is an interaction between the operator and their task. Workload is a latent variable. Workload should be determined to find a correlation with the safe manning on ships .NASA-TLX and Bedford Workload scale can be administered using survey design method to collect the data on measurement of workload.
The Shipping companies and Maritime administration will be benefitted as the data will be helpful in deciding upon the safe manning levels of deck officer's onboard a ship.

1. Introduction.

Safe Manning: Safe manning is a function of the number of qualified and experienced seafarers necessary for the safety and security of the ship, crew, passengers, cargo and property and for the protection of the marine environment.

Workload Assessments: Workload assessment is an evaluation of how much demand is put on the different types of attentional resources (cognitive, perceptual, motor, etc.). It includes the minimum hours of rest/or work, work period lengths, work schedule designs and weather a single crew can execute the tasks set in a specific work period or work period(s) per work day relating to operational functions, operational factors and task capability.

Since the adoption of the Principles of minimum safe manning resolution 2011,the framework for determining safe manning levels with respect to task capability of an individual and human element limitations has been very subjective and open ended. The issue of Human element has been in discussion in the recent times. Principles of minimum safe manning resolution A.1047(27) (Principles of Minimum Safe Manning, 2011), was adopted in 2011.The objective of these Principles are to ensure that a ship is sufficiently, effectively and efficiently manned to provide safety and security of the ship, safe navigation and operations at sea, safe operations in port, prevention of human injury or loss of life, avoidance of damage to the marine environment and to any property, and to also ensure the welfare and health of seafarers through the avoidance of fatigue. The number of deck officer's required for a particular ship is reflected in the safe manning document. The human element is one of the most important contributory aspect to the causation and avoidance of accidents (IMO, 2018). The humans are at the epicenter of all the activities, weather it is direct or indirect input through the automation.

ILO (International Labor Organization) and IMO should review the current work/rest hours regulations to align them with the evidence-based research on fatigue (Baumler et.al ,2020).

The Mission to Seafarers publishes quarterly reports on the results of the Seafarers' Happiness Index, which frequently men-

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tion the MLC2006 and remaining issues related to its provisions. Currently, the biggest problems are low manning, rest hours and the difficulty to adhere to them, low food quality, lack of recreational facilities, non-payment and a ban of shore leave opportunities (Fotteler et al., 2020). The impact of the MLC 2006 since 2013 needs to be studied more objectively and scientifically. It needs to be evaluated the extent to which the objectives and the goals of MLC has been achieved. Do the present measures are enough to mitigate the challenges that were addressed keeping in mind the formulation of MLC 2006.

A pilot study came to the conclusion that the MLC2006 radically increased paperwork for many seafarers while failing to adequately address many of the most pressing issues including manning, work and rest hours, food quality and recreational facilities (Fotteler et al., 2020). Neither convention, however provides specific or prescriptive guidance as to what constitutes an appropriate number. A safe manning level is subjective (Carey, 2018). Flag states compete to attract tonnage to their registers and according to Macdonald , this is one of the key reasons why the safe manning has reached such low levels today. Ericksen S &Lutzen M (2022) The present minimum safe manning levels are only the guidelines.

Human Element Analyzing Process(HEAP)is a practical tool designed to address the human element, to be used for consideration of maritime safety and environmental protection issues at IMO.A study was done on the Optimization of work and rest hours for navigation officers on the ship (Simkuva et al., 2016). The research was done to study the work load of navigation officers. The data was collected in the real time mode and reflected on the views of the navigation officers on violations of the work and rest regime on the ship and the fatigue issue. The study does not address workload of the navigation officer but is concerned about the frequent violations of the rest hours. A study was done on Safe manning of merchant ships: an approach and computer tool (Alapetite & Kozine, 2017). A software tool was presented to support decisions on the staffing of merchant ships. The tool is conceived as a support for the maritime authorities, certifying bodies and shipping companies to assess whether a ship is safely manned. The approach does not take account of psychological aspects into safe manning. A study was done to Compare the work and rest hours of United States Navy Sailors with existing maritime regulations(Shattuck & Matsangas, 2017). This study compared the compliance of crewmembers' work/rest hours with existing regulations. Overall, noncompliance rates were high, up to 88% of the crew. A study was done on the "Efficient Ship Crew Scheduling Complying with Resting Hours Regulations" (Rizvanolli and Heise, 2018). A mathematical model was presented for the crew scheduling problem, which is subject to complex rule sets for working and resting hours. In this model the mandatory tasks for safe ship operation and the crew qualification requirements for these tasks represent the main input parameters. They depend on variables such as the ship type and route and may differ substantially. The model consider only the task, qualification and rest hours into consideration. It does not consider all the dimension.

The purpose of the survey study will be to examine the relationship between the number of deck officer's employed and the workload assessment on merchant ship's using the multiple resource theory that assess workload on the different cognitive resources. It is based on indirect observation of the workload of deck officers as it cannot be observed and measured directly. The survey design will provide a quantitative description of the relation between workload and the manning of the population by studying the sample of the population in the context of deck officer's. NASA TLX and BEDFORD workload scale can chosen, since the method employed should be reliable, sensitive, diagnostic, and non-intrusive, face validity and require minimal equipment that might impair the participants performance. The survey tool can be used as the simulation method may not contain the features of a real task. The attitude of an operator will not be the same as in the real scenario due to the absence of the real stressors. Social environment is not possible to simulate. Observational Technique method for data collection cannot provide information of the task which require cognitive processing. Activity sampling method for data collection can provide the time spent on different activities while performing a task. All the task elements should be observable and distinguishable. It cannot be used for task which require decision making or cognitive activities. So it would not be possible to collect the exact data on the time utilized for each task. As all the task involved for a deck officer is not automated the activity sampling method will give a very crude result. This method is used when no active participation is required from the operator. Complex task with many elements are not suitable for data collection. So the data can be collected using survey to support or refute the hypothesis. The deck officers age, training, years of experience, motivation etc will influence the workload.

Problem Statement- What is the relationship between workload and safe manning of deck officers on merchant vessels.

Hypothesis- The hypothesis is "Workload of deck officer is positively related to the safe manning on merchant vessel's."

Objective- To determine the workload of deck officer's on merchant vessel. To examine weather the ship is sufficiently manned with deck officers.

The theory that we can use is multiple resources theory which has four dimensions (processing stages, perceptual modalities, visual channels, and processing codes) and each dimension has separate and distinct pools of attentional resources. It was developed by Christopher D. Wickens. It explains how and why the workload is dependent on the safe manning.

2. Legal Framework.

In 1960, IMCO convened the fourth international convention of SOLAS, the only manning legislation resulting from that convention was a vague requirement that all ships should be "sufficiently and efficiently manned" (Wang, 2014).

The IMO Assembly, at its 21st session in 1999, adopted resolution A.890(21) (IMO, 2000) on Principles of safe manning, which revoked existing resolution A.481(12) (IMO, 1981).

Amendments to the Principles of safe manning were adopted by resolution A.955(23) (International Maritime Organization, 2003) in 2003, which was subsequently revoked by the current

Principles of minimum safe manning (resolution A.1047(27) (Principles of Minimum Safe Manning, 2011), adopted in 2011.

The IMO Assembly, at its 18th session held in 1993, adopted resolution A.772(18) (International Maritime Organisation, 1993) on Fatigue factors in manning and safety. This resolution provides a general description of fatigue and identifies the factors of ship operations which may contribute to fatigue that should be taken into account when making decisions on ship's operations. The Maritime Safety committee approved the MSC.1 / Circ.1014 (International Maritime Organization, 2003) on Guidance on fatigue mitigation and management on 12 June 2001 and MSC.1/Circ.1598 on 24 January 2019 (IMO, 2019). On the relevance of the current international regulatory framework to effectively prevent fatigue and mitigate its effects, the research outcomes suggest that there is no scientific basis to ensure the effectiveness thereof (Baumler et.al 2020).

International Safety Management (ISM) Code mandates that each ship is manned with qualified, certificated and medically fit seafarers in accordance with national and international requirements and is appropriately manned in order to encompass all aspects of maintaining safe operations on board. There are Guidelines for the Development of Tables of Seafarers' Shipboard Working Arrangements and Formats of Records of Seafarers' Hours of Work or Hours of Rest.

STCW 2010 establishes and enforces rest periods for watch keeping personnel and those whose duties involve designated safety, security and prevention of pollution duties in accordance with the provisions of section A-VIII/1 of the STCW Code. STCW regulation require that watch systems are so arranged that the efficiency of all watch keeping personnel is not impaired by fatigue and that duties are so organized that the first watch at the commencement of a voyage and subsequent relieving watches are sufficiently rested and otherwise fit for duty. In addition, part A of the STCW Code sets minimum periods and frequencies of rest and requires that watch schedules be posted where they are easily accessible. SOLAS regulation V/14 requires that the ship must be sufficiently and efficiently manned.

Convention No. 180, which was adopted by the 84th (Maritime) session of the International Labour Conference (Geneva, 1996), introduced for the first time comprehensive international provisions to establish limits on seafarers' maximum working hours or minimum rest periods so as to maintain safe ship operations and minimize fatigue as required by the . ILO Convention No. 180 provides that the term competent authority means the minister, the governmental department or other authority having power to issue regulations, orders or other instructions having the force of law in respect of seafarers' hours of work or rest or the manning of ships. MLC 2006 establishes the limits on seafarers' maximum working hours or minimum rest periods so as to maintain safe ship operations and minimize fatigue.

The United Nations Convention on Conditions for Registration of Ships, 1986 Article -9 (Unctad, 1986) is regarding the manning on ships. ISPS code also mentions the safe manning requirements.

The seaworthiness requires not only the hull, machinery in such aspects as design, structure, performance, and state that resist usually appear in the contract voyage or can reasonably foreseeable risks, but also covers the manning of ship and other aspects . Therefore, Seaworthiness involves largely to commercial maritime law. The Hague Visby Rules, Art III (1) states that a carrier must exercise due diligence before and at the beginning of the voyage to make the ship seaworthy, to properly man and supply the ship, and to ensure the holds are fit to receive the goods. Port state control is empowered to enforce the rules and regulations and eliminate the substandard vessels. ILO and IMO should start considering how manning provisions for the safe operation of ships could be developed in order to make them binding in nature (Baumler et.al 2020). A large variation still exists among the MoU, a fact that demands increased efforts for harmonization of PSC procedures (Fotteler et al., 2020).

3. Gaps in The Minimum Safe Manning Levels.

In 1890, many full time industrial employees in the U.S. worked an average of 100 h per week (Ward, 2017)However, the major breakthrough came in 1926 when Henry Ford, President of the Ford Motor Company, mandated an 8 h per day/40 h work week (Caldwell et al., 2019). The mandated working hours are for the shore based job and not for the seafarers. The conditions are more severe for the seafarers .So the total number of hours per week will have to be worked out scientifically.

The Seafarers International Research Centre's (SIRC) mental health and wellbeing report reviews the limited evidence available and supports the conclusion that there are higher levels of psychiatric disorders in a seafaring occupational group and that these had increased in the years between 2011 and 2016 when comparative studies were completed. The Seafarers' Mental Health and Wellbeing Report published by Cardiff University in 2019 found that almost three quarters of the employer stakeholders it interviewed said that over the last 10 years mental health had not been identified as an issue or priority, whilst more than 90% of those had not introduced any policies or practices to address mental health; more than 50% of all the stakeholders interviewed said that they had not introduced any practices or policies relating to seafarers, mental health over the same time period (Acejo et al., 2019).

The current research found a "culture of adjustment" among seafarers; work hours are either underreported or work/rest hour records are adjusted to facilitate compliance. Eighty-five percent of seafarers interviewed attribute adjustments to insufficient manning levels, particularly during activities in ports, quick succession of ports (in particular for short-sea shipping), and when their vessel operates (in port or at sea) on the 6 hours on/6 hours off watch system. Consequently, there is an apparent inability to enforce existing work/rest hour rules which may seriously affect ship safety as well as seafarers' health and safety, cognitive performance, and their retention in shipping (Baumler et.al 2020).Surprisingly, the outcome from IMO (2018) indicates that human error in navigation decision-making has caused almost 60% of grounding and collision issues (Jeevan et al., 2020). The watch system has to scientifically structured taking all the variables into consideration .The shift watch system is inevitable in the 24 hour transport industry but the employers and the administration should strive to improve on the current framework for minimum safe manning levels.

Today, reduction of crew has, most likely, reached a critical limit. It is not an obvious solution to "reduce" in order to get better profitability. A richly documented research on safety problems (Havold 2005;Ellis 2005;Ek 2006;Hollnagel 2009), on fatigue and other health problems among the crew (Lützhöft et al. 2010;Bailey et al. 2012)testify that further reduction in crew numbers is not a viable approach (Ljung & Lützhöft, 2014). Studies done on US Naval ships have also indicated similar results .The reduction in crew size is a comprise on the performance of an individual. The major reasoning given for this reduction in crew size is to the increased levels of automation on a ship. The reduction in the crew size is directly affecting the health of individual. The seafarers are reluctant to openly express themselves in context of the rest hours onboard a ship for the fear of losing their job. The subsequent consequence can be an increased risk and hazards associated with the different task undertaken by an individual. This may result in the financial loss to the employers.

The legal requirement dealing with the seafarers are not similar in all the countries of the world. The seafarers don't have sufficient legal rights/mechanism to defend themselves when they are in any trouble in different parts of the world. The Port state control has been entrusted with the responsibility to identify and eliminate the substandard ships. But the different Port state control MOUs don't work on similar lines, so that the uniformity regarding rules and regulations are maintained throughout the globe. Although widespread use of autonomous ships is unlikely to happen on the high seas anytime soon, seafarers will remain an integral and indispensable part of the maritime industry now and in the near future. The sub-committee on Human Element, Training and Watch keeping (HTW 8) has acknowledged that psychological safety, mental health, and well-being, are serious issues in the maritime sector that require coordinated action by relevant organizations such as the International Labour Organization (ILO) and IMO.(DNV 2023)

4. Workload Assessments Factor's.

4.1. Stress.

Janos Hugo Bruno Selye was a legendary Austro-Hungarian Physician who is today recognized as the father of stress research. In 1956 he described stress as "a scientific concept which has received the mixed blessing of being too well known and too little understood".

Stress is when your brain and body change in response to change. Stress is due to unwise lifestyle choices, diet, sleep patterns and behavior (Storoni, 2017). Stress can be caused by a number of factors, including: .1 environmental factors (e.g. constant or irregular noise, vibration, temperatures, weather, ice conditions); .2 personal circumstances (e.g. family problems, home sickness, isolation); .3 inadequate restorative sleep; .4 broken or interrupted sleep or rest periods; .5 excessive working hours; .6 intense mental and/or physical workload and .7 onboard interpersonal relationships (IMO, 2019).Stress is one of the psychological aspects of a human being. This cannot be measured directly, but the consequences can be easily noticeable on the physical and emotional level.

During acute stress seven of the changes takes place: i) Emotional brain is on high alert; ii) Stress hormones are released; iii) Increase in synaptic plasticity; iv) Body clocks temporary malfunction; v) You become inflamed; vi) Temporarily resistant to insulin; vii) You suddenly feel motivated. Chronic fatigue syndrome is associated with stress (Storoni, 2017). The above mentioned changes is quite relevant to a seafaring Profession. A seafarer may be stressed in the normal course of his work, which further enhances when he tries to be extra cautious in order to avoid any mishap which may lead to any criminalization.

The various factors causing them are also known to us. The factors and sub factors responsible for stress needs immediate attention and the techniques to deal with them should be available to an individual for his assistance. A small nudge may be required which can bring a major change in his approach to any activity. A person is like an ice-berg where only ten percent of him is visible by his activities , but ninety percent of him is invisible.

4.2. Fatigue.

The medical definition of "fatigue" usually refers to a loss of physiological and psychological function as a result of extended wakefulness, heavy work, excessive stimulation, illness or stress which can usually be reversed in whole or in part by rest, sleep, treatment or recovery from the condition that caused it (Moore-ede, 2009) "Fatigue is the state of feeling very tired, weary or sleepy resulting from insufficient sleep, prolonged mental or physical work, or extended periods of stress or anxiety. Boring or repetitive tasks can intensify feelings of fatigue. Fatigue can be described as either acute or chronic." (OSH Answers Fact Sheets, 2017). The most common causes of fatigue known to seafarers are lack of sleep, poor quality of rest, stress and excessive workload. Studies and research carried out by various organizations and administrations have shown the increasing human, financial and environmental impact of maritime accidents and frequently cite fatigue as a contributory cause due to lack of sleep (ILO, 2015). In the US, fatigue has been identified as a contributing factor in a number of prominent maritime accidents (Strauch, 2015). The level of workload which a particular task demands can be measured by measuring the physical changes in an individual and the feedback given by the individual. The same needs to be worked out for each task onboard a ship.

Irregular schedules caused by shifting rotations, crossing time zones, etc. cause the circadian rhythms to be out of synchronization. Long work hours are associated with poor performance, higher injury rates, and poorer safety and/or health outcomes (both mental and physical).Performance and alertness is further impacted if vigilance and monitoring tasks need to be carried out during the night-time hours, specifically between midnight and 5 a.m (IMO, 2019). Sleep is the basic necessity of life. After 16 hours of being awake the brain begins to fail. Humans need more than seven hours of sleep each night to maintain cognitive performance (Walker, 2018). The world health organization and the National sleep Foundation both stipulate an average of eight hours of sleep per night for adults (Walker, 2018). This clearly indicates that we are not following the rhythm of the nature, but trying to manipulate the norms to maximize to achieve the material goals. We may have to pay heavy consequences for this act. As the ships are a totally an unnatural environment ,the sleep pattern ,quality of sleep ,quantity of sleep required will have to worked out in a more scientific manner corroborating with the latest research in other equivalent fields. More persons may need to be employed to streamline with the actual workload hours. The employers needs to have a closer look at the various issues concerning the seafarers fatigue and formulate a management strategy to address the same at the earliest.

The research has been consistent in demonstrating that mariners are not receiving adequate rest. Studies have shown that "mariners sleep an average of 6.6 hours per 24-hour period while on shipboard duty—this is 1.3 hours less than average sleep duration at home " and that the current work-rest scheduling for watch standers does not allow the circadian rhythm of alertness to adapt to the work schedule (Strauch, 2015). Sixty years of scientific research prevent me from accepting anyone who tells me that he or she can" get by on just four or five hours of sleep a night just fine" (Walker, 2018). Sleep is a requirement for the body like air, food or water. By analyzing the conclusions received from the various research one may come to the conclusion that sleep is natural medicine .Many of the natural phenomenon is still beyond the reach of our current scientific knowledge and sleep is one them. Nobody knows exactly why do we sleep .So in the name of development and progress the nature should not be disturbed. The body and the brain should be given enough time to rest. This assertion reveal findings from considerable research works such as the United States National Transport Safety Board (NTSB, 1990), the United States Coast Guard (USCG) (Sanquist et al., 1996), Seafarers International Research Centre (SIRC) (Smith et al., 2006), Project HORIZON (Project Horizon Consortium, 2012) and Project MARTHA (Mike Barnett et al., 2017). These studies acknowledge that the shipping industry remains sensitive to fatigue and its impacts (Singh Bhatia, 2019).

More than 750 scientific studies have investigated the relationship between sleep and human performance, many of which have studied professional and elite athletes specifically (Walker, 2018). Measures should be taken to ensure that seafarers have adequate, uninterrupted sleep for the avoidance of fatigue and associated depression (Lefkowitz et al., 2019). The consequences due to lack of sleep can be very catastrophic. So the task should be distributed such that all the people onboard the ship get sufficient sleep. A study across four large US Companies found that insufficient sleep cost almost $2000 per employee per year in lost productivity (Walker, 2018). We should not forget the Exxon Valdez Disaster that occurred on March 24 1989, which was due to the insufficient sleep by the watch keeper. Fatigue was the major cause of accident in the "Herald of free Enterprise' The employers should make sure that the seafarers have proper sleep before any operations. This will make them to perform effectively and efficiently. The effect of the sleep loss on the seafarers needs to be studied in more detail. The data should be collected and a comprehensive analysis should be done. A long term approach should be adopted.

4.3. Vibrations/Noise/Temperature/Toxins.

The code on noise levels onboard ships has been developed for protection against noise , Certain provisions of the code remains recommendatory or informative. Care will be needed to ensure that there is compatibility between the general requirements and the requirements for audibility of navigation signals. The limits for noise levels specified for various spaces onboard seems to be very high i.e- Noise level limit for cabins and hospitals as per the code is 55dB and that of washing machine is 50dB.

For vibration, reference is made to the relevant ISO standard. Workplace protection on noise, vibration and Toxin is well covered by International standards. However, more guidance is needed on how to assess noise and simple methods of noise control (Papkalla & Collison, 2017). Whole body vibration may influence the hypothalamic - pituitary - adrenal axis and consequently the vegetative neuro regulation and the behavioral reactions of seafarers. Though these Vibrations at sea are a complex phenomenon caused by mechanical equipment on board, such as the main shaft, but may also occur consequent to the propulsion of ships, the impact of waves and the rocking of the ship. Mechanisms, whole body vibration may contribute to outcomes such as fatigue and seasickness (Jensen & Jepsen, 2014). Seafarers are sometimes exposed to a high temperature in Engine room or on decks/cargo holds/D.B tanks. Studies have shown that high temperature decreases the performance of an individual. It indirectly increases the mental and physical workload. On the contrary the seafarer may be exposed to very cold temperature in certain areas .This will also decrease the performance of an individual. Presently there are no mechanism to address these issues of the seafarer. There are no proper regulatory guidelines to be followed, when the seafarer is exposed to the various levels of toxins.

4.4. Workload-Mental and Physical.

The ISO 10075 series of standards covers psychosocial risks under the heading of ergonomic principles related to mental workload. Existing studies indicate that there is a lack of awareness of work-related stress and a shortage of resources to deal with it. Nonetheless, psychosocial risk factors at work are seen as an important factor that should be addressed (Papkalla & Collison, 2017). The effect of physical workload can be measured using medical equipments. But we should also keep in mind that the physical workload has an effect on the mental workload and the mental workload will have an effect on the physical body.

4.5. Boredom and Isolation.

Boredom is generally considered an emotion which has a different definition depending on whether we are philosopher, psychologist or psychiatrist. In our work, we adopt the Hill and Perkins (1998) definition ,which says that boredom occurs when we are faced with a monotonous life combined with frustration. This combination is often found among seafarers, because of the monotony of work on board, routine deck-work or using machinery, being on watch, or doing maintenance tasks, especially at sea (Özsever & Tavacioğlu, 2018).Boredom is the Psychological aspect of a human being that is very difficult to quantify .This may vary with individuals. One can escape the boredom if there are sufficient means of entertainment and some positive means of distraction from the monotonous and routine jobs. Isolation is a phenomena were a person feels disconnected from his near and dear ones. Humans are social beings that likes to be connected with the society. The seafaring job has an inherent limitations of isolation. Some of the employers provide the internet connection onboard, so that the seafarers feel connected to their dear ones. But this connectivity needs to be improved a lot on all the ships. The multicultural seafaring environment onboard adds fuel to this issue. Companies and administration needs to work in this direction also.

4.6. Crew Performance.

Crew performance is a function of individual capabilities, management policies, cultural factors, experience, training, job skills, work environment and countless other factors (IMO, 2013). Human performance is affected by workload, stress and communication.

Characterization of hazards and risks should be both qualitative and quantitative, and both descriptive and mathematical, consistent with the available data, and should be broad enough to include a comprehensive range of options to reduce risks. There are several standards for risk acceptance criteria, none as yet universally accepted. It is also necessary to bear in mind that the data available for the last stage of human reliability analysis, human reliability quantification, are currently limited. Although several human error databases have been built up, the data contained in them are only marginally relevant to the maritime industry (IMO, 2018). As the seafarers onboard are multicultural, there approach and the level of commitment, knowledge, values and ethics towards a particular task may be different .These may require a customized type of training for an individual.

5. Research Methodology.

Many different tools are available to assess individual attributes that contributes to the workload of an individual while performing a task, like for the sleep quality we may use the Pittsburgh sleep quality Index(PSQI),to assess the stress we can use Pychological general well being index(PGWBI).Many subjective procedures exist to measure workload. The most outstanding among them are the Cooper-Harper Scale (Cooper & Harper, 1969), the Bedford Scale (Roscoe, 1987; Roscoe & Ellis, 1990), the SWAT (Subjective Workload Assessment Technique) (Reid & Nygren, 1988) ,the NASA-TLX (Task Load Index) (Hart & Staveland, 1988), multiple resource questionnaire. (David B. Boles and Lindsey P. Adair 2001) and Borg CR10 Scale. Tsang and Velazquez (1996) have proposed multidimensional subjective workload assessment instrument Workload Profile. The attributes that contribute to workload experiences vary between tasks and between raters because workload is not uniquely defined by the objective qualities of the task demands. The NASA-TLX (Task load Index) uses a multidimensional scale to measure operator task performance, which consists of six subscales: There is a common thread that unites subjective ratings that can be termed ”workload”. NASA–TLX Rating scale talks about Mental demand, Physical demand, Temporal demand, Performance, Effort, Frustration level. The Bedford Workload scale presents the operator with a 10-element scale. The Bedford scale attaches elaborate verbal descriptions to each of the 10 values along the scale.

A survey can be conducted for deck officer on 30 different ships comprising 120 participants. The operational function on a ship can be divided into ten different task. The task are navigational watch at sea, navigational watch in high traffic density, navigational watch during arrival port, navigational watch during departure port,pilotage,mooring and unmooring operation,loading operation, unloading operation, tank/hold cleaning operation and maintenance. The workload data can be collected on each of different task performed by each deck officer's. A Survey research quantitative method can be used for studying the attitudes /opinion of the population. A probability sampling method can be used for the study.

The purpose of this design is to explore the holistic understanding of the workload assessment in day to day affairs of the seafarer. So the data can be collected using survey method to support or refute the hypothesis. Statistical procedures can be employed to interpret the data.

6. Limitations.

The NASA TLX(Task Load Index) tool for measuring the workload for a task is individual centric rather than task centric. It may differ from one individual to another. The workloads are environment dependent (noise, vibration, temperature ,weather etc). The workload is an intrinsic combination of many factors. The workload assessment is subjective in nature. The assessment method is generalized in nature and the data obtained needs to be implemented on ship to ship basis. The NASA TLX workload assessment method can be utilized after the task has been completed and not before the execution of the task to decide on the minimum safe manning requirement on a ship.

Conclusions.

Each of the function Mentioned in annex-2 of the principles of minimum safe manning guidelines is to be broken down into different task. .The operational factors like personnel qualification, operational procedures, technology and automation are to be considered. The human limitations, individual capacities, Safety and multicultural environment, loneliness, the relation between fatigue and decision making ,the effect of noise ,heat, vibration ,rolling and pitching ,sleep debt needs to be studied in greater detail in relation to the ships operational condition. The risk analysis reports of various shipping companies should be collected and analyzed .The data from various PSC MOU's needs to be collaborated and an in depth study needs to be undertaken . The approach to fatigue management also varies substantially from one owner and type of vessel to the next (Transport Canada [TC], 2018) (Tsb.gc.ca.2018). An effective fatigue management strategy begins with determining operational workload requirements and matching onboard manning levels and onshore support resources, combined with efficient management of workload and hours of work and rest on board the ship (IMO. 2019). The Federal Aviation Administration currently encourages U.S. airlines to establish science-based Fatigue Risk Management Programs (Caldwell et al., 2019).The workload assessment tools can be used to evaluate tasks involving concurrent physical and mental demand. The work load data gathered for different tasks can be utilized to manage fatigue. Counselling and mentoring needs to be done on a continuous basis to improve the mental health of a seafarer. Maritime administrations needs to develop a database of workload for each ship for determining minimum safe manning, allowing full compliance at all times and in all operational conditions. It should be dynamic in nature and not fixed. The workload assessment procedure on the ships would guide the administrations to determine the safe manning of ships that would enhance maritime safety, security and protection of the marine environment. This would provide standardization of the procedures of safe manning to ensure the welfare and health of seafarers through avoidance of fatigue. The administration should honour the seafarer's by respecting their opinions about safe manning.

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Fabrication methodology and hardness influenced by hybrid layer of a novel Entada Rheedii and banana fibre reinforced epoxy resin composite

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ABSTRACT

In this study, the hardness properties of an innovative hybrid composite made of Entada rheedii and banana fibres mixed with epoxy resin were evaluated. A hand lay-up procedure in single or double layers was followed by fibre infusion. In comparison to synthetic and natural fibres, these combinations showed superior reinforcing and provided advantages including waste reduction. Utilising these combinations had the benefit of reducing waste disposal and treatment problems frequently encountered with synthetic composites. The project sought to improve material lifecycle management by utilising biodegradable polymers in industries like automotive, marine, and aerospace. In polymer composites, natural fibres are preferred due to their durability, low weight, cost-effectiveness, and environmental friendliness. Entada Rheedii, a new natural fibre that will improve the performance of epoxy composites, was introduced in the research. Rockwell-B hardness tests performed on the composite with double layers of Entada Rheedii and banana fibre at 45% volume fraction exhibited the highest hardness at 67 HRB. This hybrid composite holds promise for marine applications requiring essential hardness properties.

1. Introduction.

Novel biodegradable and recyclable natural fibre-reinforced polymer composites have gained popularity as eco-friendly alternatives for engineering applications, offering improved stiffness and a high strength-to-weight ratio. In contrast to synthetic fibre-reinforced composites like glass, carbon, aramid, and graphite, which boast desirable mechanical properties, their higher costs and environmental concerns have fueled the adoption of natural fibres such as sisal, flax, hemp, jute, coir, bamboo, banana, wheat husk, and sugar cane in various applications. These natural fibres provide several advantages, including easy accessibility, cost-effectiveness, and simplicity of processing, allergy-free properties, and biodegradability. The engineering sectors, especially aerospace and automotive industries, have increasingly utilized these eco-friendly materials in storage tanks, pump casings, structural components, sporting goods, and packaging. Extensive research has been conducted on the physical and mechanical characteristics of natural fibre composites, encompassing hardness, interfacial bonding, volume percentage, size, structure of the reinforcing phase, and their orientation. This study specifically focuses on evaluating the hardness analyses of composites made from Entada Rheedii fibre, banana fibre, and hybrid fibres reinforced matrix, with varying fiber volume fractions and unreinforced laminates. Hardness in materials refers to their resistance to confined deformation. The presence of combined fibres in the polymer matrix is expected to enhance the flexibility of fibre-reinforced composites.

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2. Literature Review on Hardness of Fibre Reinforced Composites.

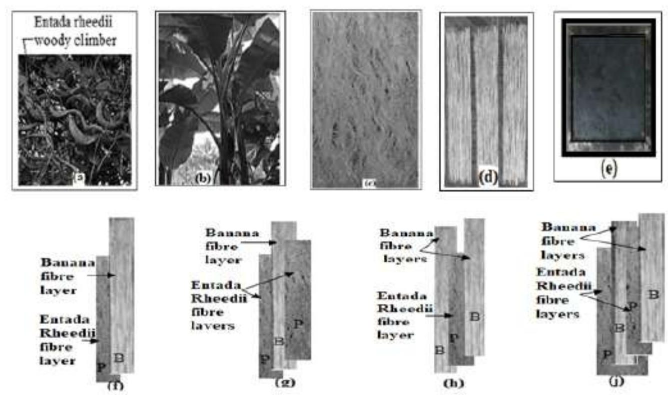
Various studies have explored the hardness properties of natural fibre-reinforced polymer composites, investigating different combinations of fibres and matrices. These composites offer potential applications as environmentally friendly and mechanically robust materials in engineering fields. Sivakumar et al. (2016) studied glass/nylon/jute fibre hybrid reinforcements in epoxy composites, with the pure glass fibre composite exhibiting a maximum hardness value of 27 HV. Madhukiran et al. (2013) evaluated pure banana and pure pineapple polymer matrix composites, which showed hardness values of 683 HRB and 708 HRB, respectively, using a diamond cone indenter. Satish Shenoy et al. (2019) conducted micro-hardness tests on Grewia Serrulata fibre reinforced unsaturated polyester composites. Acetylation and silane treatment significantly increased the hardness, ranging from 37 to 45 HV. Wilson Webo et al. (2018) investigated sisal fibre-epoxy resin composites and found that the hardness gradually increased with increasing fibre loading, reaching 51 BU at 50% weight fraction. C.V. Srinivasa et al. (2011) assessed the Rockwell-B scale hardness of areca fibre-reinforced epoxy resin matrix specimens. Increasing the volume fractions of fibres also raised the hardness, along with the composites' moduli. Yasser S. Mohamed et al. (2018) measured the micro indentation of E-glass fibre-reinforced polymer composites, observing a notable increase in hardness, measured to be 84 HV, in the reinforced polymers. Nithyashree D.G. et al. (2017) investigated the hardness properties of sisal/coir reinforced composite materials. Hardness increased with an increasing percentage of fibres, with the 40% volume fraction sisal/coir fibre hybrid reinforced polymer composite registering a hardness of 102 HRA. Chidhananda et al. (2021) examined the hardness characteristics of green polymer composites containing bagasse and coir particles in varying percentage compositions in the epoxy resin matrix. Paul Theophilus Rajakumar et al. (2022) studied the properties and hardness tests of a high impact polyethylene composite reinforced with abaca fibre. Hardness increased with abaca fibre loading, reaching a maximum of 67 shores D when abaca fibres were treated with alkaline. R. Pandiyarajan et al. (2022) created epoxy composites with silicon carbide and neem-coir fibres, resulting in a hardness of 78 shore D. Imran Musanif et al. (2018) studied coconut fiber composites with varying volume fractions, showing hardness values of 99 HRL, 100.00 HRL, and 100.80 HRL for 30%, 40%, and 50% fractions, respectively. T. Vinod Kumar et al. (2018) combined polylactic acid with water hyacinth, areca nut, and hen feather fibres, achieving a hardness of 132 HRB at 5 wt. % nano carbon. H. Ersen Balcolu et al. (2019) examined silicon carbide reinforced composites with jute and epoxy, with hardness values of 81.88 and 81.33 shore D for maximum surface and thickness. IGP Agus Suryawan et al. (2020) conducted a comparative study, revealing higher hardness in glass fibre composites due to even fibre distribution.

However, there is no reported research on the relationship between hardness and other parameters in the hybrid Entada Rheedii-banana fibre reinforced epoxy resin composite. Further investigation in this area would be beneficial to understand the mechanical properties of such composites fully.

3. Materials and Methods.

3.1. Entada Rheedii and banana fibre hybrid reinforcements.

Figure 1: (a) Entada Rheedii climber or herb,(b) Banana plant or tree, (c) Entada Rheedii fibre layer, (d) Banana fibre layer, (e) Metallic mould, (f-j) Different layers combinations of Entada Rheedii and Banana fibres .



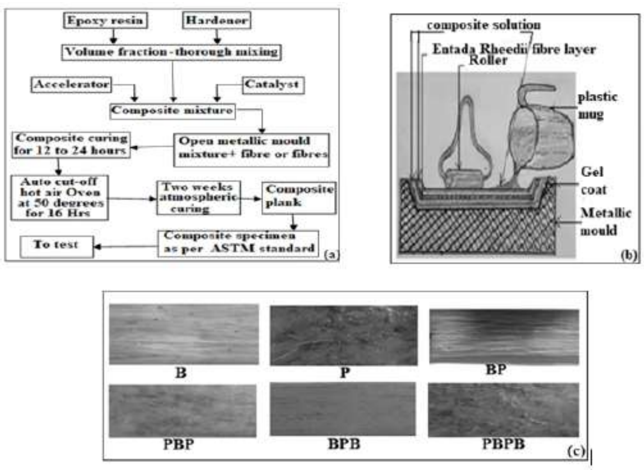
Source: Authors.

The Entada Rheedii fibre, commonly known as African dream herb, sea bean, kakkumkaya, or Parandavalli fibre (P), is a brand-new natural fibre in the world of textiles. A unique Entada Rheedii-banana fibre reinforced epoxy composite displays greater toughness in compared to existing natural fibre combinations in polymer matrix. The current study examines the hardness properties of an Entada Rheedii-banana fibre hybrid reinforced polymer, which are principally impacted by factors like the order of the fibre layers and the volume fractions of each fibre. The hardness of the resultant polymer composites increased as the volume proportion of Entada Rheedii and banana fibres increased. Entada Rheedii-banana fibre hybrid reinforced epoxy resin composites have excellent mechanical qualities, making them suitable for application in the construction of aircraft, marine and automobile body parts due to their lower cost and lighter weight without sacrificing necessary strengths. Entada Rheedii and banana fibre plants [Figure 1. (a-b)], their fibre [Figure 1.(c-d)] and fibre layers combinations are shown in Figure 1. (f - j).

3.2. Fabrication by hand lay-up method.

In the polymer industry, to create composites with varying strengths, a common practice is to add hardener to the polymer glue, typically ranging from 20% to 70%. The study prepared polymer composites using a calculated volume of epoxy resin, accelerator, catalyst, and 40% hardener, along with varying combinations of Entada Rheedii and banana fibres. Different layers of fibres, including mono layers of banana fibre (B),[Figure1(d); and Entada Rheedii fibre (P),[Figure 1(c)]; as

Figure 2: (a) Schematic of the fabrication methodology of the polymer composites, (b) Schematic of hand lay-up process of Entada Rheedii fibre layer reinforcements, (c) Specimen planks of the different layer combinations of the Entada Rheedii - Banana fibre hybrid reinforced epoxy composites.



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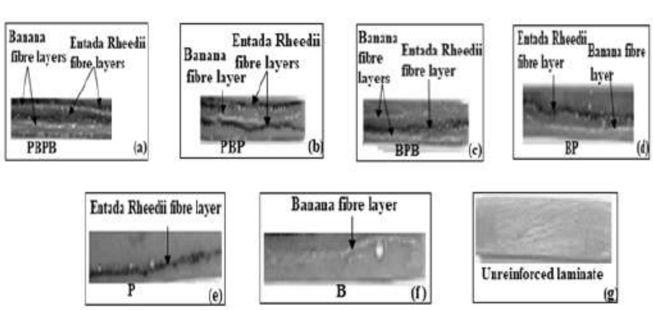
well as layer combinations such as Banana-Entada Rheedii fibre (BP), [Figure1(f)]; Entada Rheedii - Banana - Entada Rheedii fibres (PBP),[Figure1(g)]; Banana-Entada Rheedii-Banana fibres (BPB), [Figure 1(h)]; and Banana-Entada Rheedii-Banana-Entada Rheedii fibres (BPBP),[Figure 1(j)] were impregnated into the epoxy mixture in a metallic mould [Figure 1(e)]. After 12 to 24 hours of curing, the fabricated epoxy resin mixture was kept in an auto-cut-off hot air oven at 50°C for 16 hours continuously. Subsequently, the planks were left for atmospheric free air cooling for two weeks, and test specimens were cut from the planks according to ASTM D 2583 standard. The specimen planks of different layer combinations of Entada Rheedii-banana fibre hybrid reinforced epoxy composites are shown in Figure 2 (c). Various configurations of Entada Rheedii-banana fibre hybrid reinforced epoxy resin matrix layers, as well as unreinforced laminates prepared for Rockwell hardness tests, are displayed in Figure 3 (a-f) and Figure 3 (g), respectively.

Figure 3: (a-f) Different fibre - layer combinations of composite specimens, position of the fibre layers laid in the composite, and (g) unreinforced laminate.



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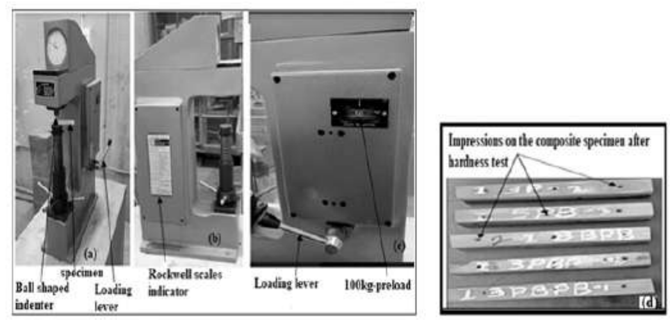
3.3. Experiment - Hardness Tests.

Hardness is the ability of a solid's surface to withstand localized deformation. By driving a strong indenter into the top of the surface, the material is forced into. The size of the resulting depression tells you how hard the material is. The composite specimens (Figure 3) were subjected to hardness tests using a Rockwell Hardness Tester [Figure 4(a- c)].

100 Kg preload was set on the Rockwell tester - B scale for polymers. (HRB /100 Kg/5 seconds ASTM D 2583 standard) Specimens size of 100 mm×10 mm×10 mm were used for the experiments of harness test.

Figure 4: (a-c). Some views of Rockwell hardness tester, (d) Composite specimens, tested for hardness, with indenter impressions.

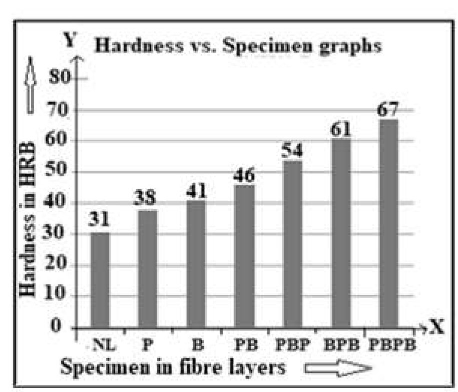


Source: Authors.

4. Results and Discussion.

Table 1 shows the variation in hardness of composites made by stacking different fibre layer combinations as well as that of unreinforced epoxy. During the construction of the composite, a 40% hardener and fibre volume fraction up to 45% were added. The hardness fluctuation in composites with loading of natural fibre layers is seen in Figure 5.

Figure 5: Hardness in HRB vs. Specimens in Fibre layer arrangement, X-axis name only as 'Fibre layers'.



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The rise in the composite's hardness is a result of the growing proportion of fibre layers within the epoxy, which leads to enhanced adhesion between the fibres and epoxy particles within the material [see Figure 6 (a-c)]. The higher volume percentage of fibres in the hybrid reinforced polymer matrix fosters stronger inter-molecular attraction between the fibres and matrix particles, ultimately contributing to the increased hardness of the composite [refer to Figure 5]. Additionally, the improved bonding between the matrix and reinforcement elements, as previously observed by S. Prakash et al. in 2016, can also be attributed to the heightened hardness of the composite.

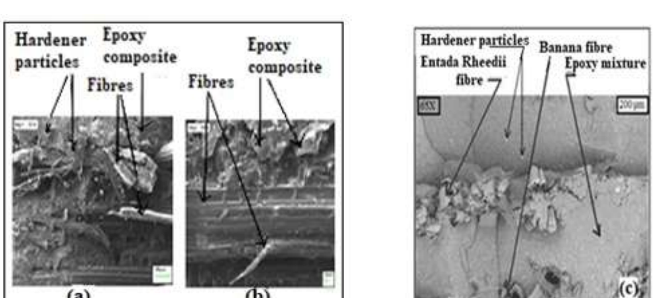
Table 1: Hardness of Entada Rheedii and banana fibre hybrid reinforced epoxy composite [NL-Nil layer or Unreinforced, P-Parandavalli or Entada Rheedii fibre layer, B-Banana fibre layer].

Specimen In Fibre layers	Banana Fibre (B) %	Entada Rheedii Fibre (P) %	Total Fibre (P & B) %	Epoxy mixture %	Hardness, HRB
N L	0	0	0	100	31
P	0	15.40	15.40	84.60	38
B	7.12	0	7.12	92.88	41
PB	7.12	15.40	22.52	77.48	46
PBP	7.12	30.80	37.92	62.08	54
BPB	14.24	15.40	29.64	70.36	61
PBPB	14.24	30.80	45.04	54.96	67

Source: Authors.

Figure 6(c) provides a clear cross-sectional view of a composite specimen, illustrating the presence of both Entada Rheedii and Banana fibres within the epoxy matrix. The increased volume percentages of fibres in the composite, along with robust intra-granular adhesion among the epoxy mixture particles [see Figure 6 (a-b)], are responsible for the composite's hardness. This behavior has also been reported by Nithyashree D.G. et al. in 2017. The highest hardness, measuring 67 HRB at 45% fibre volume fraction and 40% hardener, was achieved by the sandwich structure consisting of double layers each of Entada Rheedii and banana fiber hybrid-reinforced epoxy composite, as indicated in Table 1 and Figure 5 above.

Figure 6: (a - b) Optical micrographs of the fibre reinforced composite with hardener addition of 40% and (c) Scanning Electron micrographs of the both layers of Entada Rheedii - banana fibre hybrid reinforced epoxy resin composites with hardener.



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Conclusions.

The addition of fibre layers influenced the hardness of the epoxy composite reinforced by the Entada Rheedii-banana fibre hybrid. Such an increase in hardness resulted due to the increased dispersion of the fibre particles in the matrix leading pronounced intermolecular attractions among the hardener particles, fibre elements and the epoxy matrix. The maximum hardness of the hybrid fibre reinforced polymer epoxy registered was 67 HRB at 45% fibre volume incorporated into the matrix.

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Tidal of Malacca Straits From AIS Data

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ABSTRACT

This research focuses on investigating the correlation between ship coordinates and sea high-low levels in the Straits of Malacca, utilizing data obtained from the Automatic Identification System (AIS) through an AIS receiver strategically installed at the campus building. The raw data collected from ship traffic in the Malacca Straits undergoes meticulous processing to derive movement patterns and precise ship coordinates. By calculating the distances between these ship coordinates and referencing the AIS receiver, the research aims to identify the highest values of these distances within hourly and daily time frames, crucially indicating tidal patterns and sea high-low levels in the straits. The study proposes the application of a simple harmonic equation to estimate the tide's height based on the observed ship-sea correlation. The outcomes of this research hold significant potential for advancing our understanding of tidal and wave dynamics in the Straits of Malacca, benefiting the field of marine forecasting and navigation. Furthermore, the findings offer valuable insights for coastal management and disaster preparedness in the region, ultimately benefiting various maritime industries, environmental conservation efforts, and coastal communities. The comprehensive analysis presented in this thesis provides substantial contributions to the field of oceanography and offers practical implications for enhancing safety and sustainable practices in the straits and similar maritime regions.

1. Introduction.

The Automatic Identification System (AIS) serves as a valuable 'Big Data' source for marine traffic, providing crucial insights for risk assessment and navigation in congested waterways (Nieh et al., 2019). Introduced in 2003 to enhance maritime safety, AIS mandates certain tonnage ships, including cargo and passenger vessels, to be equipped with AIS systems. These transponders transmit and receive static and dynamic data to and from other vessels and terrestrial stations at regular intervals, making real-time and historical AIS data a vast information source. In-depth analysis of AIS data can simplify look-out and surveillance missions for watchkeeping personnel at sea and in ports.

Maritime traffic is an integral aspect of the shipping industry, encompassing various activities that directly impact security, safety, the environment, and socioeconomic factors (Kim et al., 2022). Traffic facilitates the movement of resources, thereby promoting globalization, spatial differentiation of social and economic activities, and the expansion of regional traffic networks. It plays a vital role in guiding, supporting, and ensuring regional and national development while reflecting spatial relations in trade.

The Malacca Strait, historically traversed for trade between India and the South China Sea and the Pacific Ocean, presents a complex hydrodynamic environment characterized by tidal convergence and seasonal monsoons (Abd Rahim et al., 2022). Further exploration in this domain holds substantial potential for enhancing maritime safety, navigation practices, and the comprehension of tidal dynamics in this region. The Straits of Malacca, a pivotal maritime conduit linking the Pacific Ocean and the Indian Ocean (Chai et al., 2017), experiences a sub-

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stantial influx of ships, resulting in the accumulation of extensive AIS data. Operational disruptions stemming from diverse factors are magnified by its distinction as one of the world's busiest waterways, necessitating meticulous data processing efforts. During periods of heightened traffic, an abundance of vessels can impede the system's data processing efficiency, potentially leading to delays or system malfunctions. Additionally, adverse weather conditions like rain or fog can hinder data collection and possibly compromise the effectiveness of radar systems (Qu et al., 2011)(Gonthier, 2007). Despite these challenges, the AIS system remains operative for the purpose of this study, albeit requiring an extended processing window for decoding raw data and presenting findings. Notably, despite the extensive prevalence of AIS studies, the relationship between ship movements and tides in the Malacca Strait remains relatively underexplored and will be expounded upon in this paper. This paper serves as an extension of prior research concerning the tidal characteristics derived from AIS data in the Malacca Straits (Mustaffa et al., 2023).

2. Background.

Tides, governed by the cyclical motion of seawater due to celestial forces, manifest an array of temporal variations, spanning daily, fortnightly, monthly, annual, interannual, and long-term patterns. In addition to astronomical factors, other nonastronomical elements contribute to the diverse nature of tidal fluctuations across various locations. Tides wield significant physical impacts on coastal regions, shelf seas, and open oceans, influencing phenomena such as storm surges, coastal flooding, erosion, species distribution in intertidal ecosystems, and navigational dynamics for ports (Haigh et al., 2020). The tidal cycle entails two occurrences of high tide and low tide each day, generating a rhythm of two high tides and two low tides within a 24-hour and 50-minute span, a consequence of Earth's rotation that leads to the formation of dual tidal "bulges" throughout a lunar day. The gap between consecutive high tides approximates 12 hours and 25 minutes. The transition from high tide to low tide, or vice versa, unfolds over roughly six hours and 12.5 minutes along the shoreline (Read & Heaps, 2002). Utilizing harmonic analysis proves invaluable for quantifying tidal amplitudes in terms of water levels and volumetric flux, unveiling distinct propagation patterns for tidal flux compared to water level propagation within the strait. Comprehensive explorations into tidal amplitudes yield pivotal insights into the strait's region of tidal mixing (Walde & Hanus, 2020). Meanwhile, in the context of Malaysia, the west coast of Peninsular Malaysia experiences predominantly semi-diurnal and mixed tides, while the east coast, notably Terengganu, encounters mixed tides featuring a diurnal component (Ramadhan Basiddiq et al., 2022) as illustrated in Figure 1. Noteworthy is the fact that the tides within the Strait of Malacca are influenced by tidal propagation originating in the Indian Ocean, entering through the Andaman Sea. Tidal amplitude escalates from 80 cm in the north to 250 cm in the south, particularly as it approaches the narrowest channel of the Malacca Strait, influenced by bathymetric contours and tidal oscillations (Koropitan et al., 2021).

Figure 1: Types of tides as experienced in Malaysia.

Source: Ramadhan Basiddiq et al., 2022.

3. Methodology.

3.1. Data Collection.

In the process of collecting AIS data, a high-frequency (VHF) antenna captures frequency signals in wave format, which are subsequently detected and transformed into data by the AIS receiver originating from the transponder. The resulting data is visualized on a computer screen, and the subsequent graph provides a representation of the outcomes In this study, we will focusing collected data for 2019.

3.2. Data Analysis.

Initially, an analysis of the recorded data will focus on determining the volume of traffic. Subsequently, a month characterized by the highest traffic count will be selected. For the calculation of maximum ship distances, we will utilize latitude and longitude parameters. This study adopts the Euclidean equation, as previously employed in research (Hanyang et al., 2019; Zhang et al., 2017), in conjunction with AIS receiver coordinates from our laboratory as points of reference. To achieve this, the results will be visually presented through plotting, involving the creation of two distinct types of plots:

(i) Daily Maximum Distance: This plot will showcase the maximum distances observed on a daily basis for the selected month. By examining the fluctuations in distances over the course of the month, we aim to identify any recurring patterns or trends in relation to the tide variations.

(ii) Hourly Maximum Distance: For any specific chosen day, we will plot the maximum distances observed hourly. This plot will offer a more granular view, enabling us to investigate how the ship-sea distance changes throughout the day, and potentially reveal any short-term tide-related effects on ship coordinates.

All result will be compared with tide data from nearest hydrographic station (Port Klang) (Tide Times and Charts for Klang, Selangor and Weather Forecast for Fishing in Klang in 2023, 2023). By visualizing and analyzing these plots, we aim to gain valuable insights into the correlation between ship positions and sea tide levels in the Straits of Malacca. These findings could contribute to our understanding of tidal dynamics and their implications for maritime navigation in the region.

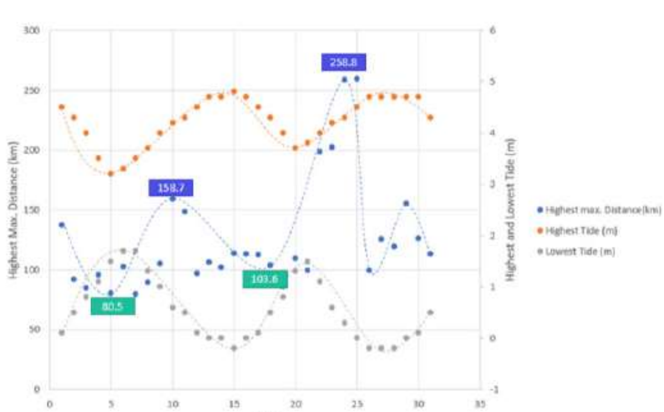
4. Result.

In this section, we present the results of our analysis, emphasizing the maximum computed distances between ship coordinates and their linkage to tidal patterns on both hourly and daily scales. Through the utilization of a straightforward curve fitting approach, we aimed to predict tide timing and cycles. These discoveries possess considerable promise for enhancing our comprehension of tidal and wave dynamics within the Straits of Malacca, while concurrently carrying pragmatic implications for marine forecasting and navigation. We will focus our detailed analysis and discussion on the month of December 2019.

4.1. Daily Data.

Figure 2 illustrates two notable peaks in ship distances, measuring 158.7 km and 258.8 km, respectively, on December 10 and 24, alongside two corresponding troughs measuring 80.5 km and 103.6 km on December 5 and 18. Remarkably, these peaks consistently align with the harmonic cycle of tide timings, even across longer travel distances, showcasing a strong correlation between ship coordinates and local tidal patterns. This graph effectively portrays the interplay between ship movement and sea tide dynamics. Table 1 provides comprehensive tide cycle data for December 2019, presenting the largest distances (in km) observed during the first and second high and low tides. Specifically, December 10 recorded the highest distance of 158.7 km during its first high tide, while December 24 marked the second high tide with a maximum distance of 258.8 km. Conversely, the first low tide on December 5 registered the smallest distance of 80.5 km, while the second low tide on December 18 saw a slightly higher minimum distance of 103.6 km. This data effectively illustrates the relationship between tide occurrences and their corresponding maximum distances throughout December 2019.

Figure 2: Daily maximum distance and tide height for December 2019.



Source: Authors.

Table 1: Tide Day for December 2019.

Tide cycle	Max. distance (km)
1st high tide	158.7
2nd high tide	258.8
1st low tide	80.5
2nd low tide	103.6

Source: Authors.

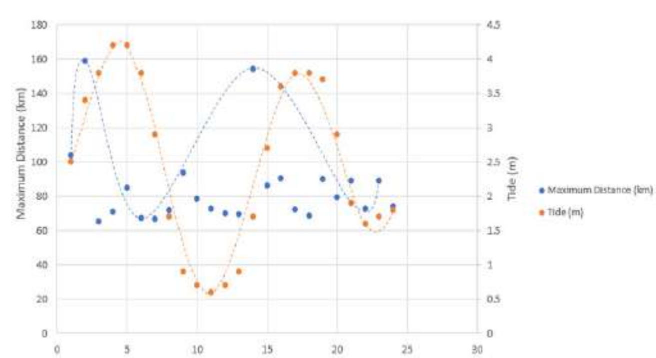
4.2. Hourly Data.

Examining the daily patterns illustrated in Figure 2, a more detailed understanding can be achieved by investigating ship distances and tidal behaviors at narrower time intervals for specific dates in December 2019, namely, December 10, December 24, December 5, and December 18. By segmenting the data into hourly intervals on these selected days, a closer examination of the alignment between ship coordinates and local tidal dynamics becomes possible, potentially revealing subtle variations and trends that might be obscured by broader daily averages. This hourly analysis has the potential to provide deeper insights into the intricate interplay between ship movements and tidal cycles, thereby enhancing our comprehensive comprehension of maritime dynamics during these particular days in December 2019.

4.3. Maximum Distance 10/12/2019.

Figure 3 depicts the hourly maximum distances (km) recorded on December 10th, 2019. The data reveals intriguing fluctuations in ship travel throughout the day, exhibiting distinct peaks and troughs that align with the observed tidal behavior during the same timeframe. Notably, the graph highlights two significant peaks at 2 a.m. and 2 p.m., registering maximum distances of 158.694 km and 154.315 km, respectively. These peaks correspond with elevated tide levels of 3.4 meters and 2.7 meters, underscoring the substantial impact of tides on maritime activities during these specific hours.

Figure 3: Hourly maximum distance on 10/12/2019.



Source: Authors.

Table 2 presents the hourly maximum distances (km) along with the corresponding tide heights (m) for the 1st and 2nd high tides observed on December 10th, 2019. The data reveals that the 1st high tide occurred at 2 a.m., coinciding with the highest travel distance achieved at 4 a.m. In contrast, the 2nd high tide occurred at 2 p.m., with the peak distance attained and recorded at 5 p.m.

Table 2: Hourly maximum distance and tides on 10/12/2019.

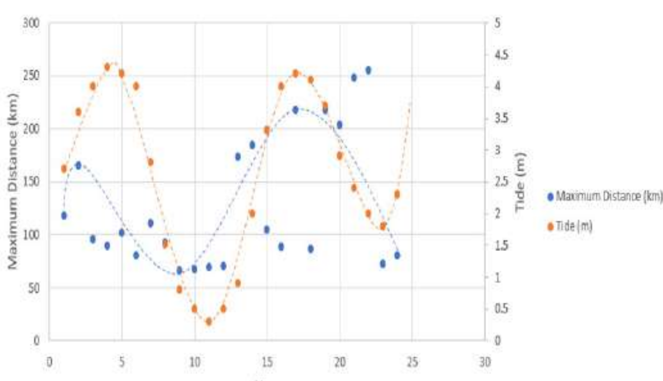
Tide cycle	Max. distance (km)	Tide (m) (m)
1st high tide	2 a.m	4 a.m
2nd high tide	2 p.m	5 p.m

Source: Authors.

4.3.1. Maximum Distance 10/12/2019.

The graph presented in Figure 4 illustrates the hourly maximum distances (measured in kilometers) recorded on December 24th, 2019. The data reveals intriguing patterns in ship travel throughout the day, directly corresponding to the observed tidal behavior during the same period. Notably, the graph exhibits two distinct peaks in ship distances at 2 a.m. and 5 p.m., with recorded maximum distances of 164.877 km and 217.948 km, respectively. Importantly, these peaks align precisely with high tide events, during which the tide levels reached 3.6 meters at 2 a.m. and 4.2 meters at 5 p.m. The strong correlation between the maximum distances and high tide levels suggests that favorable tidal conditions contributed to longer ship travel during these specific hours.

Figure 4: Hourly maximum distance on 24/12/2019.



Source: Authors.

Table 3 offers an overview of the hourly maximum distances (in kilometers) and their corresponding tide levels (in meters) for the 1st and 2nd high tides recorded on December 24th, 2019. The data highlights that the initial high tide occurred at 2 a.m., synchronizing with the maximum distance traveled within the same hour. Likewise, the second high tide transpired at 5 p.m., precisely matching the peak distance achieved during that specific hour.

Table 3: Hourly maximum distance and tides on 24/12/2019.

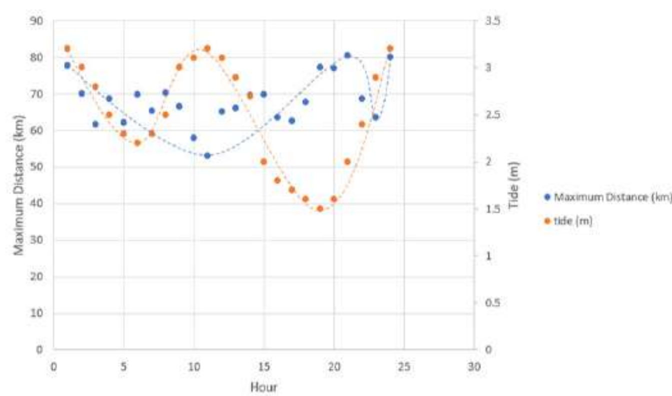
Tide cycle	Max. distance (km)	Tide (m) (m)
1st high tide	2 a.m	4 a.m
2nd high tide	5 p.m	5 p.m

Source: Authors.

4.3.2. Maximum Distance 5/12/2019.

The graph depicted in Figure 5 illustrates the maximum hourly distances (measured in kilometers) documented on December 5, 2019. The data unveils intriguing patterns in ship movements throughout the day, directly corresponding to the observed tidal behavior during the same period. Notably, the graph showcases two distinct peaks in ship distances at 1 a.m. and 9 p.m., where the recorded maximum distances were 77.779 km and 80.521 km, respectively. Interestingly, these peaks align precisely with high tide events occurring at 12 a.m. and 11 a.m., with tide levels reaching 3.2 meters for both occurrences. The strong correlation between the maximum distances and high tide levels implies that favorable tidal conditions facilitated extended ship travel during these specific hours.

Figure 5: Hourly maximum distance on 5/12/2019.



Source: Authors.

Table 4 provides a summary of the tidal patterns and hourly maximum distances for December 5, 2019, in the Straits of Malacca. Two high tide cycles are noted, with the first occurring at 1 a.m. and the second at 9 p.m. The corresponding tidal levels are listed as 12 a.m. and 11 a.m., respectively.

Table 4: Hourly maximum distance and tides on 5/12/2019.

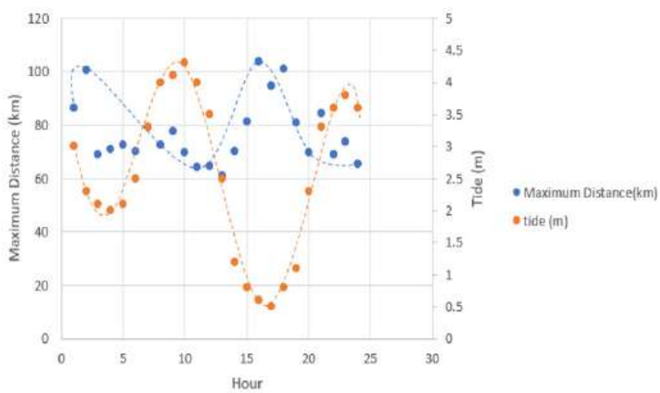
Tide cycle	Max. distance (km)	Tide (m)(m)
1st high tide	1 a.m	12 a.m
2nd high tide	9 p.m	11 p.m

Source: Authors.

4.3.3. Maximum Distance 18/12/2019.

Figure 6 presents the hourly maximum distances (in kilometers) attained on December 18, 2019. The data reveals compelling trends in ship movement that are directly influenced by concurrent tidal dynamics. Interestingly, the graph displays two distinct peaks in ship distances occurring at 2 a.m. and 4 p.m., with recorded maximum distances of 100.35 km and 103.562 km, respectively. Notably, these peaks align precisely with the highest tide levels observed on that day, measuring 4.3 meters at 10 a.m. and 3.8 meters at 11 p.m. The strong correlation between maximum distances and high tide levels suggests favorable tidal conditions during these specific time frames, contributing to extended ship travel durations.

Figure 6: Hourly maximum distance on 18/12/2019.



Source: Authors.

Table 5 outlines the hourly maximum distances (in kilometers) and the corresponding tide levels (in meters) for December 18th, 2019. The data distinctly highlights two instances of high tide occurring on this day, precisely at 2 a.m. and 4 p.m., respectively. Importantly, the peak ship movements were observed during the hours immediately following each high tide occurrence, specifically at 10 a.m. following the first high tide and at 11 p.m. following the second-high tide.

Table 5: Hourly maximum distance and tides on 18/12/2019.

Tide cycle	Max. distance (km)	Tide (m) (m)
1st high tide	2a.m	10a.m
2nd high tide	4p.m	11p.m

Source: Authors.

Conclusion and Recommendation.

The results of the study demonstrate a significant relationship between ship coordinates and tidal timing in the Straits of Malacca, emphasizing the dependability of Automatic Identification System (AIS) data as a valuable tool for forecasting tidal times. The effectiveness of this method in understanding tidal dynamics is evident in its accurate determination of the peak and trough high tide hours through analysis of AIS data. This achievement can be attributed to the harmonized alignment of tidal occurrences with ship coordinates, a consequence of the ocean's resonant motion influenced by the gravitational forces of the moon and sun (Balasubramanian, 2015).

Based on these findings, the study advocates for a deeper investigation into the practicality of utilizing AIS data for the prediction of sea levels during tidal occurrences. By harnessing AIS data for forecasting sea levels, valuable insights can be gained to fortify coastal management strategies and enhance disaster preparedness within the region. This predictive capacity holds the potential to significantly enhance safety measures and readiness against possible coastal threats, as it enables the anticipation of tidal surges and fluctuations. Consequently, this research validates the precision of AIS data in estimating tidal levels within the Straits of Malacca, thereby making a substantial contribution to our understanding of tidal and wave dynamics. Furthermore, it opens doors for future advancements in the realm of coastal management and marine forecasting methodologies. The observed correlation between ship coordinates and sea high-low levels underscores the utility of AIS data mining as an invaluable tool for a range of maritime applications, navigation purposes, and environmental conservation efforts, both within the specified area and beyond.

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Unmanned Underwater Vehicle (UUV) In The Indonesian Sea: Does Indonesian Maritime Defense Ready?

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ABSTRACT

As an archipelagic country, Indonesia has an open sea area and the existence of the Indonesian Archipelago Sea Channel (ALKI), which can cause vulnerabilities to various potential maritime threats. One form of this potential maritime threat could be foreign objects or Unnamed Underwater Vehicle (UUV) from other countries into Indonesian sea territorial sovereignty. That way, it is appropriate for the State of Indonesia to prioritize or focus on maritime security. This paper will analyze the Indonesian maritime defense strategy in response to the findings of UUV at various points in Indonesian territorial waters. In analyzing this, the authors use theories and concepts relevant to maritime defense and maritime security strategies. The research method used is descriptive qualitative, with a literature study approach. The next writer will formulate Indonesia's marine defense strategy in maintaining maritime security from potential threats that may occur. This study indicates that maritime security is not optimal in Indonesia, so that there are still many obstacles related to maritime defense in Indonesia. In conclusion, the maritime defense strategy in Indonesia can be improved in various ways, such as optimizing the Minimum Essential Force (MEF) in order to achieve targets and building sea power by fulfilling aspects of strength, capability, and deployment in order to achieve defense objectives in maintaining and protecting sovereignty. The state, the Republic of Indonesia's territorial integrity, and the safety of the entire nation from all forms of threats.

1. Introduction.

Indonesia is an archipelago, which two-thirds of them is the sea. That means most of the threatening potentials to Indonesia's sovereignty come from the sea, from the coastline to the seabed. The sea is a centralization for Indonesia. As the biggest archipelago country globally, Indonesia sees the sea as the archipelago's unifier. The sea is also seen as the national wealth source to develop the economic sector. However, the sea also has a medium role as the defence of the Indonesian nation. Therefore, Indonesia needs to maintain its maritime stability and security (Cassidy et al., 2016)

Other than that, according to geographic conditions, Indonesia is on the world's leading trading golden road that becomes the target for various parts of the world. Moreover, this condition makes Indonesia surrounded by open sea space bordering with another country. Many threatening potentials could affect Indonesia's sovereignty, defence, and security causing open potentials to come from various directions, especially from choke point control.

There are two different points of view related to threats, strategic studies, and security studies. Strategic studies are a military threat that is focused on the nation, while security studies are a non-military threat that is focused not only on the nation but also on non-state actors or sub-state groups. This research will focus on a strategic studies point of view under the Indonesian sea.

Threats from the sea, including the Indonesian Archipelago Sea Lanes (ALKI), including ALKI I, II, and III. ALKI is a strategic way because often used as a traffic way for trading around the world. The next one is the abundant of Indonesia's natural resources. Geographically, Indonesia has a strategic lo-

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cation between two oceans and two continents and threats under the sea. Indonesia is four of nine choke points of the world that potentially be violated by foreign ships (Legionosuko Tri et al., 2019). One of the recently happened cases in Indonesia is eight unnamed underwater vehicles (UUV) (see Figure 1).

That becomes a threat because of the existence of a foreign ship that unknowingly came into the nation's territory. Indirectly that could threaten Indonesia's potential, conditions, and resources, especially in the sea territory, and it violated the rules, starting Indonesian law by Peraturan Pemerintah No 36 Tahun 2002, CUES, COLREGs and UNCLOS.

Figure 1: Sea glider Points of Discovery in Indonesia.

Source: Author.

That was violating rules as is the function in UUV is to look for oceanographic data under the sea, record the existence of fishes, and predict the number of fishes, which could last for two years. It becomes a threat to Indonesia's sovereignty, specifically disrupting marine resources management and developing human resources poured into seven pillars of Indonesian marine policy.

This is because the number of ships completed by sonar is relatively limited and could not cover the entire ALKI. That written in the data published by (Ditjen KUATHAN Kemhan, 2020) stated that the amount of Indonesian Minimum Essential Force (MEF) is not fulfilled in the sea and the air and land. To build a healthy defensive posture, the Indonesian government use a capability-based planning concept that poured into MEF main strength program. MEF is the primary strength standard and minimum TNI that has to be prepared as a fundamental and main precondition Joseph di effectiveness of the leading job and function of TNI in order to face the threats (Rahman et al., 2015).

MEF rides the physical aspect of defence equipment. It recorded in 2019, MEF fulfils 74.2% of the army, 44.4% of the air force, and 68.72% of the navy or overall 62.58%, which means the defence equipment conditioned of TNI shows that Indonesia has fulfilment limitations of defence equipment to prop up Nations security system. Furthermore, when we see more detail of MEF in the navy, it divided into KRI defence equipment, submarine, aircraft, and marines combat vehicle, with each ideal posture sequentially 262 for KRI, 12 for submarines, 160 for aircraft, and 1,481 for marines combat vehicles (Ditjen KUATHAN Kemhan, 2020)

It recorded from 2010 until 2014 to the defence equipment that Indonesia has is only 55.50% from the MEF target, with the lowest percentage is the submarine physical aspect that only fulfilled 25% from the MEF target. From 2015 until 2019, generally, MEF is fulfilled only 68.72% with the same lowest physical aspect as 2010 until 2014, which is submarines defence equipment with only 50% from the ideal posture. In 2020 the total of KRI defence equipment achievement was 162, the submarine is 8, the aircraft is 100, and marines combat vehicles is 978, which is still far from the idol posture or the target of MEF (Fitri & Sanur, 2019). It compounded because not all KIR or submarines could have detected all these strange things well in the Indonesian sea and have not spread well. After all, the facilities owned are not complete in every area, specifically in the ALKI area. Other than that, the navy itself has not owned an optimal security system underwater. Thus, the foreign submarine or UUV is in high potential to pass the Indonesian sooner detection. In other words, there are still a lot of blind spots in the Indonesian sea. The underwater security system has to be prioritized, considering Indonesia is an archipelago and very vulnerable to these threats.

We are talking about defence equipment that has owned. It must be related to security industries that have owned. As contained an article 1 general provisions (Undang-Undang No. 16 Tahun 2012 Tentang Industri Pertahanan, 2012) stated that *"security industry is a national security that consists state-owned enterprises and private-owned enterprises individually or group determined by the government partly or wholly produce defence and security equipment, maintaining service to fulfil strategy interest in defence and security that located in all of the Indonesian areas"*. Next, in article 3 paragraph (b) about the aims of defence industrial operation stated that "*manifesting self-fulfilment of defence and security equipment; and"*. *Continue in paragraph (c) stated "improving the ability to produce defence and security equipment maintaining service that will use in order to build a reliable defence and security power*". This means the security industry's operation has to be the main crutch in the procurement of defence equipment that has owned to reach the ideal posture of MEF-designed standard.

The security industry becomes one of the spare heads to develop security systems independently, fulfil defence equipment quality and quantity of the risk that would be facing, and build deterrence effect to another country. The problems about answered with some defence industrial strategic steps by assembling and producing some defence equipment for TNI, defence equipment produced by national defence industrial are; Medium Tank (Joint venture PT PINDAD and FNSS Turki), CN235-220 MPA Maritime Patrol Aircraft (PT Dirgantara Indonesia) and Fast Missile Rudals 60 m (PT PAL) CSIS (in Fitri & Sanur, 2019). Unfortunately, in reality, there are several obstacles, like funding and cooperation with another country.

The funding referred to producing and data collecting on the security industry's needs to produce defence equipment with high technology that has efficient and strategic value. If we see the ministry of defence budget from 2014 to 2021 (see Table 1), it could said that it is increasing from year to year, but unfortunately, that increase is not significant. It has recorded according to data published by the ministry of defence in 2014, the budget of the ministry of defence is 86.2T, 2015 is 101.4 T, 2016 is 98.1 T, in 2017 is 117.3 T, in 2018, 106.8 T, 2019 is 108.35 T, in 2020 is 131.2 T, and 2021 137.3 T (Direktorat Penyusanan Anggaran APBN, 2020).

Table 1: Defense Budget Posture from 2014 to 2021.

Fiscal Year	Budgeting Amount
2014	86,2 Trilun
2015	101,4 Triliun
2016	98,1 Triliun
2017	117,3 Triliun
2018	106,8 Triliun
2019	108,35 Triliun
2020	131,2 Triliun
2021	137, 3 Triliun

Source: Author.

According to the Indonesia Ministry of finance in 2019, the ministry of defence is considered the most productive in the budgeting field (Kubangun, 2019). This means the budget managed by the minister of defence is well absorbed. The most significant allocation in the defence budget is in employee spend 41.6%, spend on goods 32.9%, and capital expenditure 25.4%—this time, the Indonesian military budget has mainly distributed to the army. In 2019, the army or grand forces' military budget was 44.96 billion rupiahs, to the navy 17.44 billion rupiahs, and to the air force 13.76 billion rupiahs. In 2020 the budget for ground forces was 55.92 billion rupiahs, for the navy 22.8 billion rupiahs, and for the air force is 15.5 billion rupiahs. The ministry of defence is also allocated the budget to the defence equipment modernization program in 2020 as big as 10.86 T rupiahs that consist of 4.59 T for ground forces, 4.16 T for the navy, and 2.11 T for the air forces (Zahara & Rizky, 2020). After comparing Indonesia and another 138 countries, Indonesia has the 31st position of the defence budget (Global Fire Power, 2021).

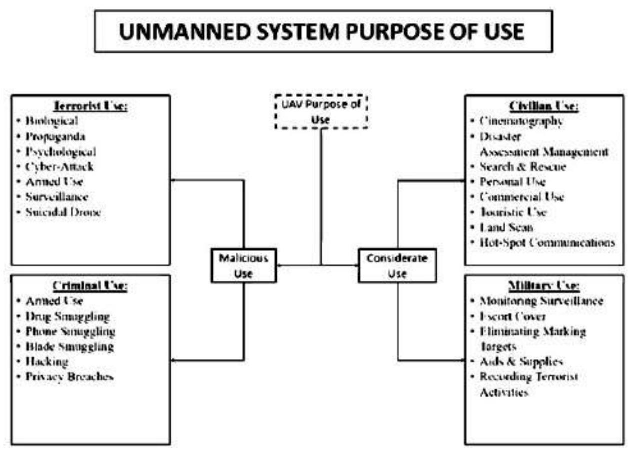
In the work and budget plan in 2021, the ministry of defence also continues the priority activity and strategy in order to support the fulfilment of MEF to ensure sovereignty, maintain Indonesia's territorial integrity, and protect the safety of the people from threats and distraction to the integrity of nation and state. Work and budget plan for the navy are Rp 3,751.2 billion for pursuant of fast patrol boats and improving the navy's aircraft also Rp 4,281.1 billion for the defence equipment supporting component maintenance (Kementerian Keuangan, 2021)

The limitation of the defence budget this time affected the detection system's ability and the limits to present surface and underwater elements. Facing this kind of condition requires creative applicative and solitude effort to keep observing ability underwater to monitor foreign submarines that passed in the Indonesian sea. The security methods referred to using acoustic technology active or passive sonar by setting solar station in ALKI gates such as Selat Sunda, Selat Lombok, and salad Makassar that radiate and receiving sound wave object reflection underwater that suspected as a submarine (Kementerian Pertahanan Republik Indonesia, 2019), the defence is a must (Adawiyah & Tobing, 2019).

2. Literature Review.

2.1. Under Sea Defence System.

Figure 2: Unmanned System Purpose of Use.



Source: Author.

There are two proposes of using the unmanned system (See Figure 2). First, as using crime and two aims to consideration. Using crime usually done for terrorist interests such as propaganda, psychology, cyber attack, weapon use, and suicide drone, while criminalism such as weapon use, drug smuggling, phone smuggling, weapon smuggling, hacking, and privacy violation. The purposes of consideration are civil use like interest for cinematography, the management or disaster assessment, livelihood and health, personal use, commercial use, tour use, scanning, and communication use. In contrast, the second purpose is used in the military sector to monitor or observe, guard, eliminate or make a target and record all terrorist activities (D. Mahamit, 2021).

2.2. Sea Defends Strategy.

The nation defence concept is arranged by prioritizing multiple defence concept which focuses on the cohesiveness of military defence and non-military defence. This concept aims to deterrence, solve and overcome military threats or non-military threats. Also, this concept is prepared to deal with drag on war.

Veterans function as a strategy that conducted in peace situations and as an effort to death defence integration that includes politics, economics, psychology, technology, and military aspects. In a national defence strategy book, this defence concept has two types: deterrence by refusing and revenge.

1. Deterrence by refusing this strategy used with a modern defence system based on sophisticated defence equipment as the main, which has a strong deterrence effect.

2. Deterrence by revenge the revenge conducted if one country has not military defence based on ideal defence equipment the execution is by the dragon war with guerilla strategy.

With consideration, Indonesia's deterrence strategy is combining both of them from the deterrence by refusing until the deterrence by revenge in the form of multi-layer circular defence with people supporting TNI as the main power (Legionosuko Tri et al., 2019).

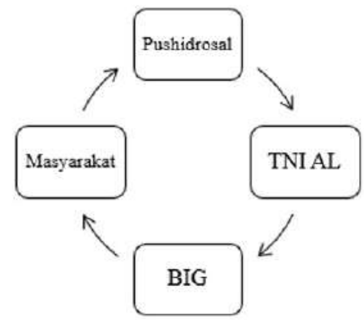
Indonesian Constitution number 34 2004 in chapter 4, article 6, paragraph 1 about the Indonesian national army (Undang-Undang RI Nomor 34 tahun 2004) explained that. The Indonesian national navy (TNI AL) is a part of TNI that has a role, job, and function as deterrence to all form of military threats and threats that use weapons that came from internal or external of the nation that could disturb national sovereignty, national integrity and national safety (DPR RI, 2004).

The implementation of Indonesian Constitution number 34 2014 in chapter 4 article 6 paragraph 1 applied in a doctrine named Eka Sasana Jaya which one of the TNI doctrines is TRIDEK (Tri Dharma Eka Karma) (DPR RI, 2004). The doctrine has a value that the national defence concept in the sea concludes that all of the defence efforts is universal and engage all of the people to guards the sea. This concept is a strategy done to support the national defence in the sea. This explained in a concept called Strategi Pertahanan Laut Nusantara (SPLN), part of the integral from Pertahanan Nusantara strategy. The SPLN principle based on three pillars that have an affinity: defence system and universal people defence, defence-in-depth, and deterrence. Active defence trait is a maritime defence paradigm is a defence strategy that has to be sustained by excellent sea power. SPLN is a strategy applied from the outermost territory of the sea according to the sea defence concept that prioritizing control enemy's approach path also maintains the security and law enforcement at sea (Legionosuko Tri et al., 2019).

2.3. Defence Under The Sea Strategy.

The defence under this strategy is one of the efforts that manifest complex defence by collaborating with several institutions. The navy TNI does the intellectual activity under the Indonesian sea, wild geospatial information institution (Badan Informasi Geospatial (BIG)) area, and strategy zone mapping, a sea defence strategic point in Indonesia. Pushidrosal does the area mapping with important information and decides the defence equipment needed to deterrence every threat that appears. The last one is people who have a role in reporting every event threat or related to the sea areas (Legionosuko Tri et al., 2019)—drawn in the picture below (See Figure 3).

Figure 3: Sea Security Synergy.



Source: Author.

Constitution number 34 2004 article 11 paragraph 1 (Undang-Undang No. 34 tahun 2004 Pasal 11 Ayat 1) explains that defence posture that has deterrence ability could be seen in three aspects: power, capability, and deployment. According to Letjen TNI (Purn), Kiki Syahnakri power is quality, and armours are quantity, showing personal skill and deployment is a placement geographically from the defence power with its supporting system a complement. The proper naval base and fleet access to every base are indicators of the maritime strategy's success. The base's role is to develop sea power to its operation area, or deployment forces position, which means has an important meaning and supports the success of the TNI navy operations (Agung, Darma; Arief, 2017).

2.4. Legal Standing.

Based on United Nations Convention on the Law of the Sea (UNICLOS) in chapter 2 article 19 about territorial sea and additional zone in innocent passage in territorial sea explained that something that passed and considered threatening nation's peace, discipline or security, if they do activities such as (a) threatens or territorial integrity or independence of a country's politic or with any other way that considered violating international law principle as listed in United Nations Charter; (b) every training or practice with weapons in any form; (c) every activity that has a purpose to collect information that could harm security and defence of a nation; (d) every propaganda that aims to influence security or defence of a nation; (e) launching, landing, or receiving every aircraft on the ship; (f) launching, landing, or receiving every military equipment; (g) loading or unloading every commodity currency or people that against Constitution physical immigration customs or state sanitary ware rules; (h) every defamation that done purposely and severely against with this convention; (i) every fishing activity; (j) survey or research activity; (k) every action that purposely disturbing every communication system or every facility or another installation; (l) every other activity that doesn't directly related to cross (United Nation, 1982). In point (a), (b), (c), (d), (e), and (f) also included in Indonesian Government Rule Number 36 2002 about Right and Obligation of Foreign Ship in Carrying Out Peaceful Crossings Through Indonesian Asea in chapter 2 article 14 (Peraturan Pemerintah Republik Indonesia Nomor 36 Tahun 2002 tentang Hak dan Kewajiban Kapal Asing dalam

Melaksanakan Lintas Damai Melalui Perairan Indonesia pada Bab II pasal 14) (Kementerian Kelautan & Perikanan, 2002).

3. Methods.

In this research, the writer used a qualitative approach with the library research data source and other data that could support this research. According to indicators that have made through Indonesia's political policy, this research's primary data source is various field data related to under the sea defence strategy. Secondary data that support this research are reports articles and any other documents related to this discussion object. Data analysis in this research uses content analysis to understand, define, compare, and analyze the national defence concept of Indonesia under the sea defence strategy.

4. Results and Discussion.

4.1. Flashback the Series of Discovery of Seaglider in Indonesia.

As an archipelago, the undersea defence strength is an essential thing for Indonesia. Various events that are potentially becoming threats from under the sea should be scrutinized. There are at least eight seed glider Discovery events in 2016 until 2020 that should be judged as a threat. Many speculations appear about the founding of the sea gliders. Many parties asked about who is responsible for those things. For the first time, on March 5th, 2016 founded Patnerplash by the local fisherman in Midai Kepri. The most recent one in December 2020 was founded Sea Wing UUV (Unmanned Underwater Vehicle) by a fisherman in Selayar. For detail, there is a picture of where the strange thing has been founded in the Indonesian maritime area (see Figure 1).

Three borders of ALKI divide several islands. First, ALKI I divides Sumatera and Java-Kalimantan. Second, ALKI II divides Java-Kalimantan Sulawesi, and third, ALKI III divides Sulawesi and Papua. In Indonesia's sea glider-founded context, those things have been at the border of ALKI that decided. As the discoveries of 6 sea gliders in ALKI, Midai Kepri, Berakit Bintan, Batu Putih, Belitung, and Bintan Kepri. There is also a discovery of sea gliders in ALKI II at Sampang Madura. Lastly, ALKI III founded sea glider in Selayar. With those funds, it has a big possibility that all this time, many sea gliders hanging around in Indonesia's territory to collect necessary geographic data and Indonesia's sea potentials, which means Indonesia's maritime security is very vulnerable to infiltration.

Numbers of experts presume unmanned sea glider that could fly above the sea. While TNI general, Jonni Mahroza, said these strange things are Sea Wing UUV (Unnamed Underwater Vehicle). According to information from KASAL (Rahayu, 2021), these sea gliders' ownership is still unknown because there are no signs of any country that owns it in the body. Nevertheless, KASAL did not deny that anyone could use the sea gliders to get important military interest information.

The opinion from KASAL is also supported by research from Pushidoral that stated sea glider released from a ship, then going down to the bottom of the sea and radiates CTD sensor, and the sensor could capture information is its mission. That becomes a typical cause. According to Pushidoral, every sea glider released has its mission. In more detail, Pushidoral stated that sea gliders have two primary purposes one used as a criminal action, and two used as consideration. However, the sea gliders founded in Indonesia are more likely used as a criminal action because the sea glider came into the Indonesian territory without any permission, and it is one of the privacy violations. Technically those sea gliders could last more than two years and operated 2000 m under the sea for six weeks with six knots speed or the same as 11 km per hour. While under the sea, gliders could float for nine days following the flow. When it rises to the surface, the data recorded will radiate and received by the operator, and it could confirm that the operator controls the sea glider through satellite (Vego, 2016).

4.2. The Existence Of Seaglider As Defence Threat Potential In Indonesian Maritime.

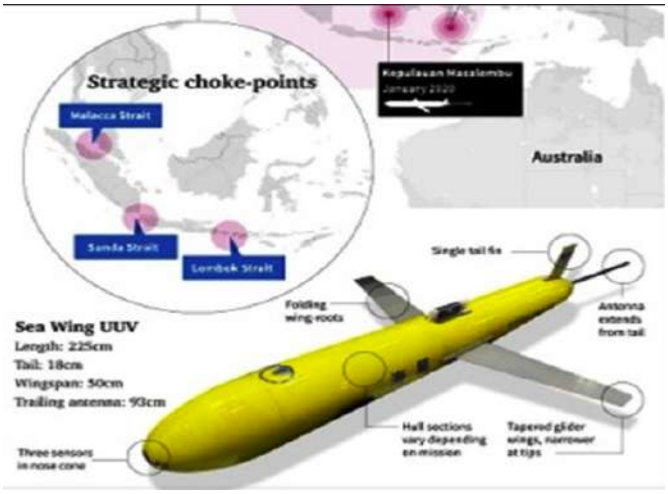
Based on the white book of Indonesian defence in 2020 (Buku Putih Pertahanan Indonesia Tahun 2020), the sea's threats categorized by two potential threats and real threats. Potential threat including military aggression that conducted by foreign parties, border dispute and conflict with never country. Real threats include law violations formed as smuggling, illegal fishing, pirates, transnational organized criminal, threats related to the sea and natural resources, and navigation dangerous threat.

In the context of sea glider discoveries in Indonesia, while 10 to the form of threat explained in Buku Putih Pertahanan Indonesia Tahun, 2020 is categorized as a real threat. It is because according to the United Nations Convention on the Law of the Sea (UNCLOS) in chapter 2 article 19 about territorial sea and addition zone in the innocent passage in the territorial sea the entry of sea glider to Indonesian sovereignty territory without any permission is one of the violations of the law of the sea in the form of launching landing and receiving strange things. The Ministry of Defence's research told that sea gliders discoveries are a real threat that potentially keeps happening and is a type of threat that has significant implications for Indonesian maritime in the present or the future.

The existence of an unknown item could threaten Indonesia's security and defence stability if it is left unchecked. If we see Indonesia's strategic location in geopolitics, it is no wonder if other countries want to take information from Indonesia through the sea. If we examine it more closely, the discovery of sea glider is using modern threat technique. It is because the threat source came from the sophisticated defence equipment from another country. The picture below shows a description of the sea glider found in Indonesia (Muhammad, 2015).

According to figure below (see Figure 4), let us see glider has several sophisticated specifications from the sensor that placed on the muzzle, antenna on the tail, and micro camera on the body. From those specifications, the seed glider has to be special attention, as KASAL conveyed that the sea glider could record data and do a survey of oceanography. This could become a threat potential when another country could hold Indonesia's sea or maritime data.

Figure 4: Seaglider Display.



Source: Author.

The existence of ALKI that could pass by international cruise formally makes the Indonesian sea open to threat potential across the country. The vast area and distribution of Indonesia's island made the supervision of the Indonesian water area very difficult when faced with TNI capabilities, especially the navy TNI as the main components of national defence in the sea. Therefore, needed special regulation or mechanisms in handling cross-country threat potential as in sea glider discovery phenomena.

This time, the Indonesian government found a little difficulty taking decisive action to respond to the sea glider discovery. This is due to no regulation in Indonesia that regulates sea gliders explicitly. If Indonesia counts on regulation in the form of the Constitution, it probably needs a long time. Nevertheless, if Indonesia considered this phenomenon a severe and precarious problem, the president could release a president's rules (Perpres).

If this rule has made, it could regulate how equipment types have to have permission to operated in Indonesian territory. Because all this time, the rules related to permission only applied for several types of equipment that has an identity, such as warship that pass across the Indonesian ocean. Sea glider found in Indonesia does not have a clear identity, so it could not confirm whether this equipment included in the warship category or military equipment for war or just industrial equipment. Therefore see glider permission could not equalized with war equipment ruled in several rules in Indonesia.

With this sea glider discovery phenomenon, Indonesia could be a reminder to improve its maritime security. There are at least three reasons for Indonesia to improve its maritime or sea security (Widyoutomo, 2020). First, under the sea is the security centre that is hardly detected and attacked by the enemy because the position and mobilization could be more concealed, without the hassle to prepare disguise as on land. The enemy could destroy the most sophisticated technology built on land and in the air at any minute. Meanwhile, under the sea, power could be more difficult to be attacked by the enemy. With a dominant sea area, decisions and mobility under the sea security power will be freer to control and give the advantage to protect the surface underwater, under the sea, or on land. National strategy objects must protected under the surface.

Second, the defence under the sea will be the superiority and uniqueness of Indonesian geography. Indonesia has a sea dominant geographic condition, and the fact that Indonesia is an archipelago country should make Indonesia underwater as the centre of gravity (COG) of Indonesian security. COG does not only have to be strong to attack but also has to be vital to stand. Indonesian active defensive defence doctrine (Doktrin Pertahanan Defensive Aktif Indonesia) needs a strong under the sea defence. Indonesia is fated to have a geographic condition that is suitable for building COG defence under the sea.

Third, still related to the geography, the enemy's entrance to Indonesia that wide open is the sea. It is illogical if we want to build a fence around the Indonesian sea. Nevertheless, Indonesia's security controls strategic points and possible, such as chokepoints and entrance along the ALKI.

4.3. Sea Defence Strategy According To Tni Doctrine In Responding Sea Glider Discovery In Indonesian Sea Territory.

In this globalization era, the interaction between individuals or countries supported by fast technological development may threaten dimensions more complex and vary. An article 30 paragraph 3 Undang-Undang Dasar 1945 (Undang Undang Dasar Negara Republik Indonesia Tahun 1945) stated that "TNI consists of ground forces, navy, and air forces as the national equipment to defend protect and maintaining the integrity and sovereignty of the country." As the mandate in Undang Undang Dasar 1945, the three dimensions must secure the country's integrity and sovereignty from any threat both from internal or external of the country following their duties. The navy TNI as the main component of country defence in the sea has three primary duties: first, to dude the duty of TNI in defence of the sea dimension. In carrying out its duties and specifically, the navy needs a doctrine as a guideline to achieve goals and as a reference to decide the direction of development policies and the use of sea dimension power.

National defence doctrine essentially teaches about fundamental principles that guide managing defence resources (Legionosuko Tri et al., 2019). That doctrine is a fundamental principle that has been believed as the truth, extracted from the Nations' value struggle and experience and then becomes guidance to develop defence and security concept for the country. As the part of TNI, Indonesian Constitution number 34 2004 in article 6 paragraph 1 (Undang-Undang RI Nomor 34 Tahun 2004 pada Pasal 6 Ayat 1) explain that doctrines of the navy TNI are Jalesveva Jayamahe. A doctrine has placed under the TNI doctrine "Tri Dharma Eka Karma" and has a position in strategic strata that becomes the highest guidance in drafting navy TNI doctrines below, while the Jalesveva Jayamahe is a strength-building doctrine for the navy of TNI (Kusuma et al., 2021).

In doing their duty, the navy TNI needs a strategy to explain its doctrines that generally is a process to decide a plan by the navy leaders that focused on the long-term goal, accompanied by the preparation of an effort to achieve the goal. According to Clausewitz, a strategy is using the battle to achieve the end of the war. Because of that, it has to give target to every military action and according to the war object (Bandaro, 2014).

In this technology development and change of order era, defence technology with the invisible ability and unmanned armour or unmanned aerial vehicle (UAV) like a drone has become a flagship product in the security industry in developed countries. With the development of underwater drone, move towards the threat that came from unmanned armours. Such as underwater drone found in the Indonesian sea (Indrawan, 2018).

Moreover, technologies changing drastically and fast, rise in this industrial Revolution 5.0, insist the military adapt faster and evolution to do a drastic change. According to this phenomenon, it could see that there is a significant move of the threats so that it is imposing Indonesia to change its security strategy. In drafting a security strategy, it has to tend to a multi-layer national defence concept. This multi-layer security is the integrity of the military defence lawyer and the non-military defence layer. This concept aimed as a deterrence, resolve and overcome military or non-military threats. When Indonesia faces a phenomenon that potentially threatened its national defence and security stability, it will automatically apply a multi-layer defence system (see Figure 5).

Figure 5: The pyramids of Indonesia's multilayer defence.

Source: Author.

The deterrence concept consists of two varieties. First, deterrence with refusing means that the strategy must build a modern and sophisticated defence system based on sophisticated defence equipment. Second, deterrence with revenge means that the strategy must do by drag on war with guerilla strategy. In the Indonesian context, the deterrence strategy used is a combination of both of them from the deterrence by refusing and deterrence that suitable for faced threat potential. Nevertheless, it should note that this deterrence strategy done by mobilizing every power that exists in TNI and people supports. In doing deterrence, it also uses TNI doctrines as guidance. The doctrines have a value that the national defence concept concludes every defence affords that universal by including every people in the national defence effort. In the response context to the sea glider discovery phenomenon, it needs a proper sea defence strategy.

The effort that could done to make a robust maritime defence is to add synergy between the elements (see Figure 2). Every element has their roles start from the navy TNI that conduct intellectual activity in Indonesian sea territory, while the geospatial information institution (Badan Informasi Geospatial (BIG)) does the area and strategic zone mapping the strategy points of Indonesian defence in sea territory. Pushidoral does the area mapping with important information that decides what defence equipment is needed and aims to deter every threat. Lastly, people or civilian that has a role in reporting every event or incident that could threaten or event related to the sea territory (Pusat Kajian Global Civil Society (PACIVIS), 2012).

In connection with the development of the situation about sea glider found in Indonesia, did navy t and I have to continuously improve sea defence strategy by continuously presenting the existing element in Indonesian sea territory. To improve Indonesia's sea defence power, at least the navy TNI has to fulfil the minimum essential force (MEF) (Pertahanan, 2010). This MEF became vital because it is a standard of primary power and has to be prepared for the central and essential precondition to achieve the effectiveness of jobs and main functions of TNI to face a threat. In more detail, MEF has three aspects power, skill, and deployment. First, in the power aspect, defence equipment informing modern defence equipment must be offset with a proper budget posture. There is a budget fluctuation when we see the defence budget from 2014 to 2021 (See Table 1).

Although the total defence budget is uncertain, the budget will still distribute to the three dimensions of TNI according to their individual needs. As the concrete steps to improve this power aspect, the navy has a prepared budget as big as 3,751.2 billion rupiahs used for the procurement of fast patrol ships, improving the sea dimension aircraft, and death looping sea glider. The navy also prepared a budget as big as 4,281.1 billion rupiahs to maintain the defence equipment and defence equipment supporting components. These steps considered well enough to imply and support MEF's fulfilment to guarantee the suffering it and the integrity of Indonesian territory and protect people and every Indonesian from the threats to the nation and country (Pertahanan, 2015). It must not stop there. The navy of TNI should be completed its base infrastructure under the sea that different from the ordinary sea base to make the country's secret be protected.

Moreover, the Indonesian security industry has to think to prioritize sea glider making with Indonesian characteristics. The sea gliders eventually could be armed with sophisticated bullet weapons, including attacking the target on land and in the air (Silmy, 2014). Then, the navy TNI capability could recalculate the navy and power that Manning the drone fleet under the water. The navy tent I projection in the future should direct to an unmanned ship fleet. Indonesia has to think out of the box, leaving the conventional navy posture that two focused on the surface with high vulnerability if attacked by the enemy. Lastly, in the navy aspect, TNI deployment could be done by mapping under the contours and plan the perfect position for the defence under the Indonesian sea. Research types and variation of the perfect weapon system to be placed around the points that have mapped.

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The China-Taiwan Dispute: A Continuity of Conflict and Resolutions

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ABSTRACT

The geopolitical position of Taiwan at the crossroads of East and West has led to political imbalance. The strong U.S. influence has portrayed Taiwan as a consequence of China's unification efforts. Recent Chinese military exercises in the region have raised concerns of conflict, affecting the stability. Escalation of military presence around the Taiwan Strait has been observed over time. Taiwan's administrative status under the People's Republic of China has gradually weakened its self-governance. China asserts Taiwan's adherence to the 1992 Consensus, while historical claims and technological importance shape its foreign policy. The historical context involves China's takeover of Taiwan in 1945 after WWII, triggering civil conflict. Struggles over the Taiwan Straits emerged in 1953 between the People's Republic of China and the Republic of China, resulting in armed conflicts for control over strategic islands.

1. Introduction.

Taiwan set-up on the crossroads amidst the east and the west represented unbalance political disorder. An overbearing domination from the U.S. objectify Taiwan as ramifications from China's unification. The inevitable conflict raising concerns for Taiwan after China's military exercise in the Straits recently this year probable to influence the undercurrents of the region. Over the years, military presence around Taiwan Strait run into intensification of the Taiwanese and Chinese forces. Taipei administration under the People's Republic of China (RPC) unofficially announced since 1st January 1979. The self-governing nation ties slowly transforming to its disadvantage at the hands of mainland China. Lindsay Maizland (2023) stated Beijing argues that Taiwan is obligated by the 1992 Consensus, an agreement signed among officials of the Chinese Communist Party (CCP) and the Kuomintang (KMT) faction that controlled Taiwan at that point in time.[2]

In particular, Taiwan drives unprecedented security dilemma and ruled-based order in strategizing democratic images and aligning support of its people. The statehood of Taiwan is questionable predicting two major power deficient to be inherent in achieving peace and negotiation process. Hence, the public view regarding the U.S. suspicion the agreement by the efficacy of U.S. policy are less credible in terms of safeguarding the national sovereignty. Nancy Pelosi's triggering visit Taiwan in 2022, coupled with her vow to safeguard Taiwan's autonomy, were not warmly received with welcoming overtures from the PRC, a country that proceeds to assert de-jure rule thru the island as part of its One-China Policy.[3] China's ambition to maintain the Status Quo paradoxically against the One China, conferring the U.S. foreign policy over Taiwan informal ties been adversely intricate. The US-Taiwan-China relations drew a sharp cognizance for policy-making decisions and delimitation of unity and freedom of sovereignty exercised by Taiwan. China's foreign policy pushed for *'One Country, Two Systems'* and penetrating frequent military drills across the Straits.

2. Background of the Study.

Reaffirming how China used to trail the pathway of 'Holy Duty' in claiming Taiwan territory are undeniably important in

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China's foreign policy. Indebting the last-pieces of domino effect, presume Taiwan listed as treasury to China's technological enhancement and development. Chinas seized the island in 1945 after the defeat of Japanese forces in World War Two sooner vented to Civil War within nationalist state movement headed by Chiang Kai-Shek, Kuomintang against Mao Zedong, the Chinese Communist Party[4]. The indicators of Taiwan Straits predicaments began in 1953 between two parties, the People's Republic of China (PRC) and the Republic of China (ROC) occasioned in armed war ruling strategic islands across the Straits.

The contrasting ideologies in shaping China's governance – politically inspired via establishing identities in nationalistic chronologies. The CCP fuse its power over the mainland and launched the attack towards the Straits thoroughly in the early 1950s. Despite the fact that the mainland of China hoped Taiwan was part of its own nation, the United States accounted for Taiwan as the only government with legitimacy of China. Nevertheless, President Richard Nixon's 1972 historic mission to Beijing ensued in deeper ties with (mainland) China, an ordinance that President Jimmy Carter carried out, declaring relations with (mainland) China with support of the "One China Policy."[5] With that, the policy acknowledge PRC as the main government and later on the U.S. permitted the affairs with Taiwan, namely the Taiwan Relations Act of 1979. As stated from Stephen Yates (1999) by preventing core enmity, the US safeguarded Taiwan from forcing itself into debates with China amid the potential of military invasion nor different kinds of intimidation[6]. Beijing further claims on sovereignty over territory initiate to amalgamate with the mainland on any possible force included military exertion. The biggest flashpoint coming from the crisis impacted the long-standing role of the U.S. as well as multilateral economic west bloc. De-facto sovereignty hardening the limit of self-ruling government as non-recognized independent country – a rising number of states have transferred diplomatic status from Taipei to Beijing throughout time, reducing Taiwan alongside barely 15 allies in diplomatic relations by the end of 2021.

The political and security confrontation of China-Taiwan adversely lead to confrontation of China-U. S affairs proxy. China's view of Taiwan nowadays remains firmly as ever, when Xi Jinping itemized "reunification with Taiwan must be fulfilled", in addition to expansion of industrial revolution on microchip technologies – renowned the pioneering supplies of semiconductor components. Caught the U.S. favouritism encircling security measurements across its military bases, especially in the island territories. Beijing leveraged Pelosi's arrival to escalate provocative military activity in apparent coordinated drills, in addition to assign how examines to be an intriguing status quo whereby its aircraft and vessels fly without restriction and occasionally in the air and maritime space around Taiwan[7].

The current overarching dilemma, Xi Jinping command in capturing Taiwan to embrace motivating factors towards high-end microchip and semiconductor industry as de-facto ascendency. Taiwan leading and manufacturing the most of microchips in the worlds – steering electronic production convening industrial leap. China is hesitant about risking a confrontation that might take away its economy of the greatest fundamental economic treasure of the twenty-first century[8].

3. Theoretical Framework.

The management and resolution of Taiwan dispute requires a sophisticated view in cater the national interests and its right to external sovereignty for China, thus the United States reemphasize the importance of Taipei administration that treats impetus of foreign policy denominator. A clash of identities mounting the consciousness between China and Taiwan respectively delicate the tensions on synthesizing national manifestation.

In particular, Taipei-Beijing relations avow the perspective of neoclassical realism theory. The rivalry of US-China depicting on the basis of internal features effect on their external behaviour, and analysing Taiwan issue as the focal point of main actor's policy argumentation and interpretation. Notable to point out that foreign policy analysis deeply accounted to neoclassical realism concept. Neoclassical realism is a comparatively intriguing approach to integrate structural realism's focus on rigorous science and the explanatory dominance of the global system with classical realists' devotion to the national structures, vision difficulties, including governance dilemmas[9]. This perspective bound to revitalize China's strength of the One China principal carriages a significant influence to the mainland policy. Realist doctrine uprise the power of politics and view nation-state actor applies its dominant functions compete to the United States present a struggle amidst the bipolar control. The dynamic of China's national policy system encouraged China's foreign policy decisions. To maintain its immense position, China starts to declare itself by determining its jurisdiction throughout a rising amount regions in its national interest, including not solely areas of conventional vitality including Taiwan, Xinjiang, and Tibet along with certain contested regions like the South China Sea[10]. Within the framework of

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[5] Global Specialty Insights Center Staff. "China-Taiwan Conflict: Increased Risk in the Region and Its Implications". Insights, The Hartford. (2022). Accessed May 18, 2023.

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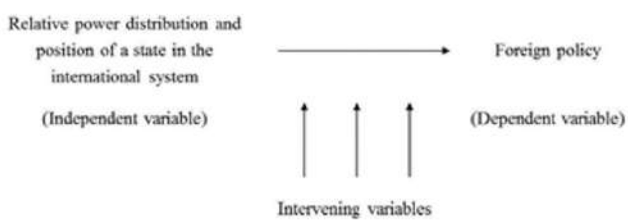
[10] Xiaodi Ye. "Rediscovering the Transition in China's National Interest: A Neoclassical Realist Approach". Journal of Current Chinese Affairs. Vol 48 (1) 76-105. (2019). Accessed May 22, 2023. https://doi.org/10.1177/1868102619876830

neoclassical realism, autonomous and mediating elements determine the foreign policy. Xi Jinping dealings with diplomatic relations reserve a principle of 'desires to achieve' strives to accommodate: (奋发有为 – fenfayouwei).

Therefore, assertive behaviour enclaves the pursuit power of China in legitimatize the state government stance. Tools for China anticipate the hegemony attain its hard power often running the state of political-security and economic outflow. Neorealist recognises that governments are human-led organisations, and hence responding to external triggers might appear improper[11]. This emerge when a state's government fails to recognise the predicament it is in. A state could opt for a futile response to external pressures due to national economic or political restrictions that hinder the state machinery from obtaining sufficient resources from its citizenry in order to compete effectively.

Figure 1: Intervening variables.



Source: B.A. Lindenmann, Neoclassical Realism and Foreign Policy Analysis. "Cross-Strait Relations and International Organizations". (2014). Accessed May 22, 2023. DOI 10.1007/978-3-658-05527-1_2.

Neoclassical realist applies in the figure 1 stimulate state's structure and domestic rivalry and measuring the identity as well as perception. The four key categories engage methodological approaches centred to distressing state's ability and willingness.

4. Source of Problems.

The tension within China-Taiwan escalation suffocates into multi-layered complexities and paradox. The conflict has been exacerbated by the increasing military power of China. In fact, China's swiftly modernizing its military exercise, and recently has the ability to launch a successful incursion of Taiwan. It is an attainable flashpoint that could ignite an overwhelming conflict. Therefore, there are three source of complications that contributed to the China-Taiwan conflict:

4.1. Historical Legacy.

The settlers from China fleeing Taiwan since the 17^{th} Century fronting hardships mostly originated were from Hoklo, Fujian (Fukien) province. This proven in the modern times, the offspring currently constitute arguably the most populated ethnic communities on the territory. However, the Qing Dynasty had to surrender Taiwan to Japan, after the defeat in the First Sino-Japanese War, 1895. A several decades later, Japan capitulated Taiwan to the ROC during the World War II – within the consent of ruling given from the United States and United Kingdom. Chiang-Kai overdrawn the civil war in China which are defeated and the leftovers, yet supporters escaped to Taiwan in 1949. Meanwhile, the CCP established the PRC on mainland, as CCP never abandoned the use of force to bring Taiwan beneath its domination. The scenario of this issue is the power of struggle and unclear status of independence that withdrawn its recognition and the UN transferred diplomatic recognition from Beijing government was dispel. Subsequently, 15 member states recognised Taipei administration tumbled considerably due to distinction political system and legal status remains unclear. Both parties argued on being part of a single China and professed as its only authorised representation[12]. As component of its democratic shift, publicly renounced its mission to reconquer China's mainland in 1991.

4.2. The Intensification of China's Economic and Military Power.

A bilateral dispute fuelled fears in the tension of sovereignty and acquisition of territorial integrity. Reckoning the economic and military costs of Taiwan conflict is intensely alarming. Firstly, China's confidence to state claims over the economic gain absolutely caught the global economic in terms of trade and businesses disturbances. The Ukrainian conflict hastened China ambition to build a financial system that protect from the Western sanctions[13]. By developing a supplementary independent financial system, China optimisms to lessen the bearing of sanctions and guard its economy. Because of the deep interdependence of the Chinese-Taiwanese economies, certain economists believe there is minimal prospect of China placing stronger economic penalties on Taiwanese enterprises, as it potentially harms vital areas of the China economy[14]. The impact of Taiwan's export easily cost a full-scale crisis to the overall region in economic performance and GDPs. Military power on the other factor, positioned at the centre of Taiwan Straits ramped up the geopolitical strike. A war-game portrayed from Jinping's ruling power – deterring the force and security alliance of the United States. The capacity to propel the US and its partner nations into frontal conflict against China's People's Liberation Army, the world's biggest the armed forces, resulting in becoming progressively well-equipped[15]. China's invasion to Taiwan territory overturns the status quo on advancing unilateralism.

[11] Sean Carver. "Sino-US Great Power Conflict from a Realist Perspective". Global Honors Theses. 84. (2021). Accessed May 22, 2023. https://digitalcommons.tacoma.uw.edu/gh_theses/84

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[13] Global Guardian. "It's High Time Businesses Started Preparing for a China-Taiwan Conflict". (2022). Accessed May 25, 2023.

[14] Gabriel Dominguez. "What would be the economic cost of a full-blown Taiwan crisis?". Business Analysis, The Japan Times. (2022). Accessed May 25, 2023.

[15] Ben Blanchard. "China-Taiwan: why tensions are rising and what could happen in 2023". Asia Pacific, Reuters. (2022). Accessed May 25, 2023.

Beijing taking benefit of the thrilling compression on Taiwan likely to exert military forces comes both an offensive and defensive validation. According to the Council on Foreign Relations (CFR) identified three possible military tactics that Beijing use Taiwan under its command: air and sea confinement across Taiwan, restricted attack offshore islands, and full-scale invasion including large number of Chinese troops on Taiwan[16].

4.3. The long-standing policy of "Strategic Ambiguity" on Taiwan.

The Unites States usefulness on 'Strategic Ambiguity' tapped its status quo in supporting Taiwan and at the same time optimistically deter the China's invasion. Whereas, the policy contributed to relatively stable ties between the United States, China, and Taiwan; whilst China could jeopardize Taiwan on a regular basis, it did not perform a complete encroachment and has not sought official autonomy[17]. The impact over the rest of the world together with uncertainty of small and middle powers – questioned its legitimacy and reassurances of Taiwan protection in aligning the United States strategic framework. The doctrine is meant not solely to prevent China from deploying force in opposition to Taiwan, nevertheless to discourage Taiwan from pursuing independence, because nor Beijing-Taipei can be guaranteed that the US might act to protect the island in the event of a confrontation[18]. Nevertheless, China's interpretation against Taiwan as provocative measurement discourages the United States strategic ambiguity in undermining policies. As Taiwan matters to the US, unofficial bilateral ties conserved more than a regular nation. Instead of Taiwan's aggressiveness, the key driving cause for conflict might to be China's perception that it may penetrate at a realistic cost[19].

5. Conflict Dynamic.

The dynamics possess in the Straits fuelled inevitable occurrences flashing the power struggles via air and seas. Figure 2 above exhibit territorial water submitting the most significant exercise series of military invasions encircle from multiple directions to seven zones. Equally to infamous proposition called 'Cross-Straits Relations' debunked upheaval of geopolitical congestion. Remembering the visit of Nixon to China does losing its momentum after more than 40 years. The rise of Xi Jinping at the wheel of CCP, configure the dynamics of China's foreign policies – "Wolf Warrior Diplomacy" acquired a paradigm alteration. The dynamics seized a collision with

Figure 2: Mapping the People?s Liberation Army (PLA) Unprecedented Seven Exercise Zones around Taiwan.

Source: Bonny Lin, et. al. "Tracking the Fourth Taiwan Strait Crisis". China Power. (2022). Accessed May 27, 2023.

new-fangled Taiwanese political party, 'Democratic Progressive Party' (DPP) dated back in 2016. With the separatist refutation to 'One China Policy' This has irritated China, prompting Beijing to enact tougher actions to maintain its stance on Taiwan, which is an essential interest topic[20]. Addressing the Taiwan dispute and achieving China's "complete unification" is described as a "historic mission" in the 2022 China's defence white paper.

Importantly, Taiwan self-protection instigate against Chinese pressure prompt to re-visit the implications with greater considerations. The objections itself landing a collision over major state's compatibility role, as such US-China crucial ties economically and politically. China's enthusiasm based on historical arguments with winning the war could winning the people's heart. All parties are concerned regards unresolving issues particularly engaging Strait's activities could harm the prospect of global economic revenues in developing technological robustness. Taiwanese and Western leaders are afraid that Beijing's armed forces actions would be accompanied by additional efforts intended for forging a different status quo surrounding Taiwan[21]. Ideology and hegemony brought China's contesting a durable hard-power in prevailing draconian administration and annex forceful exertion to Taiwan. In fact, the PLA is going to be equipped in 2027, and Xi most likely begin moves to accomplish the aspirations by 2030, as China's population matures, whereas seeking unifying to cement historic reputation throughout the lifetime[22]. Figure 3 below articulate the strength of military assets in evaluation to three offensive elements.

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[16] Peter Lyon & Michael Roi. "Military aggression against Taiwan by the People's Republic of China". Potential scenarios and consequences, Defence Research and Development Canada (DRDC). National Defence. (2023). Accessed May 25, 2023.

[17] Model Diplomacy. "Strategic Ambiguity Toward Taiwan". Council on Foreign Relations. (2022). Accessed May 26, 2023.

[18] Nikkei Asia. "U.S maintains 'strategic ambiguity' over Taiwan: security adviser. Indo-Pacific. (2022). Accessed May 26, 2023.

[19] Peter Devine. "Strategic Ambiguity Isn't Working to Deter China on Taiwan – It Will Invade Anyway. It's Time to Commit". Just Security. (2022). Accessed May 27, 2023.

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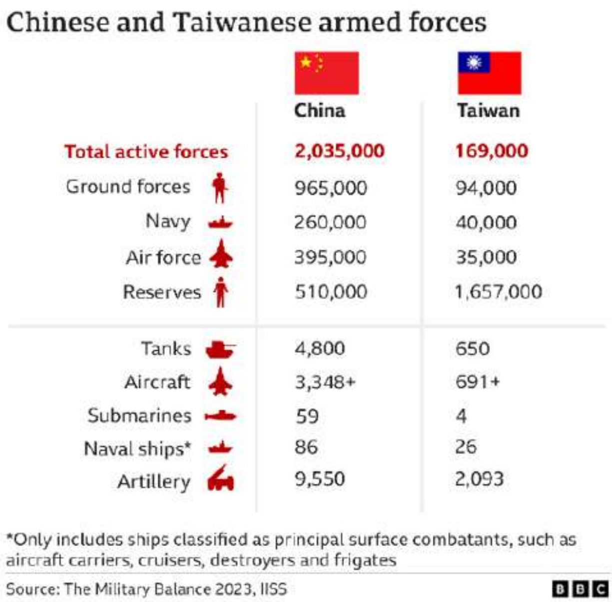
[22] Kyle Amonson & Dane Egli. "The Ambitious Dragon: Beijing's Calculus for Invading Taiwan by 2030," Journal of Indo-Pacific Affairs 6, no. 3 (March–April 2023): 37–53. Accessed May 28, 2023.

Figure 3: China and Taiwan Armed Forces Comparison.



Source: David Brown. "China and Taiwan: A really simple guide". China, BBC. (6 April 2023). Accessed May 30, 2023.

6. Conflict Resolution Approaches.

The post-civil war does aspire China and Taiwan to made up important events and space for negotiation and diplomacy. In the event of armed conflict, sea territorial base averts peaceful practice for both. It should be noted, there have been a number of former China-Taiwan conflict-resolution approaches, inclusive of:

6.1. The 1992 Consensus.

The inaugural unofficial agreement within China and Taiwan approved there is one and only China, nonetheless the clarification is differed taken into the precise context. The 1992 Consensus reached a compromise on the breakthrough of Cross-Strait's relations resting two parties between KMT and CCP. The definition to interpret on both governments claimed to be the true rulers of "China": the ROC, established in 1912, and the PRC, formed in 1949[23]. The endeavour to put emphasis on workable conversations did not represent, as critics claim, that the 1992 Consensus was determined on the two parties' capacity to bypass challenging political issues.

6.2. The Straits Exchange Foundation (SEF) and the Association for Relations Across the Taiwan Straits (ARATS).

The ROC urge to establish a semi-official organization (intermediary body), the SEF from private division to deal thru Strait issues. Density upon legal and political status formally recognized and operated on 9 March 1991. The PRC in parallel established ARATS as a counterpart corresponding to facilitate cooperation and dialogue Taiwan-China. Series of discussions held under the purposes of agreements. Then, both de-facto parties unable to reach a concluding agreement on the status of Taiwan autonomy.

6.3. The 1995-1996 Taiwan Strait Crisis.

A historical of heightened tensions across Taiwan Straits turned PRC to garner expansion and sphere of influence vis-à-vis the use of force embodied the military leverage. The crisis led to a sum of international condemnations to China's intimidation. The movement act as wake-up call to China in adopting coercive strategy – condemning response of the US-Taiwan relationship. Tensions between China and Taiwan increased ahead of the Taiwanese elections, the US responded by installing the Seventh Fleet to the area[24]. After the elections, tensions reduced and the militaries were removed. Both sides then worked to re-establish peaceful relations.

6.4. The 2008 Cross-Strait Economic Cooperation Framework Agreement (ECFA).

Agreement was signed between Taiwan and China symbolising landmark of the ECFA directed to investment and trade functions. Imposing lower tariffs and barriers reimburse the economic payoffs under Free Trade Agreement (FTA) – carries a suspension of strait crisis, thus PRC leverage the negotiation process into substantive roundtable of discussions. Its goals to solemnize business opportunities and helps Taiwan on identical equilibrium in external trade, further encourage other states to enhance the negotiable applications.

6.5. The 2016 Tsai Ing-wen Election.

Tsai-Ing Wen, a Taiwanese DPP politicians served as the President for Taiwan stimulate public-orientation in the issues of reckoning in cross-strait relations. Particularly, Tsai populism in global progressive politics diverted PRC attention and accused Tsai of seeking independence proclamation for Taiwan, yet challenging military existence in the Strait.

7. Conflict Analysis.

This section discusses on conflict analysis that interlinked to China-Taiwan conflict. Conflict analysis is a crucial feature of creating and conducting peacebuilding measures due to its centres around generating perception of circumstances in which a peacebuilding action is sought[25]. The potential direction of a conflict caused from China and Taiwan respectively, state actors assessing the initial stage of dispute and avoiding lesser

[23] Alyssa Resar. "The 1992 Consensus: Why it Worked and Why it Fell Apart". The Diplomat. (2022). Accessed May 30, 2023.

[24] Shepperd Taryn. "1995–96: The Taiwan Strait Crisis". In: Sino-US Relations and the Role of Emotion in State Action. Studies in Diplomacy and International Relations. Palgrave Macmillan, London. (2013). Accessed May 31, 2023. https://doi.org/10.1057/9781137317728_3

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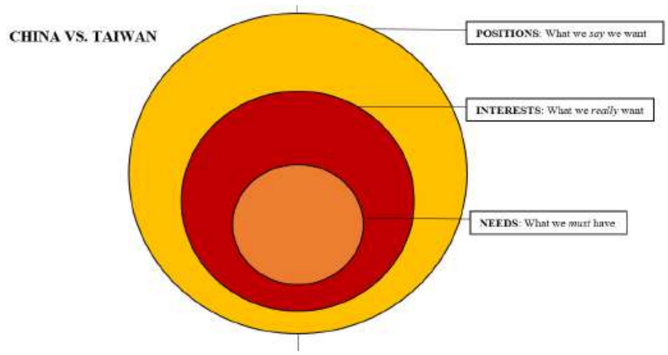
cost of peril. In the sense, understanding the process of a conflict sustaining policies and practice. In all-out war, the Strait paradoxes reasoned why the US constraint lack of support and defence to Taiwan whenever the west must prudently ponder its strategy in the incident of Chinese military pressure. Figure 4 shown the onion tool, encompass three concentric circles, contingent on involving actors' positions, interests, and needs as in the China-Taiwan conflict. Considering each dispute contains a minimum of two actors, the onion actor analysis necessitates rightful negotiation[26].

Figure 4: Onion Actor Analysis ? actor?s position, interests and needs in the case study of China-Taiwan Conflict.



Source: S. Fisher, D. Ibrahim Abhi, J. Ludin, R. Smith, S. Williams. ?Working Conflict: Skills and Strategies for Action?. Zed Books. (29 October 2020). Accessed June 1, 2023.

Using Onion-Actor analysis, two actors hinged under the pressure of the conflict. Underlying the interests reside in the conflict resolution framework. The analysis tools employ a textual model of critical relationship foremost in exchange to understand each relationship. China's potent territorial control in the usage of economy and political hotspot reconsolidate expositional view of status quo (China) versus transformational liberation (Taiwan). Conflict analysis should be done within the participatory subjective views. The transparency of position for China in conquering Straits and defending Taiwan from the external influence formulate long-game preparation in apprehending Taiwan in 2027. The nationalist government and separatist self-governing island prompt to declaring its de-facto governance – via security postures. Amy Hawkins (2023) indicates Taiwan interests relying to reinforce help from the west prior to a future invasion[27]. An intervention consolidates by proxy, the US should focus on transforming the conflict and shifting for change. The enduring 'Strategic Ambiguity' policy must re-visit and improvise the objectives of the US against China, reiterating the latest presidency envisaged by Xi Jinping deemed much passable in reducing conflict through the lens of cooperation and empathizing plausible structures of its structures and systems. Beijing pursues in conquest military bases across Taiwan borders, which strongly claims on the historical statement. This motivates Taiwan upscaling the needs of the US using geographic and technological advantages to raise the cost of China. By deterrence, full-scale invasion could circumvent however with inconsistent sustainability. Potential for China responding the conflict are more likely due to rapid military changes in strategizing growth. Thus, the conflict transformation by dynamics is particular to China as well as Taiwan since the onion analysis predict to comprehend both sides whether to raise or diplomatically in stringent manner, sharply residing to address the needs and interests for both actors.

8. Resolutions and Suggestion.

To conclude, China-Taiwan partakes grand attention in the case of conflict-resolution. Not every conflict potential to spark a resolution hence the first or second-track of diplomacy have the intelligence and ideas to propose a number of solutions. It is noteworthy that Chinese PLA's outbreak on Taiwan diverted a complex issue with no-easy outcome. In 2021, the UN Resolution 2758 inaccurately misinterpret Taiwan as part of China campaigning by PRC and formalizing on its "One China" Principle noticeably spreading fallacy into a point the UN member states strongminded towards Taiwan is a configuration of PRC. The conflict may impose different resolutions for the China-Taiwan dispute. Which commonly includes:

8.1. Direct Negotiations.

This would entail China and Taiwan sitting down and discussing face to face. This is the most straightforward method of resolving the conflict, however it can also be exceptionally challenging. Both parties must be open to compromise and make offerings.

8.2. Economic Cooperation.

Previously ongoing SEF and ARATS invalidity and lack of cohesion, a new merging cooperation in economic field stimuli a chance in working together in cross-advantage projects. Which disseminate and switching skills and labour to the extent in building trust and goodwill, in addition helping to create a common interest in resolving the conflict.

8.3. Cultural Exchanges.

China-Taiwan in public view equate in harmonious climate, thus sharing the cultures with each other potentially benefit to breakdown prejudices and stereotypes. The soft power application probably to assert a mutual understanding and empathy between two sides ? indirectly softened the elites? aggression in elevating further regional conflict and suspension of predicament.

[26] Kenneth Acha. "Conflict Analysis". (n.d.). Accessed June 1, 2023.
[27] Amy Hawkins. "Taiwan foreign minister warns of conflict with China in 2027". The Guardian. (2023). Accessed June 1, 2023.

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Comparative study of LNG/MGO emission levels on a ROPAX ship

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ABSTRACT

Maritime transport emission reduction targets are getting stricter as solutions to reduce the environmental load are actively sought. This study compares emission levels of LNG and MGO fuels on the ROPAX ship. Emission measurements have been carried out on the ship while it was operating in real conditions at sea and include results under different load conditions. The results reveal that methane slip is noticeable under partial load. The results are generalized utilizing the sustainability index approach allowing for the separation of global warming, acidification, eutrophication, and human health particulate air potentials. Although LNG performs better in terms of many environmental effects, due to the methane slip the GWP100 does not differ much from the corresponding MGO values. The values given by the sustainability index are greatly influenced by the fuel price level, and recently the LNG market has been rather turbulent.

1. Introduction.

Ship exhaust emissions mainly consist of carbon dioxide, nitrogen and sulfur dioxides, carbon monoxide, unburnt hydrocarbons, and particles, including significant amounts of water vapor, residual oxygen, and nitrogen (IMO, 2020). Carbon dioxide and methane accelerate climate change (Wang et al., 2022). At the local level, concentrations of particles, sulfur, and nitrogen oxides can rise unnecessarily high and weaken local air quality, e.g., in ports or settlements. (Li et al., 2023; Nguyen et al., 2022; Toscano et al., 2022). However, there are no simple solutions for reducing shipping emissions. Furthermore, as the lifespan of ships is usually 30-40 years, investment decisions of shipping companies have far-reaching effects in terms of emissions (Aakko-Saksa et al., 2023).

Experiences about the effectiveness of ship emission control areas are continuously being accumulated (Li et al., 2023; Yang et al., 2022). This also applies to the Baltic Sea region (Jalkanen & Johansson, 2019; Ytreberg et al., 2021), where a stricter sulfur dioxide restriction zone has been defined (SECA, Sulfur Emission Control Area) permitting a maximum sulfur content of 0.1 % in fuel (IMO, 2019). In non-SECA areas, the sulfur limit is set at 0.5%. Technologies that meet SECA requirements include using low-sulfur fuels such as MGO or LNG, or alternatively the ship must have been equipped with sulfur scrubbers. Finnish Customs statistics (Finnish customs, 2020) highlight that approximately 90 percent of Finland's foreign trade depends either partially or entirely on maritime traffic in the SECA area. Thus, in Finland, the impact of sulfur regulations on the decisions of shipping companies is significant, so the region serves as a good indicator when considering the likely effects of tightening restrictions worldwide (Solakivi et al., 2019).

The Baltic Sea has been defined as a NO_X Emission Control Area (NECA) from the beginning of 2021 when the Tier III restriction came into force for ships built after 2016. No binding CO_2 emission limits have yet been set for maritime transport. However, the greenhouse gas emissions from shipping are gaining increasing attention on global and regional level. In the initial GHG Strategy, IMO adopted a target of reducing greenhouse emissions from maritime transport by 50% by 2050 compared to emission levels in 2008 (IMO, 2018). In 2023, IMO

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revised this strategy, with an updated goal of achieving net-zero greenhouse gas emissions from international shipping by 2050 (IMO, 2023). The chosen technology-free approach may lead to maritime transport, in one way or another, being a part of the international emissions trading system in the future. Regionally, shipping will be included in the EU Emissions Trading System in 2024 (EU/2023/959).

According to the Third IMO GHG study (IMO, 2015), between 2007 and 2012 ship emissions accounted for 3.1% of annual global CO_2 emissions and 2.8% of annual greenhouse gas emissions, with NO_X and SO_X emissions accounting for approximately 15% and 13%, respectively. The latest IMO emissions inventory was published in summer 2020 (IMO, 2020), reporting emission trends between 2012 and 2018. Greenhouse gas emissions had risen to 1.076 million tons (2018), an increase of 9.6% and shipping accounted for 2.9% of global greenhouse gas emissions annually (2018). This report also noticed (IMO, 2020) an increase in methane emissions of ships during this period (approximately 150% increase between 2012-2018). Primarily, this was due to the rise in the use of LNG. The share of multi-fuel engines has grown significantly during this period, especially in the Baltic Sea. Many shipping companies have invested in LNG technology to meet the requirements of the NECA and SECA. During the period, NO_X emissions increased less (+1.2%) than the fuel consumption trend (+5.6%) due to the increase in the share of engines that meet TIER II and III requirements (IMO, 2020).

Although SO_X and NO_X requirements can be achieved by several emission reduction technologies (SCR, scrubbers, MGO, LNG, higher TIER-classified engines), there is no consensus on the best approach to reduce greenhouse gas emissions (Bouman et al., 2017). This is emphasized if the perspective is shifted from a ship-specific examination to a life-cycle approach that includes all greenhouse gases (CO_2, N_2O, and CH_4) from both fuel production and use. The life cycle approach is included in the upcoming FuelEU Maritime initiative (European Commission, 2021b). LNG has often been seen as a comprehensive solution to reduce emissions due to its low particle SO_X and NO_X emissions. Lindstad et al. (2020) recently stated that LNG increases greenhouse gas emissions compared to current diesel alternatives. In addition, according to their study, the reduction in greenhouse gas emissions from HFO/scrubber vessels is reduced by as much as 2-4% compared to MGO if the heavy fuel oil comes from conventional refineries. Thus, their research supports previous observations about the benefits of using scrubbers (Ma et al., 2012) and the challenges of LNG in reducing greenhouse gas emissions (Brynolf et al., 2014; Gilbert et al., 2018). Pavlenko et al. (2020) had similar findings, over a 100-year time horizon, the maximum greenhouse gas benefit of LNG is 15% lower compared to MGO however, this only occurs if ships have a high-pressure dual-fuel (HPDF) engine and methane emissions are well controlled. In a 20-year time horizon, the use of LNG does not benefit the climate, regardless of engine technology (Hult & Winnes, 2020). Recently, other aspects of sustainable development, such as economic and social sustainability, have attracted interest in energy and mobility topics (Wulf et al., 2019). Iannaccone et al. (2020) presented the results of a general sustainability index comparing MGO and LNG, which included environmental, economic, and safety aspects.

New fuel solutions such as liquified biogas, methanol, or ammonia are also being developed. Bouman et al. (2017) compared 150 studies published after 2009 to evaluate options for reducing CO_2 emissions from maritime transport. According to them, biofuels offer the most significant CO_2 reduction potential among alternative energy sources, around 50-80%. Correspondingly, for example, the potential of LNG is around 15-25%, wind power 10-20%, and shore power less than 10 %. In addition, Bouman et al. (2017) state that no single measure is sufficient to achieve significant reductions in greenhouse gas emissions, but emissions can be reduced by more than 75% by 2050 with a combination of measures. However, temporary solutions are also needed to reduce CO_2 emission quickly so that the IMO's previously mentioned ambitious goals are realistically achievable (IMO, 2023).

Intermittently, high expectations have been placed on LNG as a transitional fuel solution (Aronietis et al., 2016; Steuer, 2019; Tvedten & Bauer, 2022; Wood, 2012). Low NO_X emissions and practically zero SO_2 emissions, including the reduction of CO_2 per ton of fuel burned, have made LNG an interesting solution. However, especially ships equipped with low-pressure dual fuel engines cause a considerable amount of methane emissions. Methane is a potent greenhouse gas, and according to Grönholm et al. (2021), methane slip can negate the benefit of reduced CO_2 emissions. The share of LNG-powered RORO and ROPAX ships has increased significantly from 2010 to 2018 (Ushakov et al., 2019). According to Aakko-Saksa et al. (2023), gases are probably one of the applicable options, and an WtW (well-to-wake)-approach is emphasized in the evaluation, but a clear "winning technological solution" has not yet been found. Therefore, investments in multi-fuel engines will probably continue. In order to compare different alternatives, the scientific community needs significantly more measurement data recorded under real operating conditions. The objective of this paper is to present the results of empirical emission measurements carried out on an LNG ship under normal operating conditions, where the engines have been fueled alternately with MGO and LNG.

In this study, the effect of real conditions on the emission levels during normal operations is investigated using on-board flue gas measurements, and the sustainability index is applied to generalize the analysis of the recorded data. The measurements were carried out on a ROPAX ship equipped with dual-fuel engines. During the measurement period, the ship changed the use of LNG and MGO fuels, so the same voyage was undertaken several times with different fuels. The sustainability index approach is based on calculating economic and environmental indices and was used to evaluate the overall sustainable development performance of the alternatives. The comprehensive measurements and analyses carried out in this study, the impact of methane slip, and the proportion of other gaseous components on the overall sustainability performance can be assessed in detail. The results show a large variation in methane slip as a function of engine load, resulting in different environmental and sustainability performance than on MGO fueled voyages.

2. Methods.

In the Baltic Sea, the number of ROPAX vessels equipped with multi-fuel engines (LNG/MGO) has increased rapidly in ferry traffic in recent years. The common profile of these routes is that they are continuous, short intercoastal ferry services. Two vessels operate from Turku (FIN) to Stockholm (SWE), one from Vaasa (FIN) to Umeå (SWE), and two from Helsinki (FIN) to Tallinn (EST). In addition, similar routes are also operated from Sweden to Gotland and Germany. These ships have LPDF (low-pressure dual fuel)-type diesel engines without additional emission reduction technologies such as catalyst systems. On some routes, such as Turku to Stockholm, operation with partially loaded engines is common due to the wide archipelago areas.

In this study, the dual-fuel vessel was chosen as the research object, which operates a 2-hour long fixed route from port-to-port. The characteristics of the ship and its propulsion machinery are described in table 1. The shipping company agreed to sail consecutive voyages with different fuels (LNG and MGO). The route profile includes a short open sea voyage and two port maneuvering periods. The ship was commissioned in 2017, so natural wear and tear are evident in the systems. The operating hours of the measured engines are 21,500 h for ME1 (main engine 1) and 28,900 h for ME5 (main engine 5). Arriving at both ports was smooth due to the fixed schedule and installed auto-mooring system. Based on these measurements and taking into account the similar technical characteristics and solutions of other dual-fuel ferries in the region, conclusions can be drawn about the generalizability and possible needs for additional measurements.

Table 1: Ship characteristics.

Variable	Amount	Unit
Length	212	m
Beam	31	m
Draught	7.1	m
Max. speed	27	knots
GT	49,000	-
ME1 Wärtsilä 12V50DF	11,400	kW
ME2 Wärtsilä 12V50DF	11,400	kW
ME3 Wärtsilä 6L50DF	5,700	kW
ME4 Wärtsilä 6L50DF	5,700	kW
ME5 Wärtsilä 12V50DF	11,400	kW

Source: Authors.

2.1. On-board emission measurements.

The measurements were performed on a ROPAX ferry operating in the Baltic Sea in June 2022, powered by three Wärtsilä 12V50DF and two Wärtsilä 6L50DF low-pressure dual-fuel engines (DF-engine). The installed power was 11,400 kW per 12V engine and 5,700 kW per 6L engine. In normal operation, the vessel uses two 12V50DF engines. The propulsion line is a complete diesel-electric system and there are no separate auxiliary engines are on-board. All engines meet TIER III requirements in gas mode, and TIER II requirements in diesel operation, and no additional emission reduction technologies have been installed (Wärtsilä, 2019). During the measurements, the fuel was changed several times between MGO and LNG to achieve as comparable conditions as possible. The properties of both fuels are presented in tables 2 and 3 (Bunker delivery note LNG, 2022; Bunker delivery note MGO/DMA 0.1, 2022). MGO is a normal, low-sulfur DMA quality, while LNG is mainly methane. Wärtsilä dual-fuel engines require an LNG fuel with a methane number of at least 91, and MGO was used as a pilot fuel for igniting LNG (Wärtsilä, 2019).

Table 2: Characteristics of fuel MGO DMA 0.1.

Variable	Amount	Unit
gross heating value	12.75	kWh/kg
density	846.6	kg/m3
viscosity	3.858	cSt
VCF	1.00017	-
pour point	-9	°C
flash point	66.5	°C
sulphur	0.082	mass %
ash	0.01	mass %

Source: Bunker delivery note MGO/DMA 0.1.

Table 3: Characteristics of fuel LNG.

Variable	Amount	Unit
gross heating value	15.232	kWh/kg
density	429.1	kg/m3
methane	90.3186	mol. %
ethane	8.0489	mol. %
propane	1.2014	mol. %
n-butane	0.1590	mol. %
iso-butane	0.1999	mol. %
n-pentane	0.0155	mol. %
iso-pentane	0.0238	mol. %
nitrogen	0.0019	mol. %
carbon dioxide	0.0019	mol. %
oxygen	0.0000	mol. %

Source: Bunker delivery note LNG.

The exhaust gas samples were obtained from the stack immediately after the exhaust gas boiler through the holes built for this purpose. Each engine has a separate stack line, and the exhaust stream was sampled with a PSP4000-H heated filter probe. Although the flue gases from ships are quite dry, they contain a small amount of water vapor, which affects the measurement results if the sample gas is not dried. The sample was dried with a processing dryer (Permocure Minigas 2812T) that contains a suction pump and works through permeation, where water molecules are removed through ion membrane tubes. This method does not require a condensate tank, so it is suitable for tight spaces in stack structures. During the measurements, clogging was constantly monitored due to the high particle content of the flue gases. All measurements have been performed on dried gas.

Sulfur, carbon dioxides, and carbon monoxide have been measured using the infrared absorption (IR) method. The analysis was performed with a portable Horiba PG350 analyzer. This device was calibrated at the measurement site using a mixture of calibration gas (calibration gas quantity, see table 4). This measurement procedure complies with the standard CEN/TS 17021/2017 (Stationary source emissions, 2017a) for sulfur dioxide, ISO 12039/2019 for carbon dioxide (Stationary source emissions, 2019), and SFS-EN 15058/2017 for carbon monoxide (Stationary source emissions, 2017b).

The measurement of nitrogen oxides have been based on the chemiluminescence (Chemil.) method, and the sample was fed to the analyzer (Horiba PG350) undiluted through a heated sampling line via a dryer. The measurement method is based on the standard SFS-EN 14792/2017 (Stationary source emissions, 2017c). EF-NOX is corrected for ambient temperature and humidity according to the IMO NOx Technical Code (IMO, 2008).

The residual oxygen in flue gases has been determined by the paramagnetic (Param.) method. The flue gas sample was fed to the analyzer (Horiba PG350) through the drier. The analyzer was calibrated with free air (O_2=20.9%) and nitrogen (O_2=0.0%) at the sampling site (table 4). Linearity tests have been performed on the device. The standard followed is SFS-EN 14789/2017 (Stationary source emissions, 2017d).

TVOC (total volatile organic compound) emissions have been measured with a flame ionization (FID) detector (ERSATEC SmartFID analyzer), which is a gas chromatography analyzer. In the detector, the sample burns with the fuel gas, and the carbon contained in the sample generates a measurable electric current when ionized. The undried sample was led along a heated sampling line to the detector. The analyzer was calibrated at the measurement site with propane. Propane-calibrated results are computationally converted to methane-compatible ones. TVOC emission measurements are based on the standard SFS-EN 12619/2013 (Stationary source emissions, 2013).

Table 4: Emission measurement standards, methods, and calibration gas quantities.

Gas	Method	Standard	Calibr.
SO_2	IR	CEN/TS 17021/2017	0/100
NO_X	Chemil.	SFS-EN 14792/2017	0/200
CO	IR	SFS-EN 15058/2017	0/200
CO_2	IR	ISO 12039/2019	0/13
O_2	Param.	SFS-EN 14789/2017	0/20.9
TVOC	FID	SFS-EN 12619/2013	0/100

Source:Authors.

Engine power and fuel consumption data are obtained from the ship's engine control system (Valmet DNA). Atmospheric pressure, relative humidity, and air temperature are measured but these variables are subject to uncertainty due to operating in a real marine environment. In this case however, it is not estimated to cause a significant deviation in the results. The weather conditions were very similar and calm on all measurement voyages. These variables and the measured emission components are listed in Table 5.

Table 5: Research variables and their sources.

Variable	Unit	Source
Shaft power	kW	Ship system
Fuel	kg/h	Ship system
Atm. pressure	kPa	Estimated / Measured
Rel. humidity	%	Estimated / Measured
Air temp.	°C	Estimated / Measured
O_2	%	Measured
CO_2	%	Measured
NO_X	ppm	Measured
SO_2	ppm	Measured
CO	ppm	Measured
TVOC	ppm	Measured

Source:Authors.

These variables are used to determine the realized specific fuel consumption and specific emissions. They are defined in relation to engine power (g/kWh) and fuel consumption in a chosen period (g/kg$_{fuel}$). This conversion has been implemented according to the ISO 8178-1 standard (Reciprocating internal combustion engines – exhaust emission measurement, 2020). This study focuses on the following components: Carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_X), and total volatile organic compounds (TVOC). The amount of sulfur dioxide is known to be very low with these fuel solutions as is the amount of residual oxygen of the flue gases needed to process the results (ISO 8178). The amount of CO_2 emissions closely follows the actual fuel consumption. NO_X emissions are of particular interest as harmful emissions because the difference between MGO and LNG is known to be considerable. The same applies to TVOC emissions. Based on the composition of LNG (table 3), the amount of TVOC strongly indicates the residual methane in the flue gases. Furthermore, the carbon monoxide level is a good indicator of the completeness combustion process, although there are no limit values set for CO emissions.

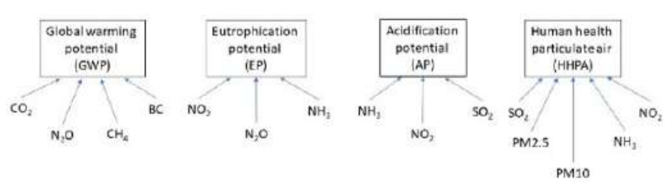
2.2. *Sustainability index.*

A direct comparison of MGO and LNG is challenging because the emission components produced by these fuels affect the environment in different ways. However, this is a key research problem, especially when considering the generalizability of the results to other LNG ROPAX vessels operating in the Baltic Sea region. This study compares the differences in emission compositions with fuel solutions (MGO and LNG) using the sustainability index.

The sustainability index describes environmental and economic indices and is based on generating, weighting, and aggregating these indices into an overall sustainability index (Iannaccone et al., 2020). For all the indexes, the highest value indicates the worst alternative. In this study, the social aspect of sustainability has been left out of the comparison because the aim is limited by the emission measurements performed. A detailed description of the sustainability index approach can be found in our previous publication (Altarriba et al., 2022), which examined the effect of fuel price, particle reduction, and black carbon.

The environmental index includes four environmental impact categories: Eutrophication potential (EP), acidification potential (AP), global warming potential (GWP), and human health particulate air (HHPA). These categories have been assessed as the most significant environmental impacts of shipping (Bengtsson et al., 2011). Global warming, acidification, and human health particulate air potentials are estimated effects on the air, and eutrophication potential concerns the aquatic environment. Figure 1 shows the emission components affecting the various categories. However, it should be noted that only the components presented in the previous section were measured from the ship, so we do not have measurement data on, for example, black carbon (BC) or particles produced by the ship. The same characterization factors as in the previous study are used to score the environmental indicators (Altarriba et al., 2022).

Figure 1: Emission components that are affecting to different potentials.



Source: Authors.

This specification follows the approach published by Iannaccone et al. (2020) and includes three different annual navigation activities, such as berthing, maneuvering, and navigation in the open sea (Maragkogianni & Papaefthimiou, 2015). This means that the estimation of impact categories is based on annual emissions and thus provides a broader view of the estimated impacts than individual emission measurements. Especially on a route such as this, where the ship operates on a fixed route and schedule, such a generalization can be performed reliably. The total fuel consumption of the ship is estimated using the same principle as Åström et al. (2018) have presented; the aid of engine size [kW], load factors, and annual hours at berth (HB), at sea (HS) and maneuvering (HM). The load factors at sea and main engine power are shown in table 8, and the following values are used for annual hours: HS=4375 h, HM=3646 h, HB=729 h. The annual number of hours figure is based on an estimate of the ship's normal activity during a 24-hour period. In this study, the ship's exhaust gas emission factors and specific fuel consumption are based on the measurements (table 8). The fuel production emission data is based on the work of Bengtsson et al. (2011).

The financial viability of alternative projects is evaluated using the Net Present Value (NPV) method (Iannaccone et al., 2020; Pohl & Nachtmann, 2011). The parameters of the economic index are obtained or evaluated based on literature and are shown in Table 6. Since no external emission reduction technology is used, the only investment cost is the additional cost of the LNG-powered dual-fuel engine compared to a normal diesel engine investment. In this case, this one-time investment naturally applies to both fuels, but the purpose of the distinction is to show the difference to normal diesel engines, which generally has cheaper investment costs than dual-fuel ones. The project lifetime has been set at 25 years, as the technical lifetime of an LNG engine is similar (Åström et al., 2018).

There are four different fuel prices estimation for both LNG and MGO. The average price estimate is based on values from Åström et al. (2018). The current figures have been estimated based on average prices from 2021 and 2022 in different time intervals. Currently, it is difficult to assess the accuracy of fuel price scenarios, especially for LNG. The price of LNG was very predictable for a long time without any significant changes. At the end of 2021 due to international political tensions the price of LNG has been very volatile. Since the outbreak of the war in Ukraine, large price fluctuations have been seen in a very short time. Whether this volatility will continue or the price will settle at a stable level is difficult to predict.

Table 6: Economic parameters.

Variable	Unit	Value	
Proj. lifet.	years	25	
LNG eng.	€/kW	800	(in ad. to norm. inv.)
Env. tax	€/tCO_2	100	(source: IEA 2021)
Disc. rate	[%]	8	
LNG	€/t	610	(mid)
		3538	(current 1)
		1961	(current 2)
		1725	(current 3)
MGO	€/t	885	(mid)
		1084	(current 1)
		1135	(current 2)
		888	(current 3)

Source:Authors.

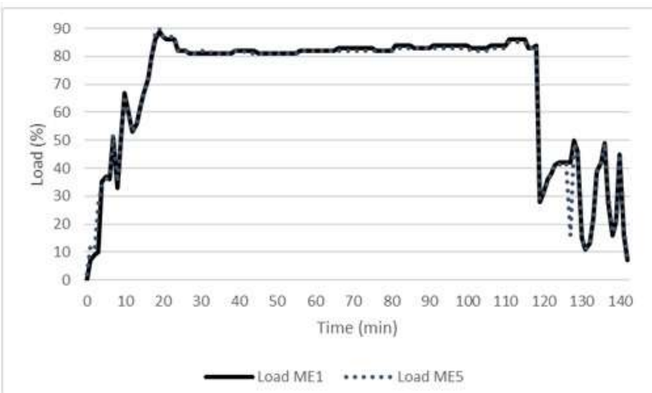
The normalization of the indicators has been performed following the same procedure as Bare et al. (2006) and Iannaccone et al. (2020). In this study, the same reference values have been used for normalization as in the previous study (Altarriba et al., 2022). The selected values are based on literature sources (Crenna et al., 2019; Iannaccone et al., 2020; Laurent et al., 2013; Sleeswijk et al., 2008). The same weighing values are used for the environmental and sustainability indexes.

3. Results.

3.1. Measurement results.

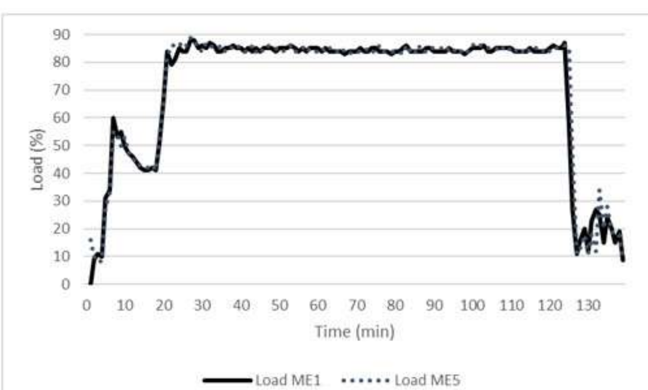
The on-board emission measurements were carried out on 21 June 2022 during two measurement sessions. MGO was used as fuel in the first leg and LNG in the second. The route and schedule are constant, which makes the operating profiles very similar. The voyage takes about 140 minutes, mostly at constant power. Approaching and maneuvering in both ports takes about 20 minutes. Figures 2 and 3 show the load profiles for both main engines (ME1 and ME5) running during both voyages. Both engines are loaded evenly.

Figure 2: Engine loading profiles, leg 1.



Source: Authors.

Figure 3: Engine loading profiles, leg 2.



Source: Authors.

We are particularly interested in two things: How much do the emission profiles of different fuel solutions differ with a constant load in real conditions, and how does operating at partial load affect the generation of emissions? The importance of this latter issue increases when operating on short and/or archipelago fairways. The most significant differences in the amount of emissions are found in the levels of nitrogen oxides and methane emissions, which is why they are the focus of this study. Real conditions present challenges that can be excluded in laboratory conditions. For example, between leg 1 and 2, in the first half, the load of the engines is slightly lower in leg 1 than in leg 2. Therefore, the emissions produced by ME1 are compared in two 60-minute-long periods. The measuring devices are only sufficient for measuring one engine at a time. The operating period of MGO in ME1 is measured at 08:00-09:00 (UTC +2, timestamps in figure 2 are 51-111 min) and LNG at 11:00-12:00 (timestamps in figure 3 are 48-108 min). The average fuel consumption has been 193.2 g/kWh (MGO) and 172.2 g/kWh (LNG). The mean, median, and deviation for each operating mode are found in tables 7 and 8 for both fuels, including measured average values for CO_2, CO, NO_X, and TVOC.

Table 7: Measurement results with MGO.

Var.	Unit	Mean	Med.	Dev.
load	%	83.0	83.0	1.0
fuel cons.	kg/h	1827.2	1838.3	15.4
spec. cons.	g/kWh	193.2	193.4	3.6
pwr	kW	9458.3	9462.0	117.7
CO_2	kg/h	5935.2	5971.2	50.0
CO	ppm	19.5	19.7	1.0
NO_X	ppm	865.4	865.0	3.3
TVOC	ppm	10.4	10.5	0.2

Source:Authors.

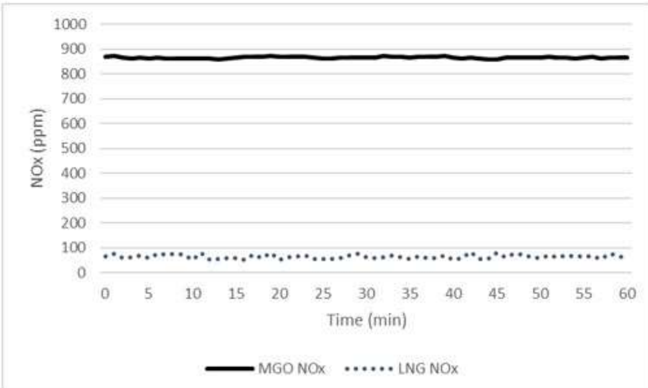
Table 8: Measurement results with LNG.

Var.	Unit	Mean	Med.	Dev.
load	%	84.4	84.4	0.7
fuel cons.	kg/h	1657.2	1652.0	52.4
spec. cons.	g/kWh	172.2	172.2	5.6
pwr	kW	9624.6	9576.0	76.4
CO_2	kg/h	4589.3	4580.5	152.7
CO	ppm	240.7	241.3	15.1
NO_X	ppm	64.4	63.3	8.5
TVOC	ppm	1533.4	1539.4	71.2

Source:Authors.

During the measurement period of LNG and MGO fuels, the load deviates slightly (83.0% and 84.4%), but this difference is not estimated to affect the results significantly. Carbon dioxide emissions closely follow fuel consumption, but high CO emissions in LNG operations indicate a more incomplete combustion process than in MGO operations. As expected, the differences in NO_X emissions are large. The concentration measurement data of the average values shown in tables 7 and 8 are presented in Figure 4. The difference is significant, but interestingly the momentary variation of NO_X emissions is perceptible, although not significantly larger compared to the emissions generated in MGO operations.

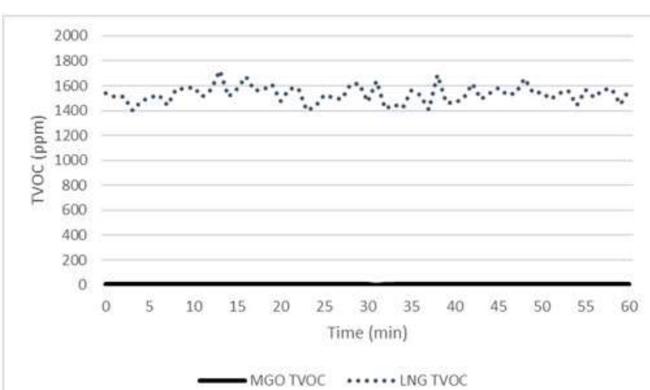
Figure 4: NO_X emissions with LNG and MGO.



Source: Authors.

TVOC-emissions (total concentration of volatile organic compounds) are unburnt fuel, which in practice means HC-emissions for MGO and mainly unburnt methane with LNG. The LNG composition, in this case is 90.32% (mol) methane and 8.05% (mol) ethane (Bunker delivery note of LNG, 2022). In addition, the gas contains small amounts of propane (1.201%) and other gases such as butanes and pentanes. A diesel engine operating with excess air does not leave many unburnt fuel components in the exhaust gases, but when using LNG, the TVOC concentrations are considerable (table 7 & 8). The variation in NO_X emission concentrations should also be considered (Figures 4 and 5).

Figure 5: TVOC emissions when using LNG and MGO.



Source: Authors.

The average emission levels measured in these periods per consumed fuel (g/kg$_{fuel}$) and specific fuel consumption (g/kWh) are shown in table 9. The conversions have been performed based on the ship's voyage data obtained from the engine control system (Valmet DNA, see table 5).

Table 9: Emission levels per fuel type.

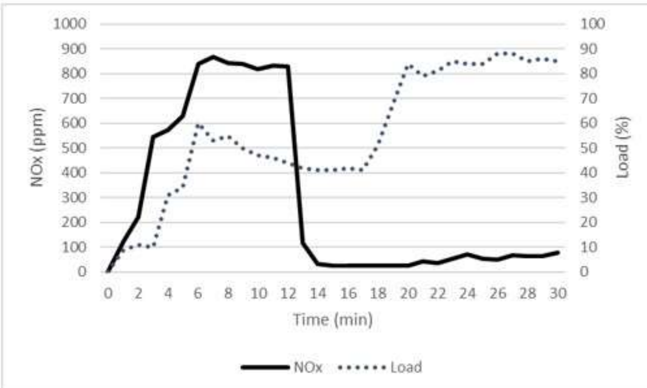
Comp.	MGO (g/kg$_{fuel}$)	LNG (g/kg$_{fuel}$)	MGO (g/kWh)	LNG (g/kWh)
CO_2	3206	2743	619.4	472.4
CO	0.7	8.60	0.14	1.48
TVOC	0.22	32.29	0.04	5.56
NO_X	51.23	3.77	9.90	0.65

Source:Authors.

Carbon dioxide emissions directly depend on the fuel consumed, although in the case of LNG, these emissions per kilogram of fuel burned are lower than MGO. The difference in nitrogen oxide emissions between fuel types is large, which is a well-known characteristic of LNG. MGO has a low sulfur quality (0.08%), so sulfur emissions are low without the use of treatment systems (1.33 g/kg$_{fuel}$ or 0.26 g/kWh). LNG is practically sulfur-free, so there are no sulfur emissions except for the sulfur in the pilot fuel. Measured SO_2 levels for LNG were close to MGO (1.11 g/kg$_{fuel}$ and 0.19 g/kWh), but this is due to equipment measurement error due to the increased amount of CO. There are no legal emission limits for carbon monoxide concentration, but it is listed in table 9 because high CO concentrations indicate an incomplete combustion process. The CO emissions produced by LNG are about ten times higher than the combustion of MGO, even though the engine operates on a fairly optimal load range (tables 7 & 8). This is reflected in high TVOC emissions, too.

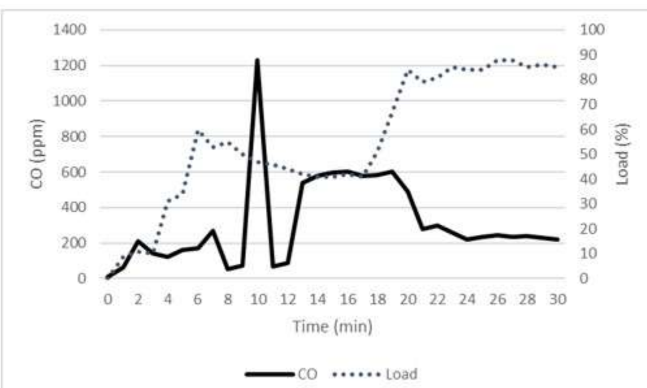
When a gas-powered engine is partially loaded, the share of methane emissions increases considerably. In general, partial loading is avoided for economic reasons, but special situations, such as operating on archipelago fairways, suboptimal scheduling, waiting times in anchorage areas, or using engines during port operations, often require partial loading. During the measurement session performed in leg 2 (figure 3), the engine is partially loaded during the first twenty minutes. In addition, the fuel has been changed during the middle of this period, and for this reason, the measurement period is examined more closely. In the Wärtsilä 12V50 engine, the fuel change from LNG to MGO can be done without significant delay. However, when switching to LNG, the process is slightly longer: The transition takes about 2-3 minutes to minimize disturbances in the gas supply system, and the engine load must be below 80%. Figures 6-8 show the NO_X (figure 6), CO (figure 7), and TVOC (figure 8) emission levels when the transition to gas has been performed in timestamps of 10-13 minutes. Immediately after the transition, NO_X emissions are minimized, and CO emissions increase significantly. However, the biggest change occurs in TVOC emissions. When operating at partial load (time stamps 12-20 min), the TVOC emissions are significantly high, and when cruising speed is reached, the level remains relatively high compared to the period when the engine is operated with MGO (figures 4 and 5, tables 7, 8 and 9).

Figure 6: Change in NO_X emissions during fuel and load changes.



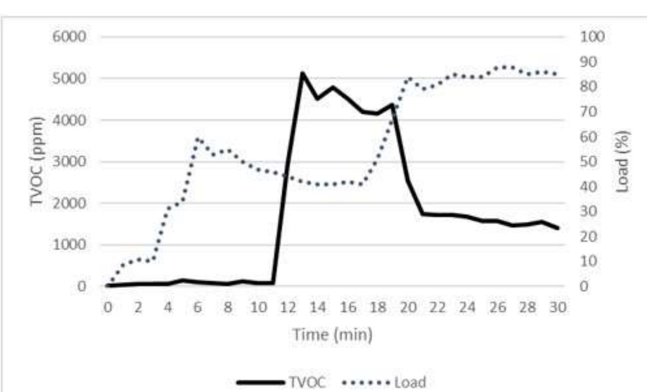
Source: Authors.

Figure 7: Change in CO emissions during fuel and load changes.



Source: Authors.

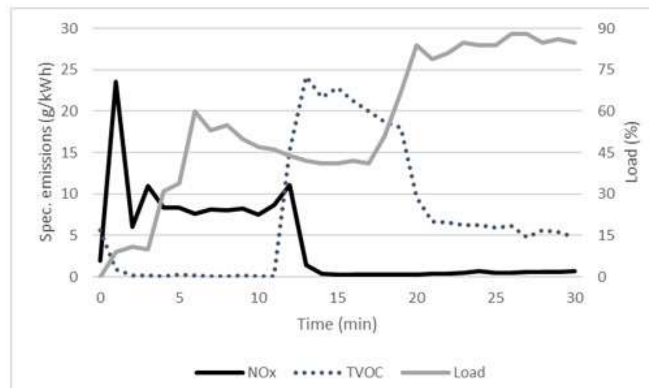
Figure 8: Change in TVOC emissions during fuel and load changes.



Source: Authors.

Figure 9 shows NO_X and TVOC-specific emission levels (g/kWh) for the same period as the data figures 6-8. In addition, the engine load has been added to the diagram. From the start, large calculated changes in specific emission levels can be found, but the more relevant period is the partial load phase at a time step of about 5-20 minutes and the fuel change event at 11-12 minutes. During this period, the average NO_X emissions are 8.00 g/kWh between 5-10 minutes and fall to 0.45 g/kWh (period 15-30 minutes) after the fuel change. Regarding TVOC emissions, there is more variation. In 5-10 minutes, the average was 0.13 g/kWh; in 13-18 minutes, 21.45 g/kWh; and finally, in 25-30 minutes, 5.45 g/kWh. The measurement periods are short due to the normal operation of the ship, but partial loading produces relatively significant TVOC emissions, which, when operating with LNG, are mainly methane.

Figure 9: NO_X/TVOC specific emissions in relation to load.



Source: Authors.

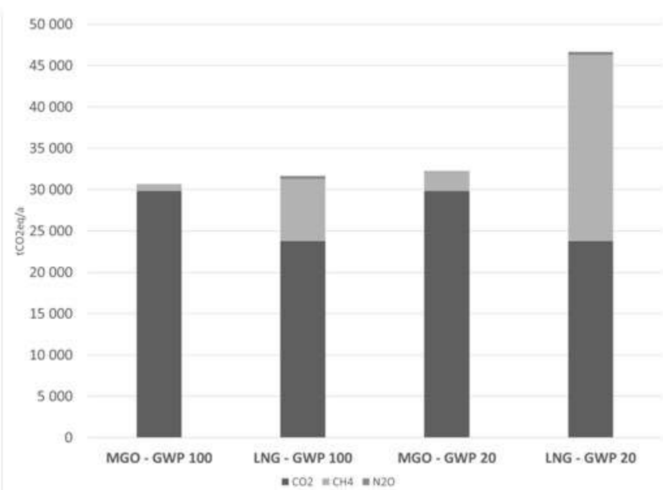
3.2. *Results from sustainability index calculations.*

The comparison of MGO and LNG using the GWP, environmental, and sustainability indices is shown in the following figures 10-12. Figure 10 presents the global warming potential calculated for twenty and one hundred years. The GWP results are presented as an annual amount as previously described. Although LNG produces lower CO_2 emissions per kilogram of fuel burned, this index gives methane much weight when evaluating the global warming impact (figure 10). However, as a short-term gas methane highlights the short-term warming effect. In general, the hundred-year GWP is used as a measure of the relative impact of different GHGs and, for example, the US has adopted this as the primary approach.. However, in this context Lindstad et al. (2020) have emphasized the relevance of twenty-year GWP values because of the urgent need to reduce GHG emissions.

The difference between the alternatives is minimal on the scale of a hundred years. LNG emits approximately 3% more GHGs than MGO. In particular, the difference is minor when the uncertainties related to fuel production and transport chain emission assessments are considered. The difference increases drastically to 45% when the time scale is changed to twenty years. In the literature, the difference between the GWP100 results was 8% in favor of MGO to LNG when considering a similar engine (LPDF medium-speed, 4-stroke engine) as in the current measurements (Pavlenko et al., 2020). On a twenty-year scale, they showed that "an LPDF medium-speed, four-stroke emits 62% more lifecycle GHG emissions than an MSD using MGO" (Pavlenko et al., 2020). Their study had a more comprehensive estimation of upstream emissions.

As mentioned in the previous section, BC emissions affect GWP results, but they were not measured in our project and have been excluded from the analysis. The BC emission factors of MGO are also load-dependent (IMO, 2020), as methane emissions of LNG and BC emission levels of the LNG ships are significantly lower compared to diesel alternatives. The characterization factor for BC changes drastically from GWP100 (900) to GWP20 (3200) (Comer et al., 2017). Therefore, measuring and considering BC emissions would be important in future studies so that the comparison of alternatives would be fair. For example, in our previous study based on values from the literature, black carbon contribution ranged from 0.4 to 13.5% GWP for comparable MGO, LNG, and HFO alternatives (Altarriba et al., 2022).

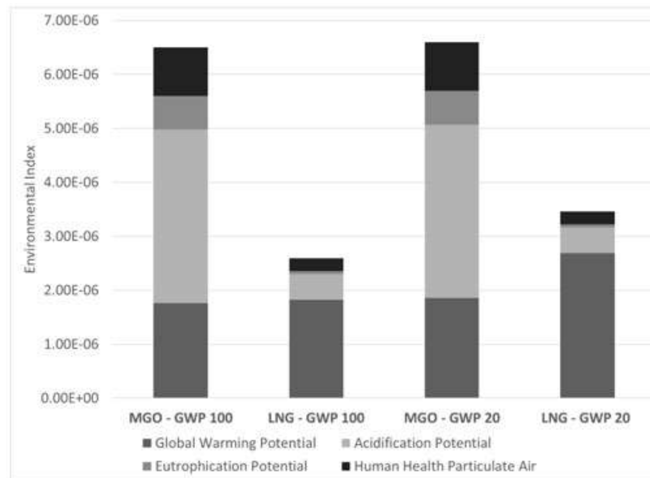
Figure 10: Global warming potential for MGO and LNG with different time scales.



Source: Authors.

In figure 11, the environmental index has been calculated for both fuels on both a hundred- and twenty-year scale. The overall environmental index combines several environmental impact categories described in the previous section. Thus, it is possible to compare alternatives with other environmental effects than, for example, climate impacts alone. Although the global warming potential, especially in the short term, does not favor LNG as an environmentally friendly option, the difference between MGO and LNG increases when other factors are added to the index. In figure 11, environmental indices at the hundred- and twenty-year scales are divided into components, including global warming, acidification and eutrophication potentials, and human health particulate air factor to show the relevance of each impact category. The acidification and eutrophication potentials favor the use of LNG. Low nitrogen oxide emissions of LNG significantly impact these two categories. There is a significant difference between alternatives in the human health index. In this study, the particle matter (PM) emissions were excluded from the measurements and, thus, also from the calculations. However, particle emissions are known to be relatively low, especially with LNG therefore, the difference could be even greater in favor of LNG. The significance of each category could be altered by using different weighting values and an expert panel could be used to evaluate the values.

Figure 11: Environmental index calculated for MGO and LNG for GWP100 and GWP20 potentials.



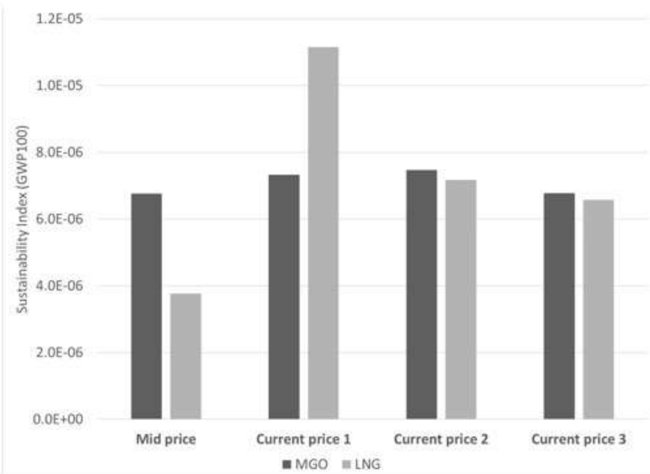
Source: Authors.

The sustainability index of both MGO and LNG, which combines environmental and economic indices, is shown in figure 12. In the mid-fuel price case, MGO receives higher values and therefore LNG is the more tempting option. However, during 2021-2022, LNG prices have fluctuated strongly due to the international political situation. Predicting how the price level of LNG (or fuel oils) will settle in the next few years or decades is challenging. The effect of the fuel prices is clearly visible. The fluctuation of the price of MGO has been lower than that of LNG, so the index values of MGO are at the same level. The greater overall environmental benefit of LNG disappears when current fuel prices are considered. Either the difference is very small (current price 2 and 3), or LNG is the worst option (current price 1). Thus, LNG can become an alternative with a 44% lower sustainability index values or 52% higher values than MGO. These values are on a hundred-year scale, so the results would even be negative for LNG even if the time scale were shorter. This shows how challenging the current environment is for maritime investment planning.

4. Discussion.

High expectations have been placed on LNG as a transitional fuel solution over the past decade. The continuation of strong natural gas price fluctuations caused by the war in Ukraine is difficult to predict, and it greatly impacts the competitiveness of gas as a fuel for maritime transport. On the other hand, the proliferation of multi-fuel engines in new ships enables the flexible use of different fuel solutions, such as the utilization of

Figure 12: Sustainability index.



Source: Authors.

biogas instead of fossil natural gas. This also applies to the possible future spread of synthetic oil and gas fuels (Speight, 2020; Wahl & Kallo, 2022). However, changing the systems always has a two-way effect.

Regarding carbon dioxide emissions during the ship's life cycle, it is clear that a ship's operation at sea dominates the generation of emissions: 96% of emissions consist of operation, 2% from construction, 0.9% from maintenance, and 0.8% from disposal (Chatzinikolaou et al., 2015). The well-to-wake analysis of fossil fuels shows the dominance of emissions during a ship's operation when the proportion of emissions generated in the refining processes or fuel distribution remains low. In practice, low-emission solutions must be sought primarily by reducing emissions during normal operation. However, the situation may be different for new, non-fossil fuels, and most of the emissions may occur during production, for example when producing biofuels. As a result, major changes are needed in assessing the harmfulness of different processes.

Methane slip is a typical characteristic of low-pressure LNG diesel engines (LPDF) (Aakko-Saksa et al., 2023; Grönholm et al., 2021), which is confirmed by our research. The measured levels of methane slip correspond well to previous observations, for example, Sintef has shown 5.3 gCH_4/kWh for LPDF engines (Stenersen & Thonstad, 2017), the same engine type as the Wärtsilä 12V50. So far, methane slip has been accepted, although the FuelEU Maritime proposal does set limits on methane emissions (European Commission, 2021b). However, the dependence of methane slip on engine load is something that has received relatively little attention, even though it is well-known in principle. This remains in a marginal position when looking at large entities, such as the spread of LNG ships worldwide and their operation in the open sea with a constant engine load.

On the other hand, it can have a surprising effect on the overall level of greenhouse gas emissions of the ship, for example, during slow steaming, navigation in archipelago fairways, or on short routes. The degree of methane slip depends strongly on the engine load level, and this depends on the design suitability of the vessel for slow steaming. Diesel-electric propulsion provides flexibility as some of the main engines can rest while others operate in the optimal load range. In shaft-powered solutions, this is more complex, and even diesel-electric ships can operate sub-optimally. In general, route planning focuses on entirely different issues than increased methane emissions during partial load operation. From this perspective, the increased methane emissions during partial load operation are not as marginal as it might seem.

There are numerous short ferry routes operating in the Baltic Sea, especially in the Gulf of Finland, between Finland and Sweden, and the Arkona basin. On short routes, port maneuvering and running of engines in ports play a relatively larger role in the operating profile than in the long-range open sea routes. Route-specific variations are large, as some ships operate daily non-stop traffic, and some others voyage at night, staying in port during the day. In addition, the Archipelago Sea and the front of Stockholm have significant archipelago fairways where voyage speeds remain low. Methane emissions are likely to be high on these routes, but LNG has the advantage of non-existent SO_2 and low NO_X emissions. This advantage is highlighted in terms of people's health when operating in the immediate vicinity of settlements and ports. The presented results of the environmental index also show the superiority of LNG in this respect. The findings of Iannaccone et al. (2020) show similar conclusions, although in their study emissions from fuel production were omitted, and the emission coefficients were based on values from the literature.

The energy crisis caused by the war in Ukraine has increased the price of fossil natural gas. The sustainability index results of this study show drastic changes in the results due to fuel price fluctuations. Even if a solution to the current international situation is found and the energy market normalizes, more attention must be paid to the reliability of energy supply. Crude oil and natural gas production is geographically concentrated in areas that are politically unstable or where political rule is based on oligarchy or dictatorship. In previous oil crises, this political risk was realized. However, there are more and more alternatives to fossil fuels, and synthetic fuels are one such solution (Speight, 2020). However, the production of synthetic fuels is energy-intensive, but in an ideal situation, the production process can be integrated to utilize renewable energy sources such as wind power, which could, in turn, smooth out the natural fluctuations of wind energy production.

Sufficient production requires the establishment of a completely new industry, taking fuel needs into account and this means that there are no quick solutions available. The situation and the EU's climate goals also create longer-term political pressure for investment (European commission, 2021a). Implementing the FuelEU Maritime regulation (European commission, 2021b) requires reducing the carbon intensity of marine fuels and therefore, synthetic fuels could be one solution. However, investments in Finland arouse much interest because there are no regional sources of oil or gas. The manufacturing process enables the recovery of carbon dioxide, reducing the need for the industry's emission allowances. In addition, a comprehensive district heating network has been built in the country, which can be used as a target for this process heat and thus improve the overall economic level of production. The end of natural gas imports from Russia in the spring of 2022 also motivates the development of alternative solutions instead of fossil LNG imports. If synthetic fuels succeed in the market, there will probably be demand for them outside of Finland and Europe as well. It is not unusual for a crisis to act as a catalyst for the development of new solutions.

The regional demand for methane in maritime transport also increases interest. LNG ships operating fixed lines from Finnish ports offer a regional customer base for synthetic methane. Of the synthetic fuels, methane is directly suitable for current dual-fuel engines, in which case additional investments in engine technology are not needed either through retrofits or new ship investments. This is a clear advantage compared to methanol or ammonia. However, in the long term, one uncertainty factor is the transformation in the energy supply of the rest of society. If, for example, methanol breaks through as a fuel in other sectors, its competitiveness as an alternative can increase significantly in maritime transport as well. Although synthetic methane is not a fossil fuel, it produces carbon dioxide emissions. In the production process, the source of carbon can be based on fossil fuels, in which case the solution itself does not necessarily prevent the increase of carbon in the atmosphere. With current internal combustion engines and fuels, reducing emissions can mainly be focused on the end user while examining synthetic fuels the focus should be on the emissions of the entire chain.

Methane emissions do not change whether the fuel is from fossil gas or synthetically produced, but the reduction of methane slip applies to ships operating with synthetic gas. In practice, the combustion process of engines must be developed, or alternatively, methane can be reduced from exhaust gases with catalyst solutions. As far as synthetic fuels are concerned, even more attention must be paid to the entire life cycle of fuel products, so that the necessary actions can be targeted effectively. This applies to new fuel solutions in general. The emissions of fuels such as ammonia or methanol under real operating conditions are an important future research topic. The goal should be to avoid a situation where a technical solution is initially recommended, and a decade later this recommendation is found to be incorrect.

Conclusions.

This paper discusses the differences between MGO and LNG as fuels from an emissions perspective in real-world conditions. To verify the emission levels measurements have been performed on a ROPAX ship operating in the Baltic Sea. MGO and LNG were used alternately as fuel. The ship is equipped with dual-fuel engines without separate emission treatment systems. Engine running data is obtained from the engine control system. The measurement results have been presented, and their environmental effects have been considered using the sustainability index method. Methane emissions have a strong impact on climate, even though their total amount is small.

On the other hand, NO_X emissions are low, and SO_2 is practically non-existent, which favors the use of LNG. However, the indices show that fuel prices also play a decisive role in the overall analysis. In the future, maritime transport will likely see alternative fuel solutions, such as biofuels, methanol, or ammonia. The general environmental effects of these still require further research in many respects. Therefore, to be able to compare them with current solutions, additional information on real operating conditions is still needed.

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The Impact of Diverse Culture Towards Safety Onboard Ship

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ABSTRACT

This study determined the impact of diverse culture towards safety onboard ship. The tendency to employ diverse culture crews is not without any problem. The consequences for both the employers and the crews, such as miscommunication, communication constraints, alienation and discrimination due to race, culture and religion differences, cannot be avoided. Those consequences may lead to serious safety risks onboard when not being overcome. This study will review the tendency of employing diverse culture crews, as well as the cultural background and characteristics. The employment of diverse culture crews has become widespread. This practice brought a number of problems in communication, including cultural misunderstanding among crew on board as it was criticized as one of the major causes of marine accidents. This study determined the impact of diverse culture towards safety onboard ship of the 30 respondents using descriptive-quantitative method. Thirty (30) respondents were the Basic Training Refresher Course inside the Cebu Technological University Carmen Campus. Given the current scarce resources of research on cultural awareness, the respondents possess a sufficient level of awareness regarding interacting with diverse cultures. Utilizing an international language for communication can contribute to establishing a more inclusive and secure work environment. Also, the respondents display a sufficient level of responsibility when engaging with different cultures. In general, they possess knowledge regarding potential issues or scenarios that may arise during intercultural interactions in the seafaring industry.

1. Introduction.

In the society, people might have many differences. Hence it isn't a hindrance to come up as one. On board ship it is hard having a co-worker with different language, culture, and ethnicity. We come up with this study in order to know what are the possibilities in coping up other's perspective of life, the way they live, and their view towards life as a human being. Safety is important onboard ship, that is the number one priority of everybody.

In the shipping industry, the practice of employing a ship with a crew that is culturally diverse is nothing new. However, merging crews can simply result in possible misunderstandings or communication difficulties. Digging deeper into the maritime industry, questions have been raised, regarding the conditions does the presence of multicultural crews influence the safety of the shipping industry? With modern shipping being open to multicultural and multilingual crewmembers, a lot of the recent human errors and accidents are caused by communication lapses. Many believe that miscommunication only exists between different nationalities; however, there are crewmembers of the same nationality but were raised in different origins or with different principles and still have misunderstandings amongst each other. While facing extended lengths of time on board, it might be difficult to deal with the diversity of people whose ethnicity involves distinctions in language, culture, and religion in addition to ethnic imbalances in terms of race (Daniels, Daija M. 2017).

Lack of multicultural awareness and cross-cultural understanding has reared its head in the shipping industry. It's been a

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factor in seafarer retention, at times for accidents and environmental damage, and can affect seafarer safety and well-being on board. An inability to foster cultural competence affects the shipping industry's bottom line.

Multiculturalism is a general feature of crews of today and in these languages play a crucial role (Silos et al 2012). About 70-80 % of world's merchant fleet has multicultural crews (Magramo & Cellada 2009; Pyne & Koester 2005). Multicultural crews and a possible lack of a common language have produced a rising worry of the competence of ship crews. Globalization has also led to major changes in ownerships as shipping companies grow internationally. Ideally this could further lead to a more organized training of professional crews in all ranks and nationalities (Lane 1999). The question remains if this is the case. Do more agents cause a more diverse culture of different degrees and qualifications? This is of crucial interest especially when technological advances have cut down the number of crewmembers, from what used to be 40-50 to about 20-25 even on large carriers (Ljung 2010).

2. Methodology.

The researchers implemented a simple descriptive-quantitative for the respondents. The design used to survey are questionnaires, which will be distributed to the respondents in order to attain the main objective which is the impact of diverse culture towards safety on board ship. The said survey will be our guide to analyze and interpret the status of respondents.

3. Results.

Table 1: Status of Employment Profile of the Respondents.

Status of Employment	Frequency	Percentage
Permanent	12	40%
Temporary	17	56.6%
Other	1	3.3%
TOTAL	**30**	**100%**

Source: Authors.

As shown in the table above, the status of employment profile of respondents is permanent, temporary and other. According to the data gathered, twelve (12) or 40 percent of the respondents were permanently employed; seventeen (17) or 56.6 percent of the respondents were temporarily employed and one (1) or 3.3 percent of the respondents prefer not to say or other. Based on the gathered data, it can be inferred that majority of the respondents were temporarily employed.

As shown in the table 2, the length of service profile of the respondents ranges from below 1 to 25 years and above in service. According to the gathered data, one (1) or 3.3 percent of the respondent belongs to the range of below 1 year of service; another one (1) or 3.3 percent belongs to the range of 1 to 2 year in service; seven (7) or 23.3 percent of the respondent belongs to the range of 3 to 4 years of service; eight (8) or 26.6 percent of the respondent belongs to the 5 to 10 years of service; four (4) or 13.3 percent of the respondent belongs to the range of 11 to 15 years of service; two (2) or 6.6 percent of the respondent belong to the range of 16 to 20 years of service and six (6) or 20% of the respondent belongs to the range of 25 years and above of service. Based on the gathered data, it can be inferred that majority of the respondents were 5 to 10 years in sea duty.

Table 2: Length of Service Profile of the Respondents.

Length of Service	Frequency	Percentage
Below 1	1	3.3%
1-2	1	3.3%
3-4	7	23.3%
5-10	8	26.6%
11-15	4	13.3%
16-20	2	6.6%
21-25	1	3.3%
25 and above	6	20%
TOTAL	**30**	**100%**

Source: Authors.

Table 3: The Level of Awareness in terms of Cultural Differences.

	Statement	Mean	Interpretation
1	I am aware of my actions when interacting with people while working onboard.	4.53	OAL
2	I usually anticipate to adjust my behavior whenever. I am interacting with my fellow seafarer from culture that is unfamiliar to me.	4.4	OAL
3	I am aware of how. I react when speaking with co-workers from other cultures.	4.7	OAL
4	I am certain of my awareness as I interact with people from different cultures.	4.56	OAL
5	I consciously reflect on how culture affects beliefs, attitudes and behaviors.	4.13	EAL
6	I often generalize my cross-cultural experiences as a guide for my intercultural interaction in the future.	4.06	EAL
7	I become more comfortable interacting with people from different cultures in different working settings as time goes by	3.43	EAL
8	I am aware that my country's culture has a broad influence on my beliefs, attitude and behavior.	4.3	OAL
9	I understand the responsibility of my roles onboard and have my own standards about my work performance.	4.46	OAL
10	I am aware with the different countries culture, traditions and religious beliefs.	3.93	EAL
11	The seafarer's own professionalism cultural values and beliefs can contribute a good performance in the seafaring decision and communication styles during working.	4.4	OAL
12	I believe some aspects of the onboard vessel organizational factors (leadership style, cultural climate, organizational processes) may alienate and discourage seafarers from certain national cultures.	3.7	EAL
13	In my seafaring experience, management level onboard seems interested in learning how their behaviors may discourage seafarers from certain cultural or ethnic groups.	4.33	OAL
14	I understand that seafarers from different national cultures might have different understanding about safety and safety culture, which would influence their performance of their assigned duties and tasks.	4.36	OAL
	OVERALL	**4.12**	**EAL**

Source: Authors.

Table above, shows that based on the responses upon the survey conducted on random seafarers on The Level of Awareness in terms of Cultural Awareness during the data gathering procedure shows that respondents rated **Excellent Awareness Level** which is the **Influencing Factors** grand mean is **4.12**.

Table above indicates that the respondents possess a sufficient level of awareness regarding interacting with their fellow seafarers anticipate and usually adjust to the language and behavior whenever they are interacting with others to prevent misunderstanding and maintain safety practices.

The awareness of the respondents enables them to be conscious on the attitude and belief of the others at the same time they are responsible enough to be mindful on their differences to hinder the possibility of misunderstanding. Skopinskaja, L. (2003) stated in their research that, they use the term cultural awareness to describe sensitivity to the impact of culturally-induced behavior on language use, communication and other cultural representations such as beliefs, values, life styles, attitudes and feelings.

Table 4: Influencing Factors.

	Statement	Mean	Interpretation
1	My communication skills enable me to change my verbal behavior (e.g. accent, tone, choice of words and expression) when a cross-cultural interaction requires it.	4.4	OAL
2	I prefer to speak English in working situations even though my colleagues maybe my national fellow.	3.93	EAL
3	The MET institution or training center I attended have adequately address cultural issues by providing relevant courses.	4.26	OAL
4	My study experience at MET Institution or training center have provided me intercultural activities to help me become knowledgeable about the possible problems or situations associated with various intercultural interactions in seafaring.	4.43	OAL
	OVERALL	**4.26**	**OAL**

Source: Authors.

Table above shows that based on the responses upon the survey conducted on random seafarers about Influencing Factors during the data gathering procedure shows that respondents rated **Outstanding Awareness Level** which is the grand mean is **4.26**.

Table above demonstrated that the respondents display a sufficient level of responsibility when engaging with different cultures. In general, they possessed knowledge regarding possible problems that may occur onboard due to multicultural and multilingual crews and potential issues or scenarios that may arise onboard. As utilizing an international language will come up to clear conversation for communication can contribute to establishing a more inclusive and secure work environment. As stated by Daniels (2017) individuals working in this field are required to possess the ability to communicate effectively I maritime English and adhere to safety protocols.

3.1. Summary of the Result.

Based on the findings and conclusions of this inquiry the following recommendations are hereby given.

1. International language proficiency course for seafarers. Respondents possess a sufficient level of awareness regarding interacting with diverse cultures. Utilizing an international language for communication can contribute to establishing a more inclusive and secure work environment. As stated by M. Daniels, 2017, individuals working in this field are required to possess the ability to communicate effectively in maritime English and adhere to safety protocols.
2. Respondents possess a sufficient level of awareness regarding interacting with their fellow seafarers anticipate and usually adjust to the language and behavior whenever they are interacting with others to prevent misunderstanding and maintain safety practices.

Conclusions.

The shipping sector has been significantly impacted by changed and as a result of globalization and the continued economic integration of the world economy. Since the 1980s, using personnel of mixed nationalities has become a common practice to cut manning expenses. It is now known that the cultural complexity onboard ships is a problem for modern shipping and a major factor in maritime accidents. Stereotyping, cultural limitations, or a lack of cultural knowledge can easily result in miscommunication, poor teamwork, segregation on board, and misunderstandings.

The examination of the literature demonstrates that academics in the maritime industry have made an effort to quantify, characterize, and pinpoint the potential advantages of multicultural crews. Unfortunately, the outcomes indicate discord or disagreement. Although there seems to be broad consensus regarding the necessity of improved cultural awareness to assure safety, rigorous study on cultural awareness, including its definition, conceptual model, influencing factors, and assessment tools, is lacking in previous studies.

As a result, the training of crew for cultural awareness in the marine industry has not progressed as anticipated. To fill the identified research gap and answer the research questions, the researchers conclude that seafarers must be educated in cultural awareness and acknowledge the importance of using international language prior to working with mixed crews despite the awareness they possessed in order to prevent misunderstanding and have zero possibility on misinterpretation leading to safety risk.

4. Recommendations.

Based on the findings and conclusions of this inquiry the following recommendations are hereby given.

1. International language proficiency course for seafarers.

2. The need for cultural sensitivity training programs, enhance new constructivist learning strategies, and the promotion of culturally sensitive management in the maritime industry.

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Port Performance as a Mediation of the Influence of Infrastructure and Superstructure Quality in Realizing Efficient and Effective Logistic Cost Ports

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ABSTRACT

Objective: This study aims to test, analyze, and explain the effect of Port Performance as mediation effect of Quality of infrastructure and Quality of Superstructure on Port Logistic Cost.
Method: This study uses quantitative approach. Population of this research is N=167 shipping line companies. Research data collection method uses survey method using questionnaire. Collected data were analyzed using Importance Performance Analysis and Structural Equation Modeling.
Results: The results of empirical analysis can be concluded that quality of infrastructure and superstructure quality has significant effect on port performance. In addition, port performance has significant effect on port logistics costs. Meanwhile, infrastructure quality and superstructure quality have no significant effect on port logistics costs. However, if mediated by port performance, effect of infrastructure quality and superstructure quality on port logistics costs is significant. Based on the results of the IPA analysis, this study also provides information that most of indicators are in quadrant II. This shows that the performance of these indicators is very good. Therefore, PT. Pelabuhan Indonesia (Pelindo) II Tanjung Priok Branch must maintain this performance.
Originality: The novelty in this study lies in port performance as a mediation effect of infrastructure quality and superstructure quality on port logistics costs.

1. Introduction.

Efficiently regulated ports equipped with sufficient facilities will provide benefits for industry and trade. the facilityincludes the transportation system and infrastructure used to carry out loading and unloading as well as boarding and boarding of passengers from ships to other modes of transportation. Road access for proper transportation is urgently needed for port users. Supporting facilities such as barges and small boats are also needed to help smooth port activities.

This shows that areas with complete and good infrastructure usually have more advanced levels of social welfare, port performance and economic growth (Department of Public Works, 2006). Thus, investment in infrastructure significantly influences development (World Bank, 2004). The World Bank also states that investment in infrastructure has greater benefits than investment in other forms of capital.

Other supporting facilities besides infrastructure, namely the superstructure also plays an important role in the smooth handling of loading and unloading at the port. Ironically, there are still many ports in Indonesia that have weak infrastructure and superstructure quality. Ports in Indonesia generally have relatively short dock lengths, shallow pond depths and old port facilities. As a result, only small and medium ships can dock, while large ships choose to dock at the ports of Hong Kong, Malaysia and Singapore, which have a deeper pool depth of at least 16 meters. This condition causes export and import activities in Indonesia to still depend on other countries.

The weak quality of port facilities has been one of the trig-

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gers for high logistics costs in Indonesia. This happens because the loading and unloading process takes a long time, namely 20-25 days. As a result, loading and unloading activities are expensive compared to shipping costs. Indonesia must be able to create efficient ports and other transportation to increase competitiveness. Thus, port revitalization is the best choice that can be made, starting from quality improvement, to modernizing port facilities.

Logistics costs in Indonesia is high when compared to developed countries and other ASEAN countries because the quality of infrastructure and logistics systems is still inadequate. Lack of adequate human resources and low port performance are also the causes of high logistics costs. An increased level of performance, which comes from adequate infrastructure and systems, will minimize the logistics costs incurred.

Based on the conditions of Indonesian ports related to cost logistics that have been described above, the purpose of this study is to test, analyze, and explain the effect of Port Performance as a mediation effect of Infrastructure Quality and Superstructure Quality on Port Logistic Cost. This research was conducted in depth on the condition of Port Logistics Performance and Costs at PT. Port of Indonesia (Pelindo) II Tanjung Priok Branch. The novelty of this research is to develop a Port Logistic Cost concept or model by Ballou (1998) which involves Infrastructure Quality and Superstructure Quality which is more comprehensive and implementable at PT. Pelabuhan Indonesia (Pelindo) II Tanjung Priok Port Branch.

2. Literature Review.

2.1. Infrastructure Quality.

Based on the publication of the World Development Report (World Bank, 1994), infrastructure has a role in increasing economic growth. This means that regions with sufficient levels of infrastructure availability have higher economic growth. Infrastructure development programs in several countries identified that in outline the program's targets were implemented in the medium term with a focus on increasing basic needs and human connectivity, from water, electricity, energy, to transportation.

Infrastructure, which is the driving wheel of economic growth, can be seen as a locomotive for national and regional development. Infrastructure also has an important influence on improving the quality of life and human welfare, including increasing the value of consumption, increasing labor productivity and access to employment, as well as increasing real prosperity and realizing macroeconomic stability, namely fiscal sustainability, credit market development, and its impact on labor market (Sukma, 2015). Thus, the quality of infrastructure can be interpreted as all the basic structures and facilities, both physical and social, needed for the operational activities of a company that have added value and meet or exceed expectations.

2.2. Superstructure Quality.

Quality according to Crosby (1979) is conformity with requirements which include availability, delivery, reliability, maintainability, and cost effectiveness. According to Juran (1962) quality is conformity with the purpose and benefits. Goetsch & Davis (1994) quality is a state of dynamic conditions related to products, services, people, processes, and the environment that meet or exceed what is expected. Superstructure quality is additional facilities or equipment needed to support smooth activities at the port in accordance with the objectives and benefits of a company, so that products, services, process people and the environment can meet or exceed what is expected.

There are two types of port facilities, namely infrastructure and superstructure. Infrastructure is a basic facility, while superstructure is an additional facility at the port. Superstructure facilities are additional equipment needed for the smooth handling of ship cargo at ports such as warehouses/stacking yards, loading and unloading equipment, road networks, and so on. Superstructure is the equipment construction structure that supports port activities in waters and or land. The main tools for land and floating applications are Container Crane (CC), Rubber Trade Gantry (RTG), Top Loader, Head Truck, and Chasis, while floating equipment consists of tugboats and Pandu boats (Purwanto, 2018).

2.3. Port Performance.

Port performance or port performance is the achievement of output or level of service success, use of port facilities and equipment in a certain period of time. Port performance is reflected in the following aspects. First, ports attract 90 percent of the world's cargo transportation and international trade, due to their large volumes and lower costs compared to other modes of transportation. Second, ports are a key element in the international trade supply chain, and port efficiency is relevant to country competitiveness (Sanchez et al., 2003). Third, increasing environmental awareness can trigger demand for transportation by ship because water transportation consumes relatively less fuel compared to other modes of transportation such as rail and road (Wu & Dunn, 1995). Final, Ports serve as an economic catalyst in terms of income and jobs. A World Bank study shows that the ratio of direct income from port operations to indirect income from port-related activities is 1:5, and the ratio of direct port employment to indirect employment is approximately 1:9. (Feng et al., 2012).

2.4. Port Logistic Cost.

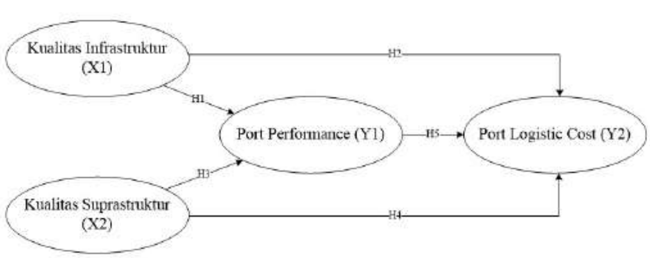
In general, logistics costs include all costs required for the transportation, storage and handling of materials required for production to the distribution, handling and delivery of finished products from producers to consumers (Bokor, 2012), where current and future profitability will be maximized by the cost-effective realization of each activity (Bartolacci et al., 2012). Therefore, the total cost of logistics needs to be clearly identified in order to understand the level of resources required to operate the logistics system (Abdallah et al., 2012). In addition, identifying the total logistics costs accurately is useful in evaluating the trade-offs between each logistics activity cost in order to optimize the use of available resources.

3. Research methods.

This study uses a quantitative approach. This approach is a type of research whose specifications are systematic, planned and structured. The location of this research will be carried out at PT. Pelabuhan Indonesia (Pelindo) II Tanjung Priok Branch in accordance with the formulation of the problem and the objectives to be achieved. The population of this research is all companies that have used the services of PT. Pelabuhan Indonesia (Pelindo) II Tanjung Priok Branch, thus the population of this study is N = 167 shipping line companies. The sampling technique used is saturated sampling technique or commonly referred to as saturated sampling. This technique is a non-probability sampling where all members of the population are used as samples

The research data collection method uses a survey method using a questionnaire research instrument with a Likert scale. The research variables are Infrastructure Quality, Superstructure Quality, Port Performance and Port Logistic Cost. The data collected in this study will be analyzed using Importance Performance Analysis (IPA) and Structural Equation Modeling (SEM).

Figure 1: Research Hypothesis Model.



Source: Author.

4. Results and Discussion.

4.1. Validity and Reliability Test Results.

This study uses a path analysis approach to estimate model parameters. Before estimating parameters, it is necessary to check the validity and reliability of each questionnaire item on each variable. A questionnaire is declared valid if the statement items in the questionnaire can show a measurement of the questionnaire. The minimum requirement for the questionnaire to be valid is if the corrected item-total r has a minimum value or is greater than the critical r (0.3). Reliability is the reliability of the instrument which shows the extent to which a measure can provide consistent results when repeated measurements are made under the same conditions with the same measuring device. Statement items are said to be reliable if they show a Cronbach Alpha (α) value > 0.60 (Solimun et al., 2017).

Table 1: Validity and Reliability Test Results.

Variable	Indicator	Correlation coefficient	Conclusion	*Cronbach Alpha*	Decision
Infrastructure Quality (X1)	X1.1	0.448	Valid	0.663	Reliable
	X1.2	0.457	Valid		
	X1.3	0.598	Valid		
	X1.4	0.431	Valid		
	X1.5	0.520	Valid		
	X1.6	0.390	Valid		
	X1.7	0.415	Valid		
	X1.8	0.643	Valid		
Superstructure Quality (X2)	X2.1	0.462	Valid	0.845	Reliable
	X2.2	0.454	Valid		
	X2.3	0.575	Valid		
Port Performance (Y1)	Y1.1	0.445	Valid	0.796	Reliable
	Y1.2	0.610	Valid		
	Y1.3	0.645	Valid		
	Y1.4	0.409	Valid		
	Y1.5	0.576	Valid		
	Y1.6	0.445	Valid		
	Y1.7	0.495	Valid		
	Y1.8	0.587	Valid		
Port Logistic Cost (Y2)	Y2.1	0.546	Valid	0.658	Reliable
	Y2.2	0.524	Valid		
	Y2.3	0.434	Valid		
	Y2.4	0.404	Valid		
	Y2.5	0.396	Valid		
	Y2.6	0.604	Valid		
	Y2.7	0.625	Valid		

Source: Author.

From the table it can be seen that the correlation value of all corrected items-total is above 0.3 so that it is said that all items have fulfilled validity. Furthermore, the table also shows that the Cronbach's alpha value of the four research variables is worth more than 0.6. From these results, the questionnaire can be declared reliable, so that the data can be used for data analysis at a later stage.

4.2. Importance-Performance Analysis (IPA).

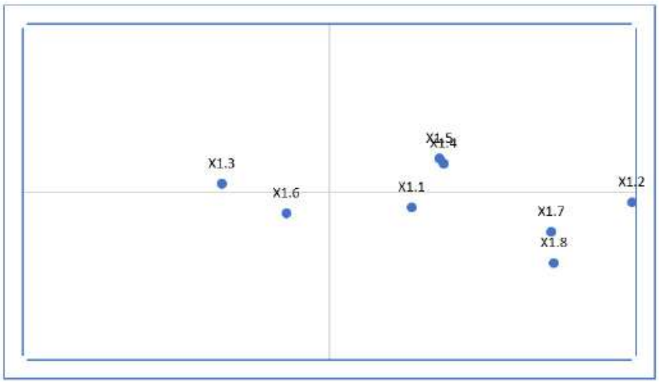
IPA was first proposed by Martilla & James (1977) to measure the level of importance and performance of a service attribute. This measurement is done from the customer perspective. The importance level shows the expectation from the customer. Meanwhile, the level of performance shows the perception of the empirical state received by the customer.

Following are the results of the importance-performance analysis for each research variable.

1. Infrastructure Quality (X1)
   Figure 2 shows that on the Cartesian chart, there is one indicator that is in quadrant I, namely X1.3. This shows that Mooring buoy (X1.3) is very important for respondents, but the level of performance is quite low, so that PT. Pelabuhan Indonesia (Pelindo) II Tanjung Priok Branch needs to focus efforts on improving this indicator. While the Wharf (X1.4) and Warehouse (X1.5) indicators are included in quadrant II. This shows very good performance, so it must be maintained.
   Based on Figure 2, there is one indicator in Quadrant III, namely the Accumulation Field (X1.6) which has a low level of importance and performance. However, there is no need to worry about this considering that the Accumulation Field indicator is not considered very important.

Therefore, the available resources can be used to improve the performance of other more important indicators.

Figure 2: IPA Diagram of Infrastructure Quality Variable (X1).

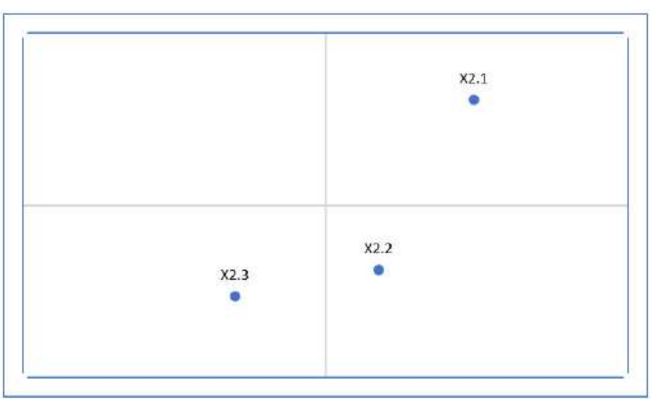


Source: Author.

In quadrant IV there are four indicators, namely Shipping Channels (X1.1), Wave Retention (X1.2), Terminals (X1.7) and Roads (X1.8). The four indicators show an unimportant position but their performance is relatively high. Customers are satisfied with the performance of these indicators, but the excessive use of resources needs to be reconsidered.

2. Superstructure Quality (X2)

Figure 3: IPA Diagram of Superstructure Quality Variable (X2).



Source: Author.

Figure 3 shows that there is one indicator each in quadrants II, III, and IV. Indicators in quadrant II areLoading and Unloading Equipment(X2.1), this shows that the performance is very good, so it must be maintained. Meanwhile, the indicator in quadrant III is Illumination (X2.3), indicatingindicators have a low level of importance and their performance is also low. Thus, even though performance is low, there is no need to worry about this considering that these indicators are not considered very important. Available resources can be used to improve the performance of other more important indicators. The indicators in quadrant IV areFloating Device (Guide Means) (X2.2), showingless important indicators, but relatively high performance. Customers are satisfied with performance, but resource overuse needs to be considered.

3. Port Performance.

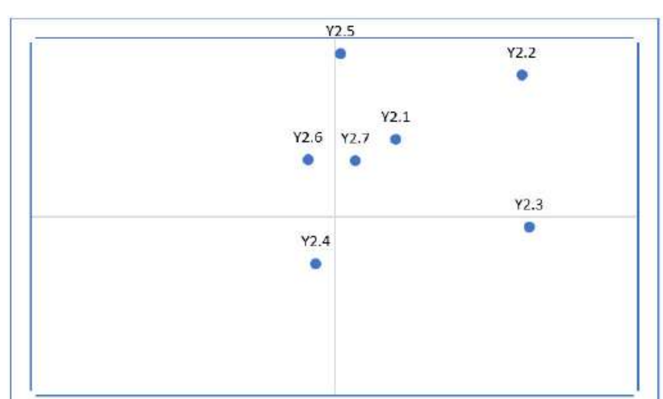
Figure 4: Port Performance (Y1) Variable IPA Diagram.

Source: Author.

Figure 4 shows that there is one indicator each in quadrants I and IV. The indicator in quadrant I is Shipside (Y1.7), where Shipside is very important for respondents, but the level of performance is quite low, so that PT. Pelabuhan Indonesia (Pelindo) II Tanjung Priok Branch needs to focus efforts on improving this indicator. The indicator in quadrant IV is Online Service (Y1.5), which showsless important indicators, but relatively high performance. Customers are satisfied with performance, but resource overuse needs to be considered. While there are six indicators in quadrant II, namely Time (Y1.1), *Flexibility* (Y1.2), *Accessibility* (Y1.3), *reliability* (Y1.4), Safety (Y1.6) and Terminal (Y1.8). This shows that the performance of these indicators is very good, so it must be maintained.

4. Port Logistic Cost.

Figure 5: IPA Diagram of Variable Port Logistic Cost (Y2).



Source: Author.

Based on Figure 5, there is one indicator each in quadrants I, III, and IV. Quadrant I shows the Port Due indicator (Y2.6), where this indicator is very important for respondents, but the level of performance is quite low, so that PT. Pelabuhan Indonesia (Pelindo) II Tanjung Priok Branch needs to focus efforts on improving this indicator. The indicator in quadrant III is Handling Fee (Y2.4), which showsThis indicator has a low level of importance and its performance is also low. Thus, even though performance is low, there is no need to worry about this considering that these indicators are not considered very important. Available resources can be used to improve the performance of other more important indicators.

In quadrant IV there are indicators*Documentation Fee*(Y2.3), where this indicator is less important, but its performance is relatively high. Customers are satisfied with performance, but resource overuse needs to be considered. While in quadrant II there are four indicators, viz *Charge Handling Terminals (THC)* (Y2.1), *Less Than Container Load (LCL) Charges* (Y2.2), *Storage Fee* (Y2.5), and *Ocean Freight* (Y2.7). It showsthe performance of these indicators is very good, so it must be maintained.

4.3. SEM-WarpPLS analysis.

The results of the WarpPLS SEM analysis are presented in the following table.

Table 2: Inner Hypothesis Testing Results of SEM WarpPLS Model.

Hypothesis	Influence Between Variables			Coefficient	*p-values*	Decision
H1	Infrastructure Quality	→	*Port Performance*	0.404	< 0.01	Significant
H2	Infrastructure Quality	→	*Port Logistic Cost*	0.052	0.35	Not significant
H3	Superstructure Quality	→	*Port Performance*	0.410	< 0.01	Significant
H4	Superstructure Quality	→	*Port Logistic Cost*	0.097	0.07	Not significant
H5	*Port Performance*	→	*Port Logistic Cost*	0.796	< 0.01	Significant

Source: Author.

Table 2 presents the results of testing the inner model of the Warppls SEM analysis as follows.

1. Infrastructure quality affects port performance with a path coefficient of 0.404 and a p-value <0.01 (less than 0.05). This shows that there is a significant influence of infrastructure quality on port performance. Considering that the path coefficient is positive, it can be concluded that the better the infrastructure quality, the port performance will increase.
2. Infrastructure quality affects port logistics costs with a path coefficient of 0.052 and a p-value of 0.35 (more than 0.05). This shows that there is no significant effect of infrastructure quality on port logistics costs. Considering that the path coefficient is positive, the better the infrastructure quality, the port logistics cost will not be significantly more efficient and effective.
3. Superstructure quality affects port performance with a path coefficient of 0.410 and a p-value <0.01 (less than 0.05). This shows that there is a significant effect of superstructure quality on port performance. Considering that the path coefficient is positive, it can be concluded that the better the quality of the superstructure, the port performance will increase.
4. Superstructure quality has an effect on port logistics cost with a path coefficient of 0.097 and a p-value of 0.07 (more than 0.05). This shows that there is no significant effect of superstructure quality on port logistics costs. Considering that the path coefficient is positive, the better the quality of the superstructure, the port logistics cost will not be significantly more efficient and effective.
5. *Port performance*effect on port logistics costs with a path coefficient of 0.796 and a p-value <0.01 (less than 0.05). This shows that there is a significant effect of port performance on port logistics costs. Considering that the path coefficient is positive, it can be concluded that the higher the port performance, the more efficient and effective the port logistics cost will be.

The influence of indirect variables on infrastructure quality and superstructure quality port logistics costs with port performance as a mediating variable is presented in Table 3 below.

Table 3: Results of Estimation and Indirect Effect Test.

Mediation Effects	**coefficient**	**p-values**
Infrastructure Quality (X1) → Port Performance(Y1) → Port Logistic Cost(Y2)	0.322	0.04
Superstructure Quality (X2) → Port Performance(Y1) → Port Logistic Cost(Y2)	0.327	0.04

Source: Author.

Based on the table above, it can be defined that the Infrastructure Quality variable (X1) has a significant positive effect on the variablePort Logistic Cost(Y2) mediated byportPerformance (Y1). Because the p-value <0.05, the statistical hypothesis states that the variableportPerformance (Y1) is able to mediate the Infrastructure Quality variable (X1) andPort Logistic Cost(Y2) of 0.322.

Based on the table above, it can be defined that the Superstructure Quality variable (X2) has a significant positive effect on the variablePort Logistic Cost(Y2) mediated byportPerformance (Y1). Because the p-value <0.05, the statistical hypothesis states that the variableportPerformance (Y1) is able to mediate the Superstructure Quality variable (X2) andPort Logistic Cost(Y2) of 0.327.

Conclusions.

Based on the results of the empirical analysis, it can be concluded that the quality of the infrastructure and the quality of the superstructure have a significant effect on port performance. In addition, port performance has a significant effect on port logistics costs. Meanwhile, infrastructure quality and superstructure quality have no significant effect on port logistics costs. However, if mediated by port performance, the effect of infrastructure quality and superstructure quality on port logistics costs is significant. This shows that good quality infrastructure and superstructure quality are followed by high port performance, thus realizing an effective and efficient port logistics cost.

Based on the results of the IPA analysis, this study also provides information that most of the indicators are in quadrant II. This shows that the performance of these indicators is very good. Therefore, PT. Pelabuhan Indonesia (Pelindo) II Tanjung Priok Branch must maintain this performance.

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The fishing vessel models used to measure the intensity of fishing activity and the number of fishing vessels operating in the ecosystem.

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ABSTRACT

In this article, we analyze the fishing vessel model as a fleet and anchorage model to measure the impact on Saudi Arabia's ecosystem. This article describes the model, its equations, and its application to current data collection. Finally, scientific references supporting the results are provided.The fishing vessel model is a mathematical model used to estimate the impact of fishing vessels on the environment. This model is based on data collected from fishing vessels. B. Vessel size, fishing activity and fishing grounds. This data is used to calculate the environmental impacts of fishing vessels, including the amount of fish caught, the amount of bycatch (unintended species caught during fishing operations), and the extent of habitat degradation.

1. Introduction.

The fishing boat model consists of two components, fleet model and berth model. A fleet model is a model that estimates the total number of fishing vessels in a particular sea area. The berth model is a model that estimates the impact of individual ships on the environment. Fleet models are based on the number of vessels in a given area, how long they have been fishing, and how much fish they have caught. Anchorage models are based on vessel size, fishing activity and location of fishing grounds. The Fishing Vessel Model (FVM) is a model developed to measure the impact of fishing vessels on ecosystems in Saudi Arabia. FVM is based on the Fleet and Berth Model, which uses mathematical models to estimate the number of vessels and types of fishing practices in a given area. The model also takes into account the impacts of fishing on marine ecosystems, including changes in fish stocks, habitat degradation, and bycatch. The FVM provides a comprehensive overview of the impacts of fishing activities on Saudi Arabia's ecosystems [14].

The Fishing Vessel Model (FVM) is a comprehensive and systematic approach to measuring the impact of fishing activities on Saudi Arabia's marine ecosystems. The model is based on fleet and anchorage models and takes into account data on fishing vessels, catches and resulting catches. It also considers the impact of fisheries on marine ecosystem dynamics, including species richness, ecosystem health and biodiversity. This paper provides an overview of FVM, its application to current data collection, and her FVM impact on Saudi Arabia's marine ecosystems [1]. Fishing vessel models are an important tool for measuring the impacts of fisheries on ecosystems, especially in Saudi Arabia. This model is based on a fleet and anchorage model and is used to analyze the impacts of fishing on the environment and on the economic and social aspects of fishing. This article describes the fishing vessel model and its application to current data collection in Saudi Arabia. We also discuss model equations and their impact on fisheries and the environment.The fishing vessel model is based on the observation that the total number of fishing vessels in a given region is an important indicator of the impact of fishing on the environment. This model assumes that fishing vessels have a constant fishing capacity at a constant size. We also assume that there are a finite number of ships and that the capacity of each ship is proportional to its size. Therefore, the total number of fishing vessels in a region can be used to estimate the total fishing capacity of that region.

The fishing vessel model is based on fleet and anchorage

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models and is used to calculate the total number of vessels that can be accommodated in a given area or "anchor". This model assumes that ships of different sizes can be accommodated in the same area and that each ship's capacity is proportional to its size. The model also takes into account the total available berth space and the total number of vessels that can be accommodated in a given area [13]. The fishing vessel model is a useful tool for measuring the impact of fisheries on Saudi Arabia's ecosystems. The model uses a fleet and anchorage approach to understand fishing vessel characteristics and environmental impacts. This article describes the components of the model, the formulas used to calculate the impact of fishing vessels on ecosystems, and how the model can be applied to current data collection in Saudi Arabia.The fishing vessel model consists of two components, a fleet component and a berth component. The fleet component takes into account the size and type of fishing vessels and the number of vessels in a given fleet. The berth component takes into account the length of time each vessel stays at a particular berth and the size of the berth. This model is used to calculate the overall impact of fishing vessels on the Saudi ecosystem [5]. The Fishing Vessel Model is a model of fleets and anchorages used to measure the impact of fishing activities on Saudi Arabia's ecosystems. This model is used to simulate the catch of vessels operating in a specific geographic area. The model takes into account the number, size, speed and fishing gear of vessels, as well as local environmental conditions. The model can be used to estimate the effects of fishing activities on ecosystems, such as total fish biomass, populations of specific fish species, and damage to coral reefs [18]. The Fishing Vessel Model is a way to measure the impact of fishing on Saudi Arabia's ecosystems. This model uses a fishing fleet and anchorage model to assess the cumulative impact of fishing vessels on the marine environment. Fleet and berth models consider the number, size and location of vessels to assess the overall pressure a vessel exerts on the environment. This article describes the fishing vessel model, model equations, data collection, and scientific references.

2. Overview of FVM.

FVM is a comprehensive approach to monitor and assess the impacts of fisheries on Saudi Arabia's marine ecosystems. This model is based on the Fleet and Berth Model, a widely used tool for monitoring fishing activity and measuring its impact. This model is based on his four main components:

(1) fishing fleets, (2) fishing efforts, (3) resulting catches, and (4) marine ecosystem dynamics. This model aims to facilitate the collection and analysis of data on fishing activities and their impacts on ecosystems [9].

FVM is an iterative model. This means it is continuously updated and revised with new data and insights. This model is based on four main components:

1. Fishing fleets,
2. Fishing efforts,
3. Resulting catches, and
4. Marine ecosystem dynamics.

This model aims to facilitate the collection and analysis of data on fishing activities and their impacts on ecosystems.

3. Data collection and analysis.

FVM aims to facilitate the collection and analysis of data on fishing activities and their impacts on ecosystems. Data on fishing activity can be collected from a variety of sources, including vessel tonnage, vessel tracking systems, fishing logbooks, and fisherman programmes. This data is integrated into the model to estimate catch and resulting catch. The model can also be used to analyze the impact of fisheries on marine ecosystem dynamics such as species richness, ecosystem health, and biodiversity [17].

4. Application of FVM.

The FVM has been applied to recent data collections in Saudi Arabia in order to assess the impact of fishing on the marine ecosystem. Data on fishing activity was collected from various sources, such as vessel surveys, vessel tracking systems, fishery logbooks, and fishery observer programs. This data was then integrated into the model to estimate the fishing effort and the resulting catch. The model was also used to analyze the effects of fishing on the dynamics of the marine ecosystem, such as species abundance, ecosystem health, and biodiversity [12].

5. Model Equations.

The FVM is composed of two main equations. The first equation is used to estimate the number of vessels in a given area, while the second equation is used to calculate the type of fishing practices used. The equation for estimating the number of vessels in an area is as follows:

$$V = F.\frac{D}{A}$$

where V is the number of vessels, F is the total fishing effort, D is the density of fish in the area, and A is the area of the region.

The equation for calculating the type of fishing practices used is as follows:

$$P = F.\frac{\sigma}{A}$$

where P is the type of fishing practices used, F is the total fishing effort, σ is the catchability coefficient, and A is the area of the region.

6. Data Collection.

Data for the FVM is collected from various sources, such as surveys, aerial photography, satellite images, and fisheries records. The data is used to estimate the total fishing effort, the density of fish, and the catchability coefficient in a given area [11].

The equations used in the fishing vessel model are as follows:

Fleet Model:

$$TNV = NVA \times LT \times AFC$$

TOV = Total Number of Vessels.
NVA = Number of Vessels in Area.
LT = Length of Time.
AFC = Amount of Fish Caught.

Berth Model:

$$IV = SV \times FA \times FL$$

IV = Impact of Vessel.
SV = Size of Vessel.
FA = Fishing Activity.
FL = Fishing Location.

A fishing vessel model can be used to measure the impact of a fishing vessel on the environment. To do this, we need to apply the model to the current data collection. In Saudi Arabia, for example, the Ministry of Fisheries and Marine Resources has been collecting data on fishing vessels and their activities since 2016. This data can be used to calculate the total number of fishing vessels in the area, hours of operation of vessels, amount of fish caught, vessel size, fishing activity, and vessel location.

Using this data, it is possible to calculate the total number of Saudi Arabian fishing vessels and the environmental impact of each individual vessel. This can be used to better understand the impact of fishing vessels on the Saudi ecosystem [9].

In summary, the fishing vessel model is a useful tool for measuring the impact of fishing vessels on the environment. The model he consists of two components, fleet model and berth model. The equation used in the model is:

$$TV = NVA \times D \times AFC$$

TV = Total Vessels.
NVA = Number of Vessels in Area.
D = Duration.
AFC = Amount of Fish Caught.
and

$$IV = VS \times FA \times FA$$

IV = Impact on Vessels.
VS = Vessels Size.
FA = Fishing Activity.
FA = Fishing Area.

The model can be applied to current data collection, such as that collected by the Saudi Ministry of Fisheries and Marine Resources, to understand the impact of fishing vessels on Saudi ecosystems.

The Fishing Vessel Model is based on the following equations:

$$Total\ Fishing\ Capacity = Total\ Vessels \times Vessel\ Capacity$$

$$Total\ Vessels = \frac{Total\ Berth\ Capacity}{Vessel\ Capacity}$$

Where Total Fishing Capacity is the total amount of fish that can be caught in the given area, Total Vessels is the total number of vessels that can be accommodated in the given area, Vessel Capacity is the capacity of a single vessel, and Total Berth Capacity is the total amount of space available in the given area.

To apply the fishing fleet model to the current data collection from Saudi Arabia, we can look at the total number of fishing fleets and total fishing capacity in the country. According to the latest data from the Saudi Ministry of Fisheries, in 2020 Saudi Arabia had about 1,700 fishing vessels with a total payload of 2.2 million tons. Using a fishing vessel model, we can calculate that Saudi Arabia's total fishing capacity is about 3.8 million tons. This indicates that Saudi Arabia's fisheries are relatively large and can have significant environmental impacts [6].

The equations used to calculate the ecological impacts of Saudi fishing vessels are based on the fleet and anchorage components of the model. The equations for the components of the fleet are:

$$TI = NV \times VT \times VS$$

TI = Total Impact.
NV = Number of Vessels.
VT = Vessel Type.
VS = Vessel Size.

The berth component equation is as follows:

$$TI = LT \times SB$$

TI = Total Impact.
LT = Length of Time.
SB = Size of Berth.

Once the equation is calculated, the overall impact of fishing vessels on Saudi Arabia's ecosystem can be determined.

The fishing vessel model is applicable to current data collection from Saudi Arabia. For example, according to data collected in 2018, the country's fishing fleet consisted of about 4,000 fishing vessels with an average size of 21.8 meters. The data also showed that the average time each vessel spent in a particular berth was her 8.5 days, and the average berth size she was 505 square meters. Using the above equation, the total impact of fishing vessels on Saudi Arabia's ecosystem can be calculated to be approximately 11,541,000 square meters [8].

7. Model Equations.

The fishing vessel model uses the following equations to simulate the fishing effort of a fleet of vessels operating within a specific area:

1. Fishing effort (E) = Number of vessels (N) x Vessel size (V) x Speed (S) x Fishing gear (G).

2. Total fishing effort (TE) = ΣEi, where i = 1 to N, where N is the number of vessels in the fleet.

3. The biomass of a particular species of fish (B) = TE x Fishing rate (FR) x Fishing duration (FD).

4. The population size of a particular species of fish (P) = B / Population density (PD).

5. Damage to coral reefs (D) = TE x Damage rate (DR) x Fishing duration (FD).

8. Application to Recent Data.

The fishing vessel model has been applied to recent data collected from Saudi Arabia?s Red Sea. The data show that there are currently 250 vessels operating in this area, with an average vessel size of 20 meters, an average speed of 8 knots, and an average fishing gear of trawlers. The data also show that the average fishing rate in this area is 0.4 kg/hour and the average fishing duration is 12 hours per day. The population density of the target species of fish is estimated to be 25 fish/m3. Finally, the data show that the average damage rate to coral reefs in this area is 0.1 m2/hour [14].

Using the model equations described above, the total fishing effort of the fleet can be calculated as:

$$TE = 250 \times 20 \times 8 \times 0.4 = 16,000 \ \ kg/hour$$

The biomass of the target species of fish can then be calculated as:

$$B = 16,000 \times 0.4 \times 12 = 76,800 \ \ kg/day$$

The population size of the target species of fish can then be calculated as:

$$P = \frac{76,800}{25} = 3,072 \ \ fish/day$$

Finally, the damage to coral reefs can be calculated as:

$$D = 16,000 \times 0.1 \times 12 = 19,2 \ \ m^2/day$$

9. Model Description.

The fishing vessel model uses fleet and anchorage models to analyze the cumulative impact of vessels on the marine environment. Fleet and anchorage models take into account the total number of ships, the size of the ships, and the area in which the ships are located. The model also takes into account the type of gear used, the number of fishing days and the duration of the operation.

10. Model Equations.

The fleet and berth model consists of several equations. The first equation is the ?total number of vessels equation? which is used to calculate the total number of vessels in a certain area[1]. This equation is as follows:

$$TNV = NB \times NVB$$

TNV = Total Number of Vessels.
NB = Number of Berths.
NVB = Number of Vessels per Berth.

The second equation is the ”total size of vessels equation” which is used to calculate the total size of vessels in a certain area. This equation is as follows:

$$TSV = NB \times ASVB$$

TSV = Total Size of Vessels.
NB = Number of Berths.
ASVB = Number of Vessels per Berth.

The third equation is the ”total area of operation equation” which is used to calculate the total area of operation for a certain number of vessels. This equation is as follows:

$$TAO = NB \times AOV$$

TAO = Total Area of Operation.
NB = Number of Berths.
AOV = Area of Operation per Vessel.

11. Data Collection.

In order to collect data for the fishing vessel model, surveys were conducted in the Red Sea off the coast of Saudi Arabia. The surveys collected information on the number of vessels, the size of vessels, the type of fishing gear used, the number of days spent fishing, and the duration of operations.

Conclusions.

The Fishing Vessel Model (FVM) is a model developed to measure the impact of fishing vessels on ecosystems in Saudi Arabia. FVM is based on the Fleet and Berth Model, which uses mathematical models to estimate the number of vessels and types of fishing practices in a given area. Data for FVM is collected from a variety of sources including surveys, aerial photography, satellite imagery, and fishing records. The FVM provides a comprehensive overview of the impacts of fishing activities on Saudi Arabia’s ecosystems [10].

The fishing vessel model is a comprehensive and systematic approach to measuring the impact of fishing activities on Saudi Arabia’s marine ecosystems. The model is based on fleet and anchorage models and takes into account data on fishing vessels, catches and resulting catches. It also considers the impact of fisheries on marine ecosystem dynamics, including species richness, ecosystem health and biodiversity. The model was applied to Saudi Arabia’s current data collection to provide insight into the impacts of fisheries on marine ecosystems. In this article, we examined FVM and its application to current data collection, and discussed its impact on Saudi Arabia’s marine ecosystem [3].

In summary, the fishing vessel model is an important tool for assessing the impacts of fisheries on ecosystems, especially in Saudi Arabia. This model is based on a fleet and anchorage model and uses equations to calculate the total fishing capacity of a given area. Applying this model to Saudi Arabia's current data collection shows that the country's fisheries are relatively large and can have significant environmental impacts.

In summary, the fishing vessel model is a useful tool for measuring the impact of fisheries on Saudi Arabia's ecosystems. The model uses a fleet and anchorage approach to understand fishing vessel characteristics and environmental impacts. The equations used to calculate the impact are applicable to current national data collection. This article has described the components of the model, the equations used to calculate the impact, and how the model can be applied to Saudi Arabia's current data collection.

The fishing vessel model is a useful tool for measuring the impact of fishing activities on Saudi Arabia's ecosystems. The model can be used to estimate total fleet catch, biomass of specific fish species, population size of specific fish species, and damage to coral reefs. Applying this model to recent data from the Red Sea in Saudi Arabia yielded a total fleet fishing effort of 16,000 kg/h, a target species biomass of 76,800 kg/day, and a target population size of 76,800 kg/day. It was shown that there is the number of fish species was 3,072/day, and the damage to coral reefs was 19.2 square meters/day [1].

In summary, the fishing vessel model is an effective way to measure the impact of fishing on Saudi Arabia's ecosystems. This model uses fleet and berth models to assess the cumulative impact of ships on the environment. The model equations, data collection, and scientific references described in this article provide an overview of how the model works and how it can be used to measure the impact of fisheries on the environment.

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Opportunities and Challenges of Implementing Green and Smart Port Concepts in Indonesia

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ABSTRACT

The implementation of green and smart port principles in Indonesian ports is explored in research articles along with potential. Ports that are "green" or "smart" aim to minimize their negative environmental effects. These ideas can greatly increase port operations' sustainability and efficiency. The infrastructure and high logistics expenses in Indonesian ports are just two of the issues they encounter. The potential advantages of smart and environmentally friendly ports for Indonesia are examined in this study. Ports can serve as catalysts for the economy, lower logistics costs, environmental sustainability, improved global competitiveness, and climate change mitigation. Ports may support efforts around the world to lessen the effects of climate change by using sustainable practices and technologies. By looking at successful examples from other countries and analyzing the potential benefits of implementing green and smart ports for Indonesia's maritime industry, economy, and environment, this study aims to provide insightful analysis and recommendations for policymakers, port authorities, and other stakeholders in the country's maritime industry. In conclusion, effective and sustainable port operations can help a nation's economy and environment in the long run by spurring economic development, lowering logistical costs, improving global competitiveness, and aiding in environmental sustainability and climate change mitigation initiatives.

1. Introduction.

The maritime sector is essential for international trade and economic growth (Sepehri et al., 2022). Indonesia, the largest archipelagic nation in the world, largely relies on its ports to facilitate commerce and business activities (Adyasari et al., 2021; Pattipawaej, 2022). However, the demand for efficient and sustainable port operations is driving interest in green and smart port designs (Iris and Lam, 2021; Khan et al., 2022; Sinha and Roy Chowdhury, 2022).

With an emphasis on infrastructure modernization, technological adoption, environmental sustainability, and cooperation with international partners and experts, this research study examines prospects to apply green and smart port concepts at Indonesian ports.

The efficacy, security, and sustainability of port operations and services can be significantly improved by implementing new concepts (Hua et al., 2020; Wang et al., 2020). Green ports prioritize energy efficiency, carbon reduction, trash management, and biodiversity preservation in order to reduce the environmental impact of port operations. (Ge and Wen, 2021; Lin et al., 2022). Smart ports, on the other hand, employ cutting-edge technology, such as the Internet of Things (IoT), artificial intelligence, data analytics, and automation, to enhance port operations and overall performance (Yang et al., 2018; Clemente et al., 2023; Cunha et al., 2023).

What are the challenges and opportunities in implementing green and smart port concepts in Indonesian ports? Despite the potential advantages of implementing green and smart ports, Indonesian ports confront a number of difficulties, including out-

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of-date infrastructure, a lack of significant commercial ports, and expensive logistics. (Iman, Amanda and Angela, 2022).

This research report examines the chances for resolving these issues as well as the challenges of implementing green and smart ports in Indonesian ports. By examining successful examples from other countries and analyzing the potential benefits of implementing green and smart ports for Indonesia's maritime industry, economy, and environment, this study seeks to offer insightful insights and recommendations for policymakers, port authorities, and other stakeholders in the country's maritime industry.

2. Literature Review.

Focus is placed on sustainability, effectiveness, and overall port performance in green and smart ports (Chen et al., 2019; Costa et al., 2021). These ports' primary goals are to reduce their environmental impact, increase operational effectiveness, and foster economic competition (González-Cancelas, Molina Serrano and Soler-Flores, 2020).

Due to its potential to lessen the environmental impact of maritime operations, increase sustainable port activities, and boost overall efficiency, green and smart ports are essential to the worldwide marine industry. These ports prioritize applying cutting-edge techniques and technology to reduce pollution, save energy, and advance sustainable development (Chen et al., 2019).

The ports and maritime industry as a whole should invest in and promote environmentally friendly and sustainable operations. (Sislian and Jaegler, 2018). They substitute fossil fuels and power-hungry terminal equipment with green technology and low- or zero-carbon alternatives (Iris and Lam, 2019). Reduced emissions, waste management, biodiversity protection, and social responsibility are the main objectives (Yoo, Moon, and Kim, 2022).

On the other hand, smart ports use cutting-edge technologies like automation, big data, blockchain, IoT, artificial intelligence, and machine learning to enhance their operations and lessen their environmental effect (Clemente et al., 2023). They aspire to improve efficiency, effectiveness, and security by making ports more environmentally friendly, economically viable, and able to handle more port traffic (Han et al., 2022; Al-Fatlawi and Motlak, 2023; Safuan, 2023a).

The essential elements of green and smart ports can be divided into two categories: technology innovation and environmental sustainability, energy efficiency, carbon reduction, trash management, biodiversity protection, and social responsibility are crucial components of green ports (Sheu, Hu, and Lin, 2013; Sadri et al., 2022). Smart infrastructure, smart traffic patterns, smart logistics, port community systems (PCS), and smart safety and security are essential elements of smart ports. (El Imrani, 2021).

3. Methodology.

A technique based on case studies and qualitative methods is used in this study. Using diverse data sources and this study methodology, researchers can thoroughly examine complicated phenomena in particular contexts. (Priya, 2021). This methodology, which may involve the analysis of one or more cases, is particularly helpful for comprehending complex problems in practical contexts.

The following actions are taken by the researcher to conduct a qualitative case study: choose the case to study, decide on the research topic, specify the data collection techniques, gather the data, analyze the data, interpret the findings, validate the findings, and report the findings (Rashid et al., 2019).

4. Results & Discussion.

4.1. Major Indonesian Ports.

With over 1,700 tiny ports and harbors, Indonesia has a large number of ports. However, only 110 of these are container ports and only 110 are commercial ports big enough to take cargo ships. A sizable amount of Indonesia's shipping traffic is handled by these important ports. To strengthen the nation's maritime industry, however, issues including congestion, inefficiency, and antiquated infrastructure must be addressed (Ahmed, 2022).

4.2. Current infrastructure and capacity of Indonesian ports.

After Singapore, Malaysia, and Thailand, Indonesia's port infrastructure is ranked fourth in ASEAN for quality. The country's shipping industry has a lot of promise, but many of its ports have outdated infrastructure that can't handle the volume of maritime traffic. Due to some ports' overburdening, this has increased vessel turnaround times and logistics expenses (Duffield, Hui, and Wilson, 2019). The Indonesian government has been working to update and modernize some facilities' infrastructure, but there are still no significant commercial ports in the nation (Ahmed, 2022). Road, rail, and port infrastructure upgrades are required to lower logistics costs, which now consume a debilitating 24% of Indonesia's GDP. In order to reduce the logistics costs of container ships, the government has also announced intentions to create international hub ports as part of the Integrated Port Network (IPN) program (Duffield, Hui, and Wilson, 2019).

4.3. Government Initiatives for Green and Smart Ports in Indonesia.

The Indonesian government has launched a number of initiatives to make the nation's ports green and intelligent ports. These programs seek to cut carbon emissions, safeguard the marine habitat, and boost sustainability and overall effectiveness (Azhar et al., 2018). Among the major projects are: By 2024, 149 ports are to be transformed into green and intelligent ports, according to the Coordinating Ministry for Maritime Affairs and Investment. These ports comprise 112 ports handled by the government-owned port operator PT Pelindo Indonesia (Persero) and 37 ports managed by a number of institutions, including businesses and the Ministry of Transportation (Nasution, 2022). The government also plans to implement the National Logistics Ecosystem at 10 ports in Indonesia. This initiative aims to improve the efficiency and sustainability of port operations and services (Haris et al., 2022). The Green Port Awards were established by the Indonesian government to honor and promote the use of innovative, environmentally friendly port operations. The prizes seek to advance environmental responsibility, operational effectiveness, and port economies in Indonesia (Ritonga et al., 2022).

4.4. Challenges and Opportunities.

The adoption of green and smart ports in Indonesia presents a number of opportunities and problems, including those related to infrastructure, environmental concerns, and technological advancements. Infrastructure restrictions are just a few of the major difficulties. Many Indonesian ports struggle to satisfy maritime trade volumes due to problems like congestion, inefficiency, and aging infrastructure (Azhar et al., 2018); Despite having a significant number of ports, Indonesia lacks large-scale commercial ports that can handle rising shipping demands (Santoso et al., 2023); 24 percent of Indonesia's GDP is accounted for by high logistics expenses, which are caused by ineffective port infrastructure (Safuan, 2023b). Key opportunities include the following: Initiatives by the Indonesian government show its commitment to upgrading the nation's ports into environmentally friendly and cutting-edge facilities by setting a goal of developing 149 green and smart ports by 2024 (Nasution, 2022); The National Logistics Ecosystem (NLE) will be implemented in 10 ports in Indonesia by the government in order to improve the efficiency and sustainability of port operations and services (Santoso et al., 2023); Technology improvements and the use of smart port technologies like IoT, AI, and data analytics can improve port operations and services' efficiency, safety, security, and sustainability (Mariska, 2022; Safuan, 2023a); Collaboration with foreign partners and specialists as well as knowledge exchange about best practices for implementing green and smart ports will be beneficial for Indonesian ports (Senarak, 2020). Indonesia can successfully implement green and smart port concepts, creating a more sustainable and effective marine industry, by solving these issues and seizing the opportunities.

4.5. Case Studies of Green and Smart Port Implementation.

Implementation Case Studies for Green and Smart Ports: Wismar's seaport, the Port of Wismar, has effectively integrated digitization with environmentally friendly port operations, proving that both principles can be realized in real-world operations (Philipp et al., 2021); The VIDEL (Virtual Dashboard of Environmentally Logistics-Port-City) project is a conceptual framework for environmentally sound governance in Jakarta and Tanjung Priok Port. To make interactions between cities, ports, and industry simpler, it is designed as a smart platform with sustainability features (Santoso et al., 2023); An example of a smart port development plan in Indonesia is the Batu Ampar Port in the island of Batam. Batu Ampar Port is employing smart port technology and concepts in order to handle the high volume of ship arrivals and cargo handling that the free trade area and port experiences (Sari and Pamadi, 2019); This case study from Indonesia, Benoa Public and Fishing Terminals, focuses on the theoretical underpinnings of implementing green ports utilizing a circular economy strategy. In order to achieve sustainable port growth, the study emphasizes the significance of cleaner industrial techniques, waste management, and renewable energy sources (Gurning and Tangkau, 2022); The future ports discussed in Blue Seaports are intelligent, environmentally friendly, and electrified, with a focus on the role that automation, digitization, and renewable energy sources play in accomplishing green port goals (Clemente et al., 2023). The Green Flag Speed Reduction Program at the Port of Long Beach In order to lessen air pollution and greenhouse gas emissions, the Port of Long Beach developed the Green Flag Speed Reduction Program. The program works to lower airborne emissions and enhance local air quality by slowing down ships. (Inbound Logistics, 2016).

Lessons from the chosen case studies and their relevance to the ports in Indonesia in order to achieve environmental sustainability, this study emphasizes the significance of tackling environmental contamination issues in port operations by using green port methods in Saudi ports. By identifying key issues and implementing green port methods to minimize pollution and improve ecological sustainability, Indonesian ports can learn from Saudi ports (Alzahrani, 2022); The case study "Smart and Green Technologies in the Mediterranean Ports: The Genoa Port Case Study" highlights the value of implementing smart and green technologies to enhance innovation, knowledge transfer, flexibility, accessibility, and environmental safety. Indonesian ports can implement comparable technologies to increase their sustainability and competitiveness (Tommasetti A., Troisi O. and Tuccillo C., 2014); In order to assess how well ports make use of sustainable practices and cutting-edge technology, the research Designing Smart Ports by Integrating Sustainable Infrastructure and Economic Incentives proposes the implementation of a Smart Port Index (SPI). This indicator can be used by Indonesian ports to assess their development and pinpoint areas for improvement (Molavi, 2020). The purpose of this essay, "Constructing the Governance Framework of a Green and Smart Port," is to highlight the importance of having a governance framework to guide the development of green and smart ports. Creating a similar structure could assist Indonesian ports in implementing smart and eco-friendly port ideas (Chen et al., 2019). This study describes cutting-edge smart seaports in automation, real-time management, connection, and accessibility control in Blue Seaports: The Smart, Sustainable, and Electrified Ports of the Future. Indonesian ports might take inspiration from these instances and implement cutting-edge technology to improve productivity, dependability, and sustainability (Clemente et al., 2023).

4.6. Recommendations for Indonesian Ports.

In order to relieve congestion, inefficiencies, and antiquated facilities, recommendations for Indonesian ports in the areas of infrastructure, technology, and sustainability include modernizing, updating, and expanding current port infrastructure. To reduce logistical costs, this entails creating substantial commercial ports and enhancing infrastructure on the roads, rails, and ports (Syafiq et al., 2022). Enhancing connectivity between ports and land infrastructure, such as roads and rail networks, will allow for more efficient cargo movement and lower transportation costs. (Syafiq et al., 2022). Make use of smart port technologies to enhance port operations' efficiency, security, and sustainability. These technologies include automation, data analytics, artificial intelligence, and the Internet of Things (Duffield, Hui, and Wilson, 2019; Safuan, 2023a). To reduce the environmental impact of port operations, promote environmental sustainability and adopt green port practices such energy efficiency, emissions reduction, trash management, and biodiversity protection (Duffield, Hui, and Wilson, 2019). Collaboration and knowledge exchange: Work with international partners and specialists to exchange information and best practices for implementing green and smart ports. This can assist Indonesian ports in adopting creative solutions and learning from successful models (Meyrick, 2012). Government policies and programs promoting green and smart port development, such as the National Logistics Ecosystem (NLE) implementation and the Green Port Awards, are encouraged by government funding (Duffield, Hui, and Wilson, 2019).

By putting these suggestions into practice, Indonesian ports may modernize their facilities, incorporate cutting-edge technology, and encourage environmental responsibility, creating a more productive and competitive maritime sector.

Conclusions.

Sustainable and effective port operations have major long-term advantages for a nation's economy and ecology. These advantages consist of Economic expansion; by enabling trade, luring investments, and bolstering supply chains, effective port management can accelerate economic growth (Alamoush, Ballini, and Ölçer, 2021). Ports can serve as economic development's catalysts, facilitating the expansion of the manufacturing and logistics industries, generating job possibilities, and raising income levels (Mlambo, 2021); By lowering operating expenses, eliminating delays, and streamlining operations, decreased logistics costs increase port efficiency and can result in cost savings. This could improve a nation's export and import competitiveness, fostering overall economic growth (Alamoush, Ballini, and Ölçer, 2021; Mlambo, 2021; Safuan, 2023b); The environmental effects of marine activities, such as air and water pollution, greenhouse gas emissions, and biodiversity loss, can be reduced through environmental sustainability and sustainable port operations. Ports may contribute to a more ecologically responsible global marine industry by embracing green port practices and technologies (Brown, 2019). Green port practices and technologies can help the global maritime industry become more environmentally responsible. A nation's competitiveness in the international maritime industry can be improved by effective and sustainable port operations, luring greater commerce and investment (Alamoush, Ballini and Ölçer, 2021); Social advantages, sustainable port development can result in jobs being created, local communities' quality of life being improved, and greater social responsibility (Mlambo, 2021); Ports may support worldwide efforts to minimize climate change and its effects by using sustainable practices and technologies (Brown, 2019).

In conclusion, effective and sustainable port operations can benefit a nation's economy and environment in the long run by fostering economic development, lowering logistical costs, improving global competitiveness, and assisting in environmental sustainability and climate change mitigation initiatives.

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From Container Terminal to Smart Ports: A State of Art

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ABSTRACT

Nowadays, the Economy relies on terminals and ports, hence 80% of trade is carried out by sea. The Smart Port aims to put technology at the service of the port, to enhance the efficiency and safety of data and goods during portal operations. Smart ports answer economic challenges by adapting infrastructures and services to accommodate as many ships as possible. Transport, handling, storage, and support activities can be enhanced with new technological solutions.
In this manuscript, we will see a state of art on building Smart ports from container terminals, based on specific technologies applied to some famous smart ports. This paper is a review study on smart ports, referring to recent studies and projects, to look for chances, strengths, and weakness points, for possible future projects.

1. Introduction.

In the international context, due to the huge amount of data, methods, information users, and complex situations to solve, there is a great tendency to transform our daily life to be smarter, and this is applied in various fields and sectors of activity: Economy, Education, Energy, transport, industry, including maritime industry.

The maritime industry is the basis on which most of the global economy depends. According to the United Nations Conference on Trade and Development (UNCTAD), it reached 10.7 billion tons in 2017, which is an increase of 411 million tons [1], In 2018 [2] Global container port traffic attained 793 million TEUs (20-foot equivalent unit)volumes expanded at 2.7 percent with 11 billion tons.

During maritime industry history, great progress was experienced in various activities and services thanks to developing supply chain management. The supply chain results from an exponential development of the logistics sector, and the need to manage uncertain and dynamic distributed environments. Furthermore, this advancement is quickened with the incorporation of new advances, similar to the Internet of Things, Artificial Intelligence, Data Science, Blockchain, and other technologies. Subsequently, every one of these elements prompted the presence of the concept of Smart logistics [3].

In this paper, we will summarize how smart ports are built and their importance for the maritime industry and the global economy. In the second part, we will focus on the background of the maritime industry, we will give an overview of the container terminals concept, then we will present the terminal actors and the terminal information systems involved taking the example of Casa Port. In the third part, we move to the description of the process: the smart port notion, and some port's performance indicators, we will present the most important smart port projects, and some technologies integrated into smart ports; Finally, the last part concludes this paper with some indications for integrating technologies in smart ports, advantages and drawbacks.

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2. Container terminals.

Due to the lack of information concerning the maritime domain, this research is built on an interview with some specialists in Casa Port, to understand the Moroccan maritime context and especially the Moroccan procedure for establishing a smart port or precisely the operations and projects related to it.

2.1. Container terminals.

A container terminal is a port infrastructure specialized in the loading and unloading of containers, transported by ships specifically container ships, It is characterized by a large draft, a quay for mooring, gantries or cranes for loading and unloading containers; transport networks; and an area devoted to stacking containers;[4]

Stacking containers in the port territory is divided into three types of cargo:

a. Conventional: concerns various goods that are non - containerized (non-containerized general cargo) transported in bags, boxes, and on pallets, as well as heavy and unpackaged packages. These goods are stored in stores or considered as full-ground storage.

b. Solid bulk: concerns all products that are handled, stored, or transported without packaging such as sand, and butter. These products are unloaded directly from ships.

c. Liquid bulk: liquid product with no packaging, like oil, petroleum... It is transported directly to tank trucks and gets permission to a direct exit.

2.2. The terminal stakeholders.

Many actors interact within each other in the maritime industry, for example, port authority: The harbor master's office, and The National Ports Agency (ANP) , the ship-owners (the partner who owns the ship and takes responsibility for delivering goods or containers to the port terminal), carriers, maritime operators, shipping companies, the end customers, etc...

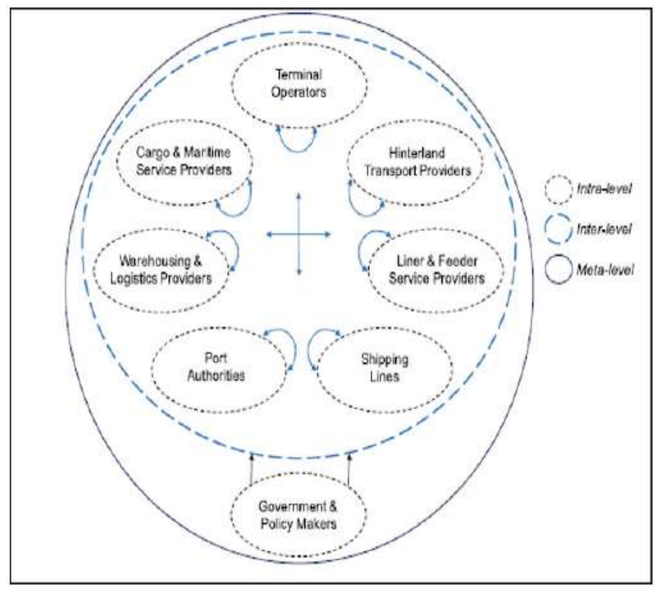
- Port authority: In the Moroccan case, the port authority is represented by the National Port Agency (ANP) which takes the responsibility for managing shipments and products in the best circumstances concerning management, expenses, time constraints, safety, equipment investments, and the growth of working capacity. It has control of the use of new Technologies of Information and Communication. This agency aims to enhance the competitiveness of the Moroccan port sector. The most important operations within stakeholders and port operators are done through the ANP with the portal PORTNET platform [5].

- Ship owners: A ship owner is an entity (a company or a person) that owns a merchant vessel (commercial ship) and is involved in the shipping industry. It equips and exploits a ship, usually for delivering cargo at a certain freight rate, calculated as either per freight or per day. Ship owners hire a certified crew and captain rather than take charge of the vessel in person [6].

- Carriers or hinterland transport providers: a person or company that transports goods or people for any person or company and is responsible for any possible loss of goods during transportation.

- Maritime operators: the maritime operators implies anyone or entity who enters into a contract with a shipper or a passenger to convey goods or people by water on their behalf.

Figure 1: Different stakeholders interacting in the port hinterland.



Source: Authors.

- Supply chain stakeholders: All entities that have an interest in a business, either affect or are affected by it. Stakeholders in the supply chain Include internal and external actors.

- Shipping companies or shipping lines: It is a business that transports cargo aboard ships. It includes Bulk cargo (transporting goods in large quantities), General cargo,(goods that must be loaded individually to different ports), oil and passenger cargo (the business of transporting people abroad a shipping line), and Special cargo (a term used for one specific product being shipped to a specific port) [7].

- Warehousing and logistics providers: It involves packing and delivering the order as well as providing storage for finished items. Both the company and the consumers may economically gain from efficient warehousing.

All these actors interact on three levels: intra-level, inter-level, and meta-level, creating an intermodal system of flow within the port territory and contributing to establishing a strong supply chain management system in the port, it's a significant factor for building a smart port.

2.3. Information Systems involved in Casa Blanca terminal.

According to [9] "Information systems have become indispensable to the competitiveness of ports, facilitating communication and decision making for enhancing the visibility, efficiency, reliability, and security in port operations under various conditions".

In the Moroccan context, ports are managed with the same information system connected to the Port-net platform; this platform is directed by an authority office the ANP (National Port Agency).

The National Ports Agency is a "Public Establishment with legal personality and financial autonomy". The Agency's technical supervision is provided by the Ministry of Equipment and Transport [10]. The Agency exercises its powers over all the Kingdom's ports except the port of Tangier Mediterranean (33 ports) [10].

Created in 2012 by the ANP (the national port agency), the limited company PORTNET is in charge of the project to set up a National Single Window to facilitate all port and trade procedures [11]. Currently, Portnet has crossed the 50,000-user mark, including over 45,000 importers and exporters, 1,500 freight forwarders, 20 banks, and over 43 administrations [11].

PORTNET also allows the exchange of data at the regional level through interoperability with the one-stop shops of other countries, thus allowing a simplification and an end-to-end integration of the logistics and commercial chains between the supplier and his customer [11]. Thus, sharing information between the various stakeholders in the port is done through the PORTNET Platform.

The relationship between the banks and the various operators of the CASA PORT is nonexistent since the financial flow is not included in the exchanges of the supply chain crossing the port.

The customs information system is BADR, The BADR system (Automated Network Customs Base) is the new online customs clearance system for goods in Morocco, both for import and export operations. It takes care of all customs procedures while integrating new concepts such as anticipation and interactivity with the port operator [12].

For each port operator, an information system is developed separately and installed to manage and facilitate its information processing.

3. Smart Ports and port performance.

In recent years, there has been an increase in maritime trade, due to the rapid expansion of e-commerce, building larger ships equipped with expanded container terminals, and the establishment of liner shipping alliances.

3.1. Smart Port Notion.

Any transformation of cities to become smart cities has involved the integration of several factors, sciences, and fields of study; it involves the appearance of the concept of intelligence in different areas of the city: smart education, smart transport, smart industry, smart logistics, etc. Therefore, it is necessary to define the concept of "Smart" before starting the rest of this article.

"Smart means: no waste of space, time, money, and natural resources. These elements depend on the current challenges of ports: spatial constraints, pressure on productivity, fiscal limitations, and the need to be green. Technology and innovations can help, but being smart is also a mindset" [13].

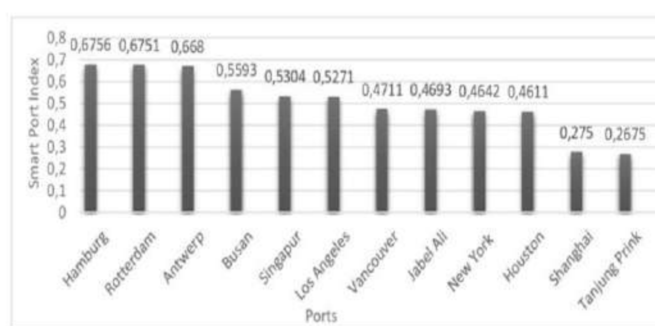
In the context of globalization and the liberalization of international trade, the number of players raised in port terminals, of different organizations, institutes, and companies interacting in the different functions of the terminal. In addition, the increase in containerization according to the report by [14], it is expected that the increase will continue in the coming years.[3] The port is the center of interest in the maritime supply chain; it establishes the connectivity of nations and the development of international trade. It integrates the modes of transport and connects producers to consumers in different markets. [3]

Smartness is being able to manage many data sources and promote sustainable activities. Effective use of technology speeds up information communication, product movement, and storage, providing the port community with the best efficiency [15].

The economy may be considered "smart" when it can provide a person with the ideal information at the ideal time to enable him to take the ideal decision, carry out the ideal course of action, and, in an ideal world, adopt the ideal strategy to change his environment in a way that will increase opportunities while minimizing risks and threats [16], [17].

According to [18], there are two different perspectives for this implementation: the first insists that the intelligence of the port is based on the ideology behind, not only the amount of integrated technology and the infrastructure of the port, that is to say: the smart use of resources and policy decisions are more important than the implementation of technologies.

Figure 2: Comparison of the Smart Port index between different ports.



Source: Salinas, 2021.

The second perspective is based on the use of recent technologies to improve the performance of the port. (port technology 2016) [18].

By [19] "A smart port may be defined as a fully automated port where all devices are connected via the so-called IOT Smart Port. A network of smart sensors and actuators, wireless devices, and data centers make up the key infrastructure of the smart port, which allows the port authorities to provide essential services in a faster and more efficient manner. The major drivers in smart ports are productivity and efficiency gains."

3.2. Port Performance.

Port performance indicators are straightforward measurements of various aspects of port operation. To serve their purpose, such indicators should be easy to compute and interpret. They should provide port management with insight into the performance of key areas [20].

In [18], authors made a smart port platform, based on quantitative metrics: SPI (Smart port index) calculated using indicators gathered from literature; these indicators are divided into four domains: operations, environments, energy, safety, and security. This method is based on analyzing use cases from 16 ports.

The Performance of the port is measured based on some criteria: the degree of interlinking the information and the communication system, more efficient traffic management, control and ability to plan proactively, the amount of TEU (Twenty-foot equivalent unit) throughput per year, turnaround time, time spent in the truck (driver), the distance calculated in kilometers driven by the truck, the stay rate of ships in their berths.

In the Moroccan context, the performance of the port depends on some factors:

Duration of treatment of the ship: the global time spent on all operations from its berth to its departure.

TEU: equivalent to twenty feet (the smallest container) it's the unit to calculate the amount of product trade.

The port draft: defines the smallest depth of water through which a ship or boat may safely sail. It means the capacity of a port to serve ships in number, but more important the type of ships and vessels served.

3.3. Smart port projects.

Several smart port projects have been created in recent years, in each case different criteria were applied, for different port functions and operations. In these smart ports, the notion of Industry 4.0 with the digitalization process remain a necessity to transform gradually a port terminal to a smart port. In this direction, the implementation of the newest technologies is only a step, on the transformation process to intelligent ports.

In the next table, we present the most important ports that became Smart Ports, with their functions and their capacities, mentioning technologies integrated into these ports and terminals and port operations and services where they are used.

The port of Singapore is a global port terminal that is specialized in transshipment and crude oil. In this port technology is based on IOT platforms to maintain cyber-physical security, as well as the technical aspects of a new port transport system.

In The port of Rotterdam, the capacity is More than 140,000 ships are handled annually, policy in this port consists of implementing the digital Twin technology that provides information about the degree of interaction of different pieces of equipment. Moreover, Digital transformation is expanded to IBM and Cisco, and IOT system with Iot sensors are installed to provide a path for autonomous shipping and logistics, as well as improving g data processing and network intelligence. IoT sensors, in other hand, monitor the pressure, turbidity, and water flow.

Concerning the port of Hamburg, it is an automated port that receives more than 8,000 ships call annually, more than 200 cargo trains arrive and quit daily. In the port of Hamburg, a group of technology is integrated, for example: the 5G-enabled IOT. The SAP HABA cloud platform, Augmented Reality, and Augmented Reality glasses, and finally, Sensors which are fixed on the resident shipping fleet.

Table 1: Most important ports with their activities and technologies implemented.

Ports	Country	Port function	Capacity	Technologies	Disruptive changements
Port of Singapore	Singapore	Global maritime capital for transshipment and crude oil	Will be increased by 21 million TEUs by 2027, to 65 million TEUs by 2040	IOT	Develop cyber-physical security and smart port operations, as well as the technical aspects of a new port transport system.
Port of Rotterdam	Netherlands		More than 140,000 ships are handled annually	- Digital Twin Digital transformation is expanded to IBM and Cisco; to incorporate the Watson IOT system and the Kinetic IOT platform - IoT sensors	Information on how the various pieces of equipment interact with one another. Enhancing data processing and network intelligence, and to provide a roadmap to autonomous shipping and logistics. IoT sensors monitor water flow, turbidity, and pressure.
Port of Hamburg	Germany	Port automation	More than 8,000 ships call annually, --more than 200 cargo trains arrive or depart daily	- 5G-enabled IOT - The SAP HABA cloud platform - Augmented reality - Using Augmented Reality glasses. - Sensors fixed on the resident shipping fleet	Remote control of traffic lights and shipping) To operate remotely Cellular-enabled traffic (more responsive to traffic flows) Real-time location movement and environmental data

Source: Authors.

3.4. Technologies integrated in smart ports.

According to [21]," A smart port is an automated port that uses new technologies such as big data, Internet of Things (IOT), Blockchain solutions and other smart technology based methods to improve performance and economic competitiveness. With these technologies, smart ports can also improve environmental sustainability. In an ideal smart port, processes would be automated and connected via IOT."

In the Hamburg port, It has processed containers automatically through its docks for quite a long time. More recently, it has engaged IOT technologies to make smarter use of its urban setting, which has bounded its expansion.

As confirmed by [19], Various sensors such as inertial sensors, ultrasonic sensors, eddy current sensors, radar, lidar(laser detection and ranging), imaging sensors, and RFID readers and tags are used to collect required data in order to transform the "port" into a "smart port".

4. Related Works.

By [41], the authors aim to provide an overview of existing publications on environmental protection in smart cities, this paper focuses on structuring the research field into a research process to gain a more systematic view of the application of Green IS, with more than 1500 articles of detailed literature.

The success of the supply chain stands on building trust among stakeholders, [22] proposes an experimental study where they conduct a designing and developing software connector module that connects an Ethereum-like Blockchain to a general business information system. for companies to send data to the Blockchain and check the data authenticity.

In [23], authors used service science to re-conceptualize a supply chain port to a Smart port by using a case study approach in the port of Salerno in Italy, by implementing a logistic framework.

Authors in [24] propose some practices and initiatives for transforming the Croatian port to a smart port while specifying digital integration that makes the seaport smart.

According to [25], the establishment of a smart port in China requires multiple fields, industries, and benefits, authors suggest key points for the construction of future smart ports from the perspective of Internet of Things (IoT) information platform, logistics supply chain integration and supply chain financial information platform construction, by integrating Big data, Internet of things, and artificial intelligence.

In [26], authors propose a systemic framework for evaluating the benefits of microgrids, focusing on demonstrating how a set of smart port index (SPI) metrics integrated into the microgrid planning process can improve the smartness of the port. This framework, according to writers, is capable of improving port operations' productivity, sustainability, and reliability.

According to [27], authors used input-output analysis combined with Delphi surveys to estimate the economic impact of the intelligent port industry on the economy in Korea with sophisticated parameters.

Conclusions.

Integration of technologies in the process of transforming seaports to smart ports should take charge of some points:

- Information systems included in the port have great importance either in port performance [28] or in data integration and compatibility, which infects the different technologies used with the information system. The integrity of the technology within the terminal operating system is crucial to judge its success.

- The large amount of information circulating to and from the ports requires sophisticated data management and sufficient storage space with the fluidity of sending and receiving between the different ports. That said, the scalability of the system and the technologies adopted is important.

- During the Covid 19, one of the most noticed problems is the great impact of intermediaries on the delay of operations and delivery of products of all kinds, so the integration of technology capable of overcoming this problem is an important change for smart ports.

One of the technologies proposed to overcome intermediaries is Blockchain technology. The integration of this technology has already been achieved despite its few drawbacks. Blockchain has proved its efficiency concerning transparency of transactions, immutability of data, trustless scalable and interoperable network.

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Shipping Revenue Performance and the Global Economy: Evidence from Nigeria

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ABSTRACT

The purpose of the study is to assess the effect of shipping revenue performance on the global economy using empirical evidence from Nigeria, and to find answers to factors hampering optimal performance in the maritime sector. The study used secondary data which represents the revenue performance for 2008/09-2021/22 fiscal years and data were analyzed with multiple regressions statistics. Findings revealed that shipping revenue performance has a positive and significant effect on the Nigerian economy which invariably is a boost to the global economy. However, pandemics and man-made factors (corruption, political bureaucracy) adversely affect the performance of the maritime industry. It is suggested that nations engaging in maritime transportation should carry out critical and progressive maritime reforms to create wider room for concession of maritime facilities to private companies and utilize public private partnership (PPP) formula to attract investments into the sector.

1. Introduction.

The importance of the maritime industry to economic development came to fuller realization in the 18th century when Adam Smith made reference to water-carriage and its significance in his book "the Wealth of Nations"(Panayotis, n.d). Then imports and exports were 10% lower than world's production in the 19th century, but increased astronomically to more than 50% of world's production in 2015/2016 (Ortiz-Ospina and Rosa, 2016 cited in Panayotis, n.d). The increase or revolution in global maritime trade is linked to the advancement in technologies and innovations.

Hassiba (2018) holds the view that "shipping is the glue binding economies of the world. It connects countries, markets, businesses and people, makes economies rely on one another, moves assets across borders and fixed assets (ports) within borders. Also, shipping provides freight transport services and connects maritime clusters (e.g., ship building, ship repairs, port services, insurance, towage, dredging, offshore support services, financial and legal services, etc)". According to Hassiba (2018) report, 80% of global merchandise trade by volume is in maritime and 10.7 billion tonnes of cargo were moved in 2017 (representing +4% over 2016) with a fleet of 94,169 ships. Hassiba contends that the world seaborne trade growth forecast for 2018 to 2023 volume is expected to grow by +3.8% (i.e, +6% for containerized trade, +4.9% dry bulk, +1.7% crude oil, +2.6% products & gas). Therefore, shipping has become the backbone of international trade (connecting supply chains), engine for growth and positively affects sectors like tourism and fishing. However, it attracts negative externalities which call for mainstreaming sustainability principles (ESCA, 2017; Hassiba, 2018).

Maritime transport is a major component of the blue economy playing a unique role in the EU and accounts for about 40% of total value added at factor cost. Investments in maritime port infrastructure are directly and positively correlated to economic growth and the absence of maritime activities will create vacuum and imbalance in economies (Fratila, 2021). Andrew (2016) defines shipping to mean a vital facilitator of world trade. Shipping has increased the world's GDP in real terms in

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the last two decades by 73% and the value of the EU's trade with the rest of the world amounted to 3.5 trillion pounds in 2015. The shipping industry transports both containerized and non-containerized by sea, carrying out diverse but complementary services (offshore support services, tow, and dredge at sea. In Andrew (2016), the impact of maritime the industry is divided into three; direct impact (e.g, freight services, passengers services, towing, dredging, renting and leasing), indirect impact (e.g, ship building, ship repairs, port services & insurance, financial & legal services), and induced impact (e.g, food & beverages, recreation activities).

Shipping and transport logistics are integral components of the maritime industry across the globe. Both are synchronized into the daily operations in the ports. The world over, ports are serving as takeoff points for loading cargo into ships and discharging the same at another destination, usually between two or more countries. Port operations, shipping operations, and transport logistics operations are a network of operations. It is better described as chains of related functional activities/services that lead to satisfactory revenue and worker's performance and economic growth and development (Edih, et al., 2022a, 2022b; Inah and Elijah,2018; Omoke et al., 2019; Osadume and University, 2020).

Globally, many countries such as China, Singapore, Britain, and America, Ghana, South Africa and Nigeria are trying to harness the vast opportunities in the maritime industry (Imide et al., 2022), and about 90% of transportation needs are transported through carriage by sea(ESCA, 2017). The UN (2021) has predicted that global shipping and transport logistics would grow by 3.5%. Despite the robust picture painted above the sector is being retarded from performing at its full capacity because of natural (pandemics) and man-made disaster/or factors (unnecessary politics and high profiled corruption).

Hence, the study assessed the effect of shipping revenue performance on the global economy using empirical evidence from Nigeria and proffered solutions to the factors limiting full performance of the maritime industry.The hypothesis tested in the study is, shipping revenue performance does not have a positive and significant effect on economic growth.

2. Literature Review.

2.1. Maritime activities and the global economy.

The maritime industry largely engages in the transportation of persons (passengers), and cargo from port A to port B in two or more countries by sea. It entails the carriage by sea (different from carriage of goods by land and air, however the trio are complementary) (Edih, et al., in-press). Simply put, maritime business is shipping and port operations that are regulated by international laws, bilateral or multilateral treaties and conventions (Edih et al.,2022a). Peretomode (2014) and Elem (2008) mentioned some operations that are taking place in the ports as coastal shipping, trawler services, dredging service, tourism, pilotage and towage, dry docking, etc. It also includes terminals and jetties infrastructures, offshore construction and fabrication, warehouse activities, loading and unloading of cargo, and many more.

Ports play the role of facilitators between internal or domestic markets and international or external markets (Edih et al., 2023; Turnbull and Hughes, 2017). Many countries in the world are sustained by imports and exports; New Zealand, Singapore, America, Britain, Ghana and Nigeria. Specifically, Nigeria and New Zealand's economies cannot be sustained without importation and exportation of goods and services (Edih et al., 2023). Ports and terminals, as well as ships and tugboats are facilities that enhance maritime transportation and seaborne transport aids humanitarian services during emergency in the waterways and its environs (Margarita, 2021). In a similar context, maritime transport logistics are a major boost to the delivery of humanitarian assistance in times of disasters (Kovacs and Spens, 2007; Margarita, 2021). Ports have been depicted as measures for diversifying an economy by providing various opportunities; anchor handling of cables, pipes laying vessels, and diving support vessels, etc (Edih et al., 2023; Elem, 2008; Peretomode, 2014).

According to Jung (2011), the ocean is the global route for international trade and global economic integration, and shipping and transport logistics are strong catalyst that energized maritime trade, economic growth and development (Edih et al., 2022a, 2023; Omoke et al., 2019; Osadume and University, 2020). Low cost of transportation has been traced to shipping (Edih et al., 2022a). In this web of trade networks necessitated by carriage of goods by sea, the modified neoclassical theory pushes for investments to create more opportunities in the maritime sector (Grossman and Helpman, 1991; Edih et al., 2022a; Omoke et al.,2019). Research has affirmed that in the Archipelagic Regions of the world, maritime activities and infrastructures propelled economic growth. Also, shipping networks and other transportation modes affect per capita and fiscal revenue (Banerjee, 2009; Edih et al., 2022a; Essoh, 2013; Sjafrijal, 2008). Promoters (activities) of seaborne transport logistics improve socioeconomic growth and international competitiveness in such geometrical or exponential proportion, that every job in the shipping and transport logistics creates 4.4% additional jobs in the U.S economy (Fintell, 2004; Haralambides, 2014).

In Peretomode (2014) and Edih et al.,(2022a), the contributions in percentile of the maritime sector to specified economies were enumerated. Holland, Italy, Belgium and European Union's maritime region has aggregate of 40% to their GDP and in 2012, countries like India got 28.1% from maritime sector, China got 9.7%, Russia had 5.9%, Brazil had 2.8%, while South Africa got 1.3% and 0.15% from the industry respectively. The lackluster performance of the maritime industry in the continent of Africa (especially in Nigeria) calls for urgent maritime reforms. There are arguments that ports or port operations accelerate economic growth, while or at the same time, economic growth pushes the need to establish ports. These are diverse economic postulations or philosophizing from the understanding of various development economists. But, Edih et al, (2022a) argued that a positive link exists between the desire for growth and the development of port's, which in turn produce employment opportunities, generate revenue and other socioeconomic rewards.

Also, in Pearl River Delta, container ports contributed to foreign direct investments (FDIs), and modes of shipping, marketing or promotion strategies, and operations affect human resource and its production capacities and performance (Mobalaji et al.,2012; Zhang and Zhang, 2005). Whether, port operations, shipping operations and/or transport logistics management, represent comprehensive productive activities that are carried out in the maritime industry and connected to the smooth functioning of maritime business in the world of trade. Shipping is that aspect of maritime operations which entails the transportation of cargo (including passengers) from one point to another on a stretch of navigable waters (Ekpo, 2012; Edih et al., 2022a). Shipping and transport logistics, as well as port operations generate employment to the local population where such activities take place.

Bottasso, et al.,(2014) states that a million ton of throughput provides 400-600 jobs and 10% increase in throughput causes 6-20% GDP growth in West European countries, while spillover results in 5-18% increase in employment in neighbouring regions. Port's terminal concession and liberalization increase its efficiency and profitability (Benson and Adekemi, 2018). Concession of port infrastructure and operations empower private operators in cargo handling, shipping and growing an economy. They (ports) have become the economic hub of maritime nations by linking it to the economies of the hinterlands through networks of roads, lowered freight transport cost and access to global markets (Benson and Adekemi, 2018; Ziaul and Hans-Joachim, 2018). However, the studies of Jung (2011) and Deng et al., (2013) showed that the effect of ports on South Korea and China's economies were negative.

Shipping and global trade are complementary since their growth may be retarded without networking. Based on this knowledge, EU's external shipping policy has been expanded to accommodate; global markets, free and equal access to International maritime transport services, strengthen bilateral maritime dialogue and flexibility (ESCA, 2017). Seaborne trade creates demand for shipping services making it to become the nexus between intercontinental trade. It facilitate bulk transportation of manufactured goods and raw materials by providing cost effective method of carriage (Tsaini, n.d). Shipping activities have become the backbone of global merchandise since more than 80% of the world's commerce is done by carriage by sea (ESCA, 2017; Tsaini, n.d).

2.1.1. Maritime industry and the economy of Nigeria.

Maritime or shipping operations in Nigeria date back to 1906 (Crown, 2017 ; Edih et al., 2022a). As posited in Edih et al., 2022b), Nigeria is in a vantage and safe state to appropriate her coastal endowments that are highly favourable to maritime operations as it will necessarily contribute to GDP growth (Banerjee, 2009; Essoh, 2013). The GDP of Nigeria is improved by the increase in gross registered tonnage of vessels (Omoke et al.,2019; Osadume and Edih, 2020) and shipping operations are significant to economic growth (Obed, 2006). According to Ekpo (2012) and Edih et al.,(2022a), maritime activities serve as measures for economic diversification and encourage international relationships. As reported, Nigeria transports 80% of goods coming to West and Central Africa by sea (UNCTAD, 2015), and the World Bank (2008) has asserted that 55% of private investments in waterborne trade takes place in Nigeria.

There is a mutual and compelling relationship between seaport operations and maritime laws across the world (Edih et al., 2022b). While seaports are the doors to trade and growth (Inah and Elijah, 2018; Jung, 2011), maritime laws provide the "dos and don'ts" that guides and regulates the entire activities going on between nations, companies and persons in the maritime sector. Shipping and other operations in the sector in Nigeria are regulated by the Nigerian Port's Authority (NPA) and Nigerian Maritime Administration and Safety Agency (NIMASA). Basically, the two agencies perform the landlord, the regulator and the operator functions. Regulating competition between port structures is the landlord's function, while the creation and setting up benchmark standards for operations constitute the regulator's function and the operator's function simply means providing port services (Osadume and University, 2020). Based on the combination of factors (human & technological) prevalent in the sector, Ziaul and Hans-Joachim (2018) emphasized the role of human resource and effective ports management for effective and efficient transport logistics performance.

2.1.2. Limitations to shipping and transport logistics management.

The outbreak of Covid-19 pandemic has a negative effect on maritime operations across the globe by disruption of travels by sea (Ozturk and Turan, 2020). As a result international borders were closed depriving the hiring of foreign workers (Lowe, 2012), and reduction in international tourism and business travels (Verikios, 2020). In 2020.2, many countries experienced economic contractions, namely; the U.S economy contracted by by (-35%), the U.K (-31%), France (-32%), Germany (-31%), Singapore (-27%), and the rest of EU (-29%)(Verikios, 2020). Also identified as militating factors to maritime trade are damage to cargo due to delays, breakdown of machineries and security risks (Prosertek, 2020). On the basis of the UN's prediction, 24.7 million jobs would be lost as a result of the coronavirus pandemic and its consequences would be worse than the 2008 financial crisis (BBC News, 2020 ; Panayides, 2019).The Asian financial crisis tempered with the growth of seaborne trade in the late 1990s and the 2008 economic downturn limited the volume of maritime business (Tsaini, n.d). The great depression of 1923-33 and great recession of 2008/09 wreaked havoc on global economy leading to collapse of banks, drastic reduction in trade (Edih et al., 2023). Recession could be caused by failure to anticipate risks, and not reflecting on the "continuity bias effect"(Barry 2017) and pandemics/wars (Muhammad et al., 2022).

Currently, there are eight (supposed) ports and terminals in Nigeria; Apapa port, Port Harcourt port, Onne Port, Warri cluster of ports, etc. However, some are operating below optimality while others are in a moribund condition due to a variety of bottlenecks. Among the identified limitations are;

1. Paucity of port infrastructure (Benson and Adekemi, 2018;

Ekpo, 2012).
2. Lack of incentives for investments (Edih et al., 2023).
3. Lack of funding (Benson and Adekemi, 2008).
4. Decline in port calls (Omoke et al., 2019; Edih et al., 2022b).
5. Lack of adequate computerization of port daily operation's data (Edih et al., 2022b).
6. Insecurity in the waterways (sea pyrates) (Edih, et al., 2022b).
7. Political interference and corruption (Edih et al., 2022b).
8. Port congestion and demurrage.
9. Lack of dredging operations leading to shallowness of the waterways, preventing the docking of the required ships in the Nigerian ports.
10. Abandonment of other ports apart from Lagos cluster of ports- Apapa port, Tincan port, etc.

Based on these factors hampering maritime operations, the need for maritime reforms toward addressing them cannot be overemphasized (Jerome, 2008; Osadume and University, 2020).

3. Methods and Materials.

Secondary data representing the revenue performance of the Nigerian maritime industry for 2008/09 - 2021/22 fiscal years were extracted from official bulletins and publications of CBN, Bureau of Statistics, NPA and NIMASA. The data are relevant determinants of the impact or significance of the shipping and transport logistics sector (i.e. the maritime industry) to GDP for a given period. Data were subjected to the multiple regressions statistical test at five percent (5%) level of significance.

3.1. Definition of variables.

The selected variables are; gross domestic product (GDP), gross registered tonnage (GRT), and port throughput (or total tonnage of cargo handled). GDP is the parameter for measuring economic growth of a nation, usually for a given period (fiscal years). GRT is the actual record of internal volume or capacity of ships (water going vessels) registered for maritime transport, and port throughput represents the amount of cargo (or number of vessels) handled by the port authority for the period.

3.2. Model specification.

The study adopted the model used in Osadume and University (2020) and Imide et al., (2022), however with minor modifications in line with the performance indices and other crucial measurement metrics designed by World Bank.

1. Income/expenditure per GRT transformed into Total Revenue/Expenditure divided by Total GRT/or NRT of shipping.
2. Operating surplus per ton of cargo handled (port throughput) is measured Operating surplus divided by Total Tonnage of cargo handled.
3. The rate of return on turnover is measured by Operating surplus divided by Operating income.
4. GDP or TRGDP is a function of total revenue to gross registered tonnage (TRGRT), operating surplus to total tonnage of throughput (OSTP), and operating surplus to operating revenues of the ports (OSOR).
5. Therefore, two models are formulated as follows ;

$$GDP = f(TRGRT, OSTP, OSOR) \quad (1)$$

$$TRGDP = f(TRGRT, OSTP, OSOR) \quad (2)$$

By econometric linearization process, we arrived at;

$$GDP_t = b_0 + b_1(TRGRT)_t + b_2(OSTP)_t + b_3(OSOR)_t + e_t \quad (3)$$

$$TRGDP_t = b_0 + b_1(TRGRT)_t + b_2(OSTP)_t + b_3(OSOR)_t + e_t \quad (4)$$

where;
b_0 is the intercept.
b_1, b_2, b_3 are coefficients.
e_t is stochastic disturbance or error term.
t is the trend for the specified time.
$b_0, b_1, b_2, b_3 > 0$ as a priori expectation.

4. Results and Discussion.

The revenue performance data and analysis as well as discussions are presented in sections 4.1 and 4.2 below.

4.1. Tables of revenue performance data and analysis.

Three Tables were used to analysis (See tables 1 to 3 next pages):

4.2. Discussions on findings.

Table 1 above is the revenue performance data for the maritime industry in Nigeria for 2007/08 to 2021/22 fiscal years. It demonstrates the total revenue, total expenditure, operating surplus (amount remitted), contributions to GD, GRT and port throughput in millions of naira. Contributions to GDP were highest in 2014 with 568, 499 million naira and lowest in 2008 with 295,630 million naira. However, total revenue was highest in 2019 with 277,650 million naira and lowest in 2008 with 90,100 million naira with the GDP of 446,543 million naira and 296,630 million naira respectively. Though total revenue for the period 2007/08-2021/22 was highest in 2019 (277,650 million naira), its contribution to GDP of 446, 543 was lower than the GDP in 2014 of 568,499 million naira. This could be partially attributed to the volume of GRT (156.0714 million) and port throughput (84.951927 million) that represent the highest for the period of assessment. It is evident that the negative consequences of the Covid-19 pandemic were felt in 2020 with a reduction in TR to 201,360 million naira from 277,680 million naira in 2019, while contributions to GDP fell from 446,543 million naira in 2019 to 391,010 million nairas.

Table 2 is a derivative of table 1. In that table 2, the highest contribution to TRGDP is 70.68% (0.70686) in 2017 and lowest

Table 1: Data on Port's Performance, 2008/09-2021/22.

Yr	Amt. realized (TR, Million)	Amt. Exp. (TE, Million)	Amt. Remitted (OS, Million)	GDP (Contrib. Millions)	GRT (million)	Throughput (Million)
2008	90,100	87,050	3,050	295,630	66.2414	42.394336
2009	98,250	94,120	4,130	301,540	75,8481	56,656,142
2010	101,050	95,030	6,020	339,848	106.6896	76.744,727
2011	115,020	105,140	9,880	374,099	122.6147	83.461,697
2012	136,010	125,200	10,810	405,441	129.5069	77.104738
2013	157,310	144,140	13,170	514,966	138.6722	78.281634
2014	172,800	154,770	18,030	568,499	156.0714	84.951927
2015	177,200	158,780	18,430	481,066	144.6152	77.387638
2016	182, 420	158,550	23,870	404,650	139.4065	70.819092
2017	265,600	255,290	10,310	375,745	137.4802	71.903266
2018	270,560	245,910	24,650	398,186	128.6718	73.175127
2019	277,680	248,960	28,720	446,543	131.8975	74.698136
2020	201,360	190,150	11,210	391,010	125.4876	70.245813
2021	223,010	201,090	21,920	401,020	127.5643	69.316715

Source: Nigeria Port Authority, National Bureau of Statistics and Central Bank of Nigeria.

Table 2: Data on Port's Performance, 2008/09-2021/22.

Yr	OSTP	TRGRT	OSOR	TRGDP
2008	71.944	1,360.179	0.03385	0.30477
2009	72.896	1,295.352	0.04203	0.32583
2010	78.442	947.140	0.05957	0.29734
2011	118.378	938.060	0.08590	0.30746
2012	140.199	1050.214	0.08590	0.33546
2013	168.239	1134.402	0.07948	0.30548
2014	212.238	1107.186	0.08372	0.30396
2015	238.152	1225.321	0.10434	0.36835
2016	337.056	1304.547	0.13085	0.45081
2017	143.387	1931.915	0.03882	0.70686
2018	336.863	2120.714	0.09111	0.67948
2019	384.481	2105.271	0.10343	0.62184
2020	159.582	1,604.621	0.0557	0.51497
2021	316.229	1,748.216	0.0983	0.55611

Source: Author's computation, 2023.

Table 3: Multiple Regression Tests Results.

Dependent Variables: TRGDP

Variable	Coefficient	State Error	t-statistic	Prob.
C	0.191756	0.042043	4.560948	0.0198
TRGRT (1)	0.000248	4.9805	4.974443	0.0156
OSTP (-1)	0.000216	0.000253	0.855946	0.4549
OSOR	-2.053840	0.304135	-6.753058	0.0066
R-Squared	0.990857	Mean dependent var		0.396911
Ady. R-Squared	0.981713	S.D dependent var		0.146382
F-statistic	108.3680	Durbin-Watson stat		1.924644
Prob (F-Statistic)	0.001480			

Source: Author's computation, 2023.

in 2010 with 29.73% (0.29734). This explains the significance (based on its minimum contribution) of the maritime sector to economic growth in Nigeria.

Table 3 shows that TRGRT (1) at led 1 had a t-statistics value of 4.9744 and a p-value of 0.00156 revealing a positive and significant effect on TRGDP. The t-statistics for OSTP(-1) at lag 1 is 0.8559 and a p-value of 0.4549 showed a positive but statistically not significant effect to TRGDP at the chosen level of significance (0.05) because the p-value is higher. The OSOR had a t-statistics value of -6.7553 and a p-value of 0.0066 indicating a negative relationship but statistically significant effect on TRGDP since the p-value is less than 0.05. This result affirms that shipping and transport logistics operations have a positive and significant effect on economic growth. And the positive effects of TRGRT and OSTP on economic growth (TRGDP) is supported by the findings in Osadume and University, (2020); Omoke et al.,(2019); Imide et al., (2023), Turnbull and Hughes, (2017), and Jung,(2011) among others. However, the challenges hampering optimal performance of global maritime transportation were identified in Ozturk and Turan,(2017), Lowe (2012), Prosertek,(2020), Tsaini, (n.d), Edih et al.,(2022b), and Benson and Adekemi, (2018). The implication is that government or policy makers should take urgent steps towards addressing the problems.

Also, the adjusted R-square of 0.3817 means 38.17% change in GDP is caused by the activities of shipping and transport logistics. The F-statistics of 0.00148 which is less than the significant level, 0.05 indicates that at least one of Independent variables can predict or effect a change in the dependent variable.

Conclusion and Recommendations.

The study affirmed that shipping revenue performance (shipping and transport logistics) are critical components and success factors of the global maritime industry. In essence, the world has become more interconnected and interdependent due to the advancement in maritime trade (carriage of goods and persons by sea). More so, shipping activities, and transport logistics have positively impacted the economies of nations doing maritime business and the multiplier effects are; creation of Investments in maritime facilities, construction of hinterlands roads to connect the ports, vast opportunities for employment, improved per capita income, enhanced diversification policy, and increased GDP. However, multiple factors that are limiting the optimal performance of the maritime sector were unraveled. Among such challenges are unforeseen and unexpected global pandemic and recession, political interference (more pronounced in developing economies), insecurity, wars, lack of maritime infrastructure, moribund and non-functional ports, natural disasters causing damage to ports and ships, etc. Based on these limitations hindering full performance of the maritime industry, the following measures have been suggested;

1. A robust maritime reform should be put in place to stabilize the industry. Reforms on maritime security architecture, concession of maritime facilities, to boost revenue generation, revive moribund ports, will necessarily drive sustainable growth in the sector.
2. A robust public private partnership plan (4ps) to accommodate both foreign and indigenous investors. Such joint arrangement would boost capital generation for the building of major infrastructures in the industry. The PPP formula should address negative externalities from the foreign companies in terms of competing with the local firms (using tax waiver).
3. Government should restructure the supervisory agencies (NPA and NIMASA) to enable them to perform maximally. The restructuring model should strengthen the whistle blowing policy to fish out corrupt officers and flush out endemic corrupt practices from the system.

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The 2001 Bunker Convention: Needs for Completing Civil Liability Regime for Oil Pollution Damage Caused by Ships

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ABSTRACT

So far, the CLC isn't the most effective liability and compensation for oil pollution damage in the world. It should be acknowledged that there are still weaknesses in the CLC, and other liability mechanisms have been developed to cover those gaps. The 2001 Bunker Convention is one influential Convention. Although most of the catastrophic oil spills seem to have been caused by large tankers, one of the first sources of oil pollution at sea is bunker oil to operate ships. Bunker oil means any hydrocarbon mineral oil, including lubricating oil, used or intended to be used for the operation or propulsion of the ship, and any residues of such oil. (Article 1(5) of 2001 Bunker convention), so it presents the risk of causing pollution damage, which even more difficult and expensive to clean than a tanker spill. However, the bunker oil isn't covered by the CLC; therefore, 2001 Bunker Convention was born to fill it. Within the article's framework, the authors will analyze and evaluate the significance of 2001 Bunker Convention for damages caused by oil pollution from ships.

1. Introduction.

The 1969 International Convention on Civil Liability for Oil Pollution Damage (CLC 1969) has been in effect since 1975. This Convention was adopted with the aim of ensuring that compensation for oil pollution damages is fully, promptly, and effectively paid. However, CLC 1969 was revised under the 1992 Protocol, which is called the International Convention on Civil Liability for Oil Pollution Damage 1992 (CLC 1992) and entered into force on 30 May 1996. The CLC system has established the vessel owner's liability for damage caused by oil pollution, and shipowners must purchase compulsory insurance or financial security to ensure their liability for oil pollution damage caused by the ship.

International Maritime Organization - IMO met from 19 to 23 March 2001 to ratify the International Convention on Civil Liability for Bunker Oil Damage (the 2001 Bunker Convention) [1]. The object of this Convention is to unify mandatory international regulations relating to liability for damages caused by bunker oil pollution. On the basis of the provisions of United Nations Convention on the Law of the Sea, 1982 (UNCLOS 1982); CLC 69/92; International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND 71/92); International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996, and other related international conventions adopted by the IMO, the 2001 Bunker Convention was created. The 2001 Bunker Convention regulations and the rules of other relevant international conventions are directed towards a clean ocean (Recalling article 194 of the United Nations Convention on the Law of the Sea, 19821, which provides that States shall take all measures necessary to prevent, reduce and control pollution of the marine environment).

Since then, the CLC Convention has established an efficient and distinctive worldwide legal framework for civil liability and compensation for environmental pollution. A number of other civil liability regimes have been formed to address the signif-

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icant shortcomings of the CLC, such as Limited the scope of application, and compensation, etc. On the one hand, some countries have developed their own civil liability scheme and compensation for ships- sourse oil pollution (The United States is not a party to the international oil pollution liability regime. It has its own oil pollution liability regime, contained in the Oil Pollution Act,1990 (OPA 1990). Although the OPA 1990 is similar in structure to the international liability regime, the OPA 1990's scope is wider than that of the international regime. See The Oil Pollution Act of 1990).

On the other hand, some other countries have adopted treaties and conventions to tackle these specific problems. Both national and regional laws seem to be working in tandem with the civil liability system of the CLC. Moreover, there is a civil liability regime for the damage caused by the bunker oil contamination, which also operates in parallel with the CLC's civil liability regime. Since the 2001 Bunker Convention was ratified, the 2001 Bunker Convention has fulfilled the gaps left by the CLC and FUND in fuel oil emissions for engine service. (CLC and FUND conventions only regulate pollution caused by persistent oil). However, the 2001 Bunker Convention still has a number of limitations; for effective implementation of the Convention, it is highly dependent on the member states of the Convention. This will be clearly analyzed in the next presentations.

2. Main Contents of the 2001 Bunker Convention.

2.1. Liability of ship owners.

The 2001 Bunker Convention applied the concept of strict liability, meaning that owners are responsible for damage caused by bunker oil pollution of their ships, whether or not their ships are at fault unless otherwise provided by this convention. And an example of this issue can be analyzed as follows: A cargo ship was docking in the port and was struck by a tugboat of the port, leading to pollution caused by bunker oil of cargo ship. The owner of that cargo ship would be liable for the harm caused by such pollution, even if the pollution is caused by 100% of the tugboat's negligence, provided that accident was not caused by an act or omission done with intent to cause damage by the person who suffered the damage or from the negligence of that person. The liability of shipowners under the 2001 Bunker Convention is strict but not absolute, because shipowners are still excluded from liability in some cases. This implies that the shipowner is not responsible for polluting damage if he can prove that the damage is caused by one of the following reasons: the damage resulted from an act of war, hostilities, civil war, insurrection, or a natural phenomenon of an exceptional, inevitable and irresistible character; or the damage was wholly caused by any act or omission done with the intent to cause damage by a third party, or the damage was wholly caused by the negligence or other wrongful act of any Government or other authority responsible for the maintenance of lights or other navigational aids in the exercise of that function.[3]

2.2. Party responsible for pollution damage under the 2001 Bunker Convention.

As defined in the 2001 Bunker Convention, the party responsible for damage caused by the pollution of vessels carrying bunkers is the shipowner. And the Convention also establishes the concept of shipowners to include the shipowner, the manager, the operator, and the charterer. Thus, according to this concept, the party responsible for the damage to fuel oil pollution of the ship (shipowner) has a broader meaning, including many people rather than merely the owner of the ship.
The 2001 Bunker Convention states that in the event that two or more parties are liable for damage caused by pollution, they shall be held jointly or separately liable for such damage. This means that a damaged third party[4] known as a shipowner, ignores litigation against each other and fixes the damage according to the best option available from the financial conditions of the shipowner.

2.3. Limited liability.

Subject to Article 6 of this Convention, the rights to limit the liability of shipowners or insurers shall not be impaired under the regime of limitation of liability of international or any country. It means that this Convention does not set out any independent limits to apply to it. However, member states have the right to choose the limited liability regime to apply. The Convention gives an applicable example of the Convention on Limitation of Liability for Maritime Claims 1976 as amended by the Protocol of 1996 (1976 /1996 LLMC Convention).

2.4. Compulsory insurance or financial security.

According to Article 7 of the 2001 Bunker Convention, the registered owner of a ship with a gross tonnage greater than 1,000 GT registered in a Contracting State shall retain insurance or financial protection to secure its liability for damage to bunker pollution in an amount equal to the limit under applicable international or national law, but in no case shall the amount be exceeded in accordance with the 1976/1996 LLMC Convention.

The 2001 Bunker Convention applied the 1976/1996 LLMC Convention to restrict the amount insured. However, there is no

[3]According to Article 3 (2), (4) of The 2001 Bunker Convention: 3. No liability for pollution damage shall attach to the shipowner if the shipowner proves that: (a) the damage resulted from an act of war, hostilities, civil war, insurrection or a natural phenomenon of an exceptional, inevitable and irresistible character; or (b) the damage was wholly caused by an act or omission done with the intent to cause damage by a third party; or (c) the damage was wholly caused by the negligence or other wrongful act of any Government or other authority responsible for the maintenance of lights or other navigational aids in the exercise of that function; 4. If the shipowner proves that the pollution damage resulted wholly or partially either from an act or omission done with intent to cause damage by the person who suffered the damage or from the negligence of that person, the shipowner may be exonerated wholly or partially from liability to such person.

[4]Third party who suffer a specific loss that was originally regulated in the relationship between the wrongdoer and another party. Art.3(2) of 2001 Bunker Convention provides that where more than one person is liable in accordance with paragraph 1, their liability shall be joint and several. The above provision, in essence, means that the damaged third party or state authorities can ignore litigation between the parties falling under the definition of Shipowner and recover in accordance to the best option available from the financially healthiest shipowner.

minimum claim in this Convention, resulting in varying coverage levels in different member states.

2.5. Judgment of a competent court.

The courts of the polluted state have jurisdiction over any claims for damage caused by the pollution of the vessels carrying bunkers to the shipowner, the insurance company, or its guarantor. Any judgment of the competent courts shall be recognized by any Contracting State to this Convention. When an award is recognized, it shall be enforced as soon as possible in each Contracting State.[5]

3. The relationship of the Bunker Convention 2001 and the CLC in compensation for oil pollution caused by ships.

3.1. Authority and scope of application.

The 2001 Bunker Convention refers to damage caused by oil pollution in the territorial sea or the exclusive economic zone of a Member State and to preventive measures wherever taken to avoid or mitigate damage caused by pollution. However, the 2001 Bunker Convention would not cover pollution damage that has been applied under the CLC regime.[6] Therefore, we should also recognize that the 2001 Bunker Convention is applicable to ships other than oil tankers in large quantities such as cargo, for example, container ships, passenger ships, etc. Ships carrying oil in bulk as cargo can also be subject to the 2001 Bunker Convention if they do not carry oil in clean cargo tankers.[7] The CLC regulatory exclusion of oil pollution damage means that only claims are recognized under the 2001 Bunker Convention for damages arising from a non-persistent fuel oil spill. Any claim or other failure to indemnify under the liability regime of the CLC would not be recognized under the liability regime of the 2001 Bunker Convention. Therefore, the 2001 Bunker Convention is set up to govern matters of civil liability for oil pollution damage rather than to govern all matters relating to oil pollution damage without being protected by the CLC regime's regulatory scope.

3.2. Liability for oil pollution.

According to the 2001 Bunker Convention, shipowners at the time of the incident causing oil pollution damage are strictly liable for such pollution damage. It is worth noting that unlike CLC 1992, the definition of the shipowner in the 2001 Bunker Convention is not limited only to the registered owner of the ship but also includes persons exempt from liability under CLC 1992, such as charterers and ship operators, etc. And the liability of those called shipowners is interrelated or separate. Thus, compared with CLC, ship owners, according to the 2001 Bunker Convention have broader meanings, including: including the registered owner, bareboat charterer, manager, and operator of the ship, which lead to more people responsible for oil pollution losses according to the 2001 Bunker Convention according to the CLC.

3.3. Insurance or financial security.

Under the CLC convention, shipowners of a ship registered in a member state carrying more than 2,000 tons of cargo oil are required to buy insurance or financial security. According to the 2001 Bunker Convention, the owners of a vessel of a member country with a gross tonnage greater than 1000 GT must maintain insurance or financial security to cover liability for pollution damage caused by the fuel oil of their vessel, in a proportion corresponding to the limit of liability under the applicable national or international limitation of liability regulations.

Claimants for oil pollution damage under the 2001 Bunker Convention can sue insurance companies that have given financial insurance to shipowners. And like CLC's liability regime, insurance companies have the right to protect their interests against claims for damages; be entitled to limit the same liability as to the owner of the ship; can be protected against polluting damages caused by intentional misconduct causing the shipowner's damage; may request the shipowners involved in proceedings in the lawsuit for compensation of oil pollution damage.

3.4. Limitation of Liability.

Shipowners or suppliers of insurance or financial security under the 2001 Bunker Convention have the right to limit liability under national or international law, for example, under 1976 /1996 LLMC Convention. Thus, the limitation of liability for bunker pollution damage is not specific but depends on the vessel owner's choice of liability regime. Hence, unlike the CLC's rule of liability, which sets a specific limit, the 2001 Bunker Convention provision on the limitation of liability for damage caused by bunker pollution could cause inconsistencies in the application of this Convention since various countries have different laws regarding this liability issue.

During the on the ratification of the 2001 Bunker Convention, there were difficulties in negotiating the establishment of an international fuel oil pollution fund. Although there is a high risk of oil pollution from a fuel oil spill, no international fund for bunker pollution damage has been created.[8] Therefore, unlike the CLC liability regime, there is a high possibility

[5] Article 10, 2001 Bunker Convention.

[6] Article 4, 2001 Bunker Convention.

[7] Art.4(1) provides that the Bunker Convention does ?not apply to pollution damage as defined in the Civil Liability Convention, whether or not compensation is payable in respect of it under that Convention?. The Bunker Convention has been developed for the purpose of filling the gap left open by the CLC/Fund scheme in respect of oil pollution caused from bunkers and not as an alternative or additional scheme to the CLC/Fund. Art.1(4) preserves this balance. Therefore, pollution damage caused by tankers (either from their cargoes of ?persistent? oil) where the CLC/Fund regime is applicable is covered by the CLC/Fund scheme only. Claimants cannot look at the Bunker Convention for recovery of damages caused by oil pollution from such ships because adequate compensation (or compensation at all) cannot be retrieved under the CLC/Fund scheme.

[8] Many delegations at the IMO Legal Committee debates in the late 1990s recognised that bunker spills were a great source of pollution and there was an assumption that they accounted for a significant number of pollution incidents. The 65th Session of the Legal Committee in September 1991 established a small Working Group of Technical Experts on Bunker Fuel Oils (for non-tankers), bunegotiationst it was not able to reach a consensus. Most delegations

that 2001 Bunker Convention damages claims will not be adequately compensated for lack of funds.

4. The value of the 2001 Bunker Convention in compensation for oil pollution caused by ships.

The 2001 Bunker Convention is modelled on the provisions of the CLC. Therefore, most of its main terms are similar to the international liability regulations and the oil pollution compensation regime, including regulations related to the applicable geographic extent, jurisdiction, and mandatory insurance or financial security. Some provisions, such as provisions on terms, apply from the CLC regime, although there were necessary adjustments. Besides, there are different provisions between the two regimes, such as the provisions on who is responsible and the limit of legal liability, in particular:

The regulation on the person responsible for oil pollution damage under the 2001 Bunker Convention has a wider application than under the CLC regime; it includes shipowner, operator, charterer. Meanwhile, according to the CLC, the person responsible for oil pollution damage includes only the ship's registered owner.

For the limit of liability, the CLC has provided a specific set of limitations of liability. According to the 2001 Bunker Convention, there is no specific limitation of liability, which depends on the legal framework of the country, which decides to apply it, typically the law of that Member State. If the country has a clear system of compensation laws for oil pollution damages, then the 2001 Bunker Convention's implementation will be smooth and effective; in contrast to an incomplete national system of oil pollution compensation laws, the implementation of the Convention is likely to be ineffective. This can be proven by a particular situation where two ships are the same (all aspects are the same) due to the application of the laws of two different countries, there is a different level of insurance, but both are certified in accordance with the 2001 Bunker Convention.[9]

As such, the 2001 Bunker Convention has developed a compensation mechanism for bunker pollution damages. It is expected to fill the void left by other oil pollution conventions, the CLC, and the Fund Convention. Although the 2001Bunker Convention established strict liability for member states, it did not agree on the limit of liability, and the amount insured. It was determined by the indemnity regimes that the selected countries apply. Therefore, whether the implementation of the 2001 Bunker Convention is successful or not depends very much on the laws of member states.

The 2001 Bunker Convention effectively complemented the shortcomings of the CLC in reimbursement for damage caused by oil pollution from ships. This allows us to better protect the marine environment from emissions from the oil supplies of our vessels, as well as to provide fair coverage for victims of both the pollution of cargo oil and fuel oil. The 2001 Bunker Convention applies to all ships, including tankers, so it covers oil pollution losses that have not been controlled by CLC regulations. As such, there will be no alternative between these two regimes; in order to complete a liability and compensation regime for oil pollution damage caused by ships, a nation must be a member of both the CLC and the 2001 Bunker Conventions.

Conclusions.

The comparison and analysis of 2001 Bunker Convention and CLC 1992, to determine the role of the 2001 Bunker Convention has allowed us to take a closer look at these two conventions, as well as international legal documents on liability for damages caused by oil pollution from ships. There are different or identical rules in each treaty, but all these international agreements are usually enacted in order to create a legal corridor, an international legal standard for member states to apply in order to minimize negative impacts on the marine environment, to resolve and cope with the impacts on the marine ecosystem and the blue ocean on Earth.

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favoured the inclusion of bunker fuels within an HNS regime. The Legal Committee noted the differences of opinion, but there was support for the view that there should be no contribution to a second tier HNS Fund by such cargoes in any event. At the 67th Session of the Legal Committee in September 1992 an indicative vote was held as to whether bunker fuel oil should be included in the HNS Convention. 20 delegations were against. The Committee decided, therefore, to leave bunker fuel oils outside its further work on hazardous and noxious substances, and the HNS Convention 1996 does not therefore cover bunker pollution. See LEG 65/8, 11 October 1991, and LEG 67/9, 13 October 1992, para 45. An attempt to reintroduce bunker oils was rejected at the 72nd Session in 1995.

[9] According to Art.7(1), the insurance or other financial security must be enough ?to cover the liability of the registered owner for pollution damage in an amount equal to the limits of liability under the applicable national or international limitation regime, but in all cases, not exceeding an amount calculated in accordance with the Convention on Limitation of Liability for Maritime Claims, 1976, as amended'. The amount insured is limited upwards by the limits set by the LLMC 1976 as ammended; this is, at most, around one third of the total limitation fund because the Bunker Convention does not cover claims in respect of death or personal injury (this amount is approx. double to that in respect of any other claims). However, there is no provision for minimum insurance as this was left to the ?applicable national or international limitation regime? of the State Party which is the ship's Flag State. There is no uniformity therefore on the level of cover. This may lead to situations where two ships (in all respects identical) have different levels of insurance cover but still both being properly certificated under the Bunker Convention scheme.

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Research and Design of Fire Alarm Systems using Virtual Reality Technology Enhance Safety Training in the Maritime

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ABSTRACT

Today, water transportation plays a vital role in transporting goods and international trade. Therefore, maritime safety and fire prevention on ships are urgent issues that are being deployed quickly. There are many methods of training and fire-fighting skills for crew members and fire alarm devices installed on ships. This article develops the hardware design of a fire alarm system on ships incorporating virtual reality simulation technology. Next, build a successful connection between HMI hardware devices and simulation software, such as fire alarms. Therefore, the Seafarer can practice, detect fire areas and have basic fire-fighting skills on ships. Build and simulate virtual space on ships, fires, and fire point spaces in Unity 3D software. The system helps save training costs and human life safety, improving the ability to operate equipment before a real-life situation occurs and rescue scenarios onboard a ship.

1. Introduction.

Ship fire accidents account for many marine disasters and are vital to a ship's ability to operate. Recent ship fire damage has prompted research related to fire training on ships. Many fire alarms, fire-fighting equipment and fire simulation technology on ships have exploded rapidly. In recent years, many fires on ships have caused severe consequences. In October 2021, the Malta-flagged MV Zim Kingston transporting 52 tons of xanthates caught fire and released toxic gases into the environment, causing harm to marine life (MV Zim Kingston, 2021). In 2022, the Singapore container ship APL CAIRO caught fire in Vung Tau waters, causing damage to property and people.

Some fires, such as the fire on the cargo ship Xpress Pearl in 2021, lasted 13 days, causing substantial economic losses and was one of the worst ecological disasters in Sri Lanka's history (X-Press Pearl, 2021). In 2021, the Felicity Ace ship carrying many luxury cars and supercars caught fire in the middle of the Atlantic Ocean; more than 4000 cars must have been destroyed and left on the ship.

In the world, there are many studies on fire alarm systems on ships and VR simulations in some areas on ships for training purposes. Several fire training principles were established by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW, 1978) and adopted by the International Maritime Organization (IMO), which also issued Evacuation Analysis Instructions for passengers in case of fire.

Some research related to the history and emergencies on ships, or some experiments that simulate fires at dangerous levels for students to practice (Chu, B.; Chang, D., 2017). The research has built a virtual reality building environment to train children, staff and teachers to collect their behaviours and attitudes towards the fire and assess the advantages and disadvantages of using virtual reality glasses (David Oliva. et al.,

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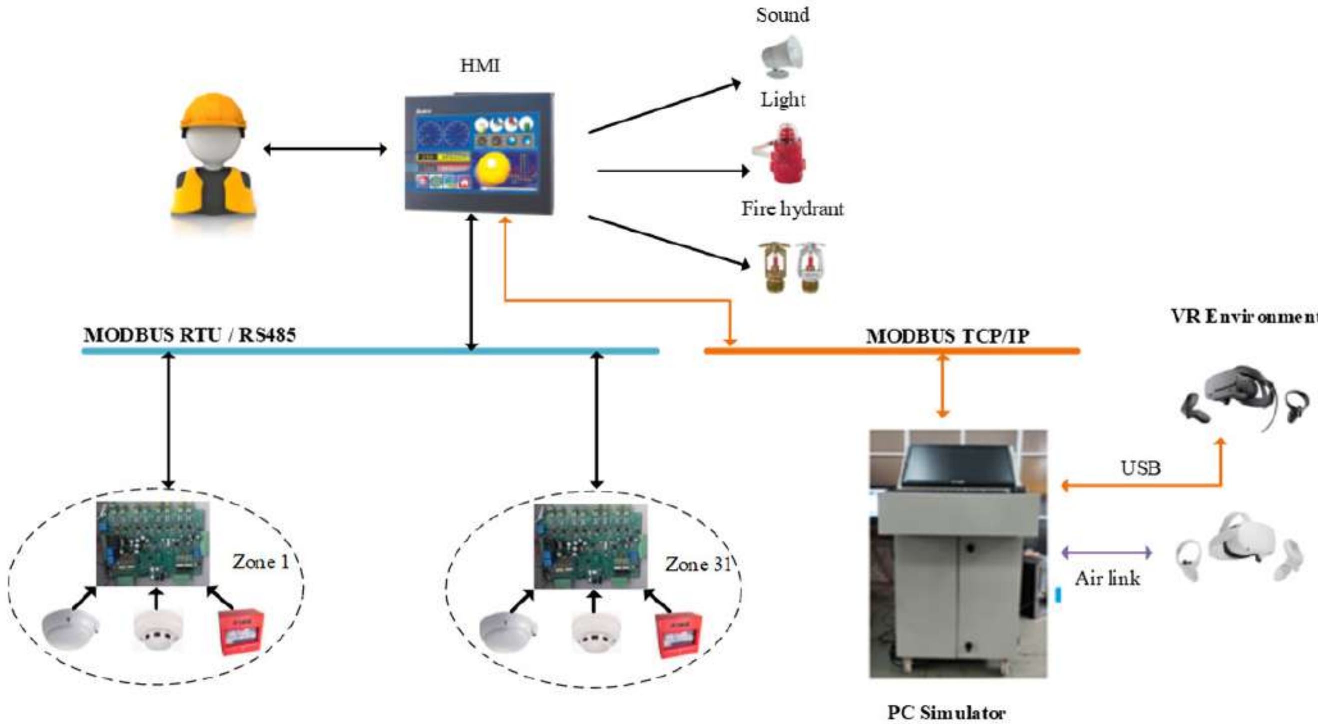
Figure 1: Fire alarm functional block diagram.



Source: Authors.

2019). The study calculated the prediction of the time the fire started and the temperature sensor was impacted, built a fire model, and made a relationship between time and smoke propagation speed. (Wang, J. et al., 2018). In some recent studies, virtual reality simulation technology has brought better results than traditional video-watching methods. VR training helps increase students' ability to perceive fire hazards (Lovreglio et al., 2020). In addition, when VR training with fire extinguishers, employees have better skills than those who start using real fire extinguishers (Melo. et al., 2016). As such, there is no study investigating the effectiveness of VR training for fire mitigation in terms of knowledge acquirement and retention. On the other hand, there is no comparison of possible VR training solutions with traditional training solutions focusing on using a fire extinguisher (Feng Z, et. al., 2018).

In Vietnam, several projects are related to fire alarm system design on ships. Author L. K. Thanh has researched and designed an automatic fire alarm system on vessels based on the (actuator-sensor-interface) network technology (Thanh, L . K and Thanh, N . K, 2007). In addition, Khanh et al. have built an intelligent fire alarm system for the building using IOT technology. The fire area warning system with sound and display helps people escape easily when there is a fire (Khanh, Đ. H. et al. 2018). Research on building fire alarms and fire fighting software on ships has created scenarios in virtual reality. However, the interaction with the device is still limited, and some models are simple (Van, Tuan and Hung, 2022).

To prevent unfortunate fires occurring on ships, in addition to raising awareness and equipping crew with fire prevention and fighting skills, a fire alarm system works stably, reliably and promptly. Timely giving fire warnings and the location of the fire has a significant meaning to minimize the damage to people and property.

The rest of the paper is described in Section 2, design of Fire alarm system hardware, and Section 3 proposes to build 3D models in Unity 3D software. Section 4 analyses the testing of some fire scenarios on ships. The conclusions and future work are summarised in Section 5.

2. Fire Alarm System Design.

2.1. Functional block diagram design.

The authors built the functional block diagram for the system, as shown in Figure 1. The diagram includes a Delta Dop-100 HMI touchscreen as a central control. On the other hand, this screen also plays a role in monitoring the entire system, such as displaying the fire area, displaying the alarm list, saving alarm history, and some other interactions with the user, such as editing the name of the fire area to convenient for monitoring.

Figure 1 depicts a Delta Dop-100 HMI screen that not only acts as a central control but on the other hand, this screen also plays the role of monitoring the entire system, such as displaying the fire area and the list, alarm books, saving alarm history;... and some other interactions with users, such as editing the name of the fire area to facilitate monitoring.

The system is designed to support a maximum connection of up to 31 fire alarm panels for fire monitoring corresponding to a Modbus RTU network that can support 32 devices. The author designs each fire alarm blister to include eight zones, but it supports stacking two blisters on top of each other to keep a maximum of 16 zones. Each zone can connect up to 16 sensors or fire alarm buttons. These zones are all defined with Modbus addresses so the central controller can determine the exact location of the fire when there is a problem (Khanh, Đ. H. et al., 2018).

The SCADA computer will communicate with the simulation computer through the Modbus TCP communication protocol. From the computer simulation, images will be sent to VR glasses, bringing users into a virtual environment to perform operations and procedures in case of fire on the ship under the supervision of teachers.

2.2. Fire alarm circuit design.

The authors designed the fire alarm panel using the ATmega32 microcontroller. The manufactured fire alarm grill includes several main modules: sensor circuit module, configuration circuit module for microcontroller, communication module with touch screen, power module, alarm circuit and function test. With the design principle that the controller will inject a current value at the output of each zone, each zone will connect to a sensor or fire alarm button based on the measured current value the controller will know. It supports combining two zones on top of each other to get a 16-zone blister. Each zone is defined with a corresponding Modbus address. Figure 2 is a picture of the manufactured fire alarm panel.

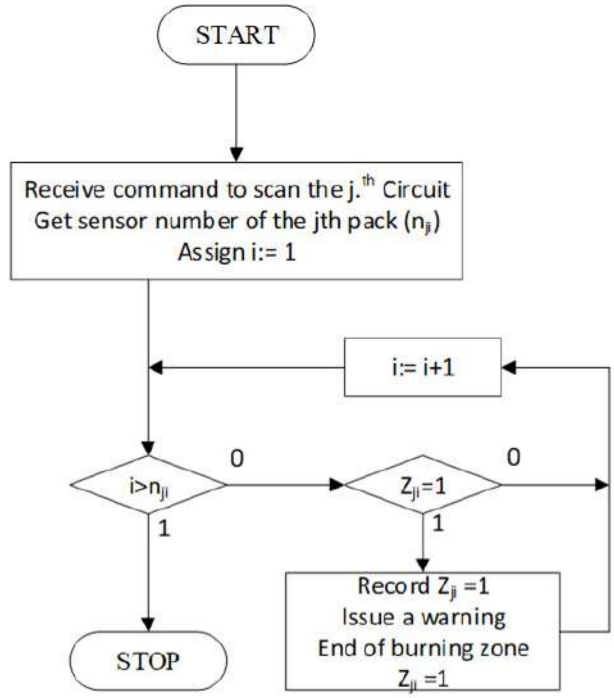
Figure 2: Fire alarms have been built.

Source: Authors.

3. Control Algorithm.

After designing the circuit board hardware, the authors proceeded to build a control algorithm for the fire alarm system. Figure 3 is the control algorithm 1, which the author built for the j^{th} fire alarm.

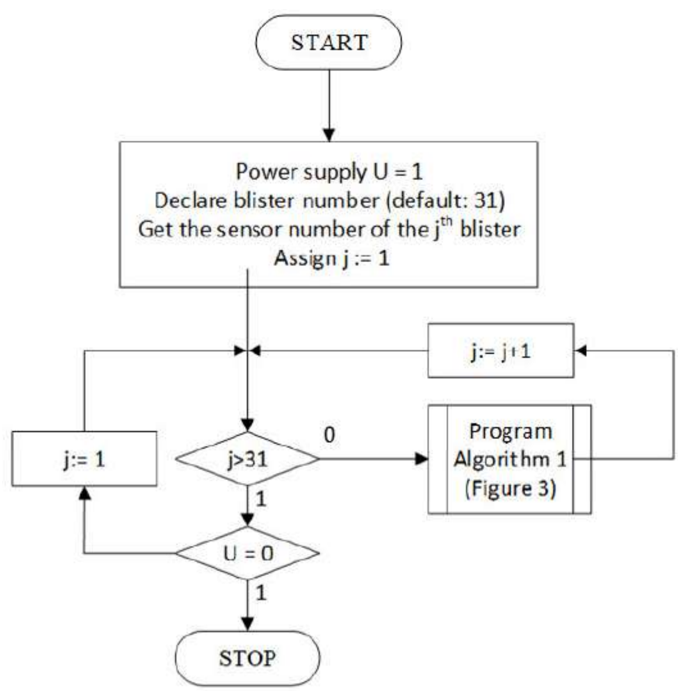
Figure 3: Control algorithm 1 of the j^{th} fire alarm panel.



Source: Authors.

where: j - Serial number of the fire alarm in the system (max multi by default j=31); i - Serial number of sensors play in the jth round; n_{ji} - Number of sensors connected to the blister j^{th}; Z_{ji} - Burning area i^{th} of j.

Figure 4: Control algorithm 2 of fire alarm system.



Source: Authors.

In algorithm 2, the controller will initially receive a scan command and the sensor number of the j^{th} blister. i will be assigned a value of 1 corresponding to the first sensor connected to grid j to be scanned. If at this first position I, a fire occurs in area i, then Z_{ji}=1 and this value will be recorded and issued a fire alarm in the Z_{ji} area.

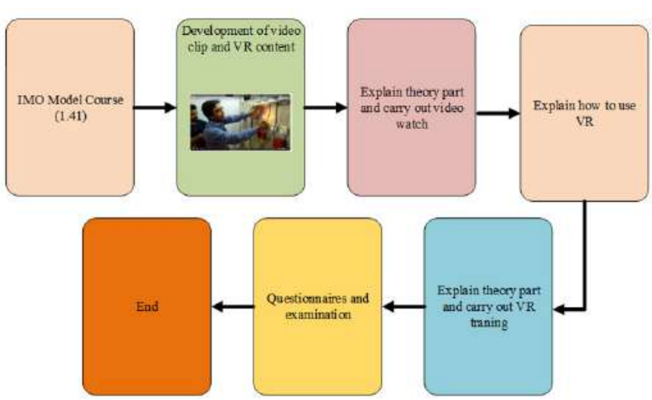
4. 3D model on Unity.

4.1. Build a simulation training process.

According to the International Standard on Training, Certification and Supervision for Seafarers (STCW 1978), as revised, several training and education courses are required to be completed by seafarers. In this study, the authors aimed to quantitatively determine the impact of VR anti-submersion fire training training by comparing it with video-based training methods. To develop video content and VR content, the content scope is defined in IMO Model Course 1.41. "Assisting passengers on exit routes" was selected from the range of the 1.41 sample course and developed into video and VR training content. The participants then watched the video and then practised on VR.

Figure 5 shows the training process of the virtual reality simulation system. In this system, based on the theory based on the IMO Model Course (1.41), the authors reconstructed video tutorials on using life-saving devices. Next, explain the idea to students and let them watch the sample video. Students will become familiar with VR glasses and function buttons. Once mastered, practice in VR glasses.

Figure 5: Fire alarm simulation system training process.

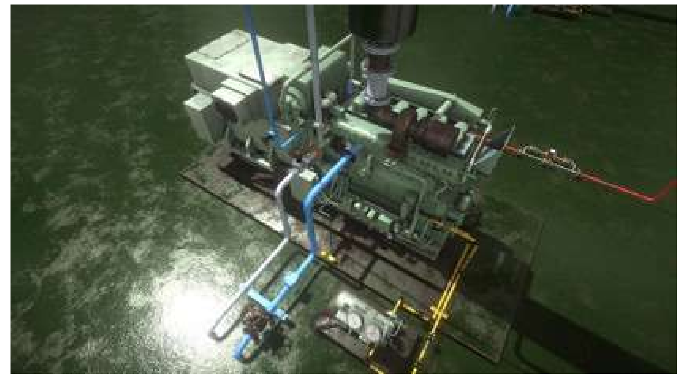


Source: Authors.

4.2. Build a model ship.

The authors built ship models with many different types of engines from several companies around the world. The container ship model has a size of 361.5m. The team uses specialized graphics software to create 3D objects. Blender software is a powerful tool to help build machine models, engine room models, cockpits and lifeboats.

Figure 6: Ship generator model.



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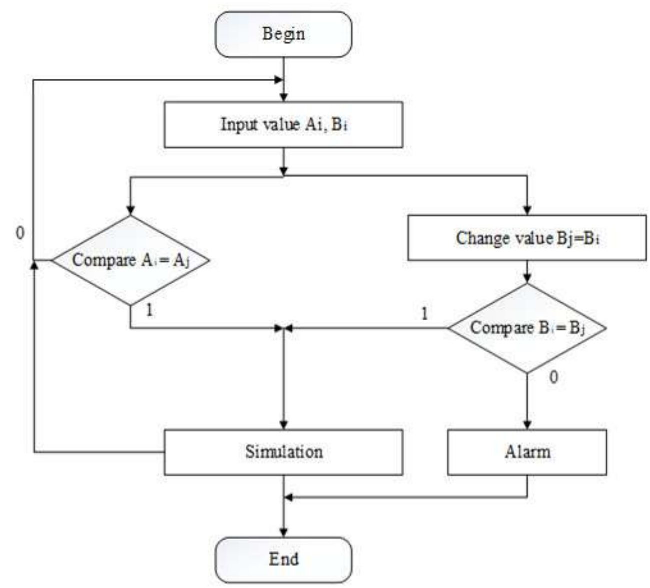
4.3. Fire simulation algorithm.

Figure 7: Fire simulation algorithm.



Source: Authors.

Figure 7 describes the fire simulation program in the software. Initially, when the program receives input values from the teacher's computer, they include A_i is the fire value in the areas to be simulated. B_i is the value that can be changed during the simulation. During the simulation process, the system can be intervened to change the nature of the fire as requested by the teacher. The input values that can be changed are compared with the original setting value. If the cases are not satisfied, it will stop sending a warning signal to the teacher.

4.4. Fire and smoke in unity 3D.

To build the fire, the authors used the Particle tool, which is a tool that helps simulate any effects. These fires have different shapes and levels depending on the burning material, space and fire area, and the fire's time until it is extinguished. The fire is simulated with its actual physical properties. We can also change these values depending on the requirements and burning materials. The duration, looping, colour and speed in the simulation will be set for each fire (Chen,2014). After creating the effect, the authors converted and programmed it based on the C# programming language platform and transferred the built algorithm into Unity. The modules are as follows:

- FireParticle.cs: contains values that create fires in each simulation area.

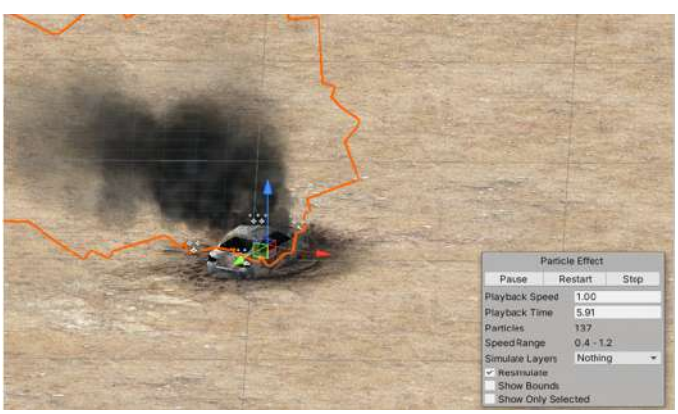
- FireChangeValue.cs: helps change the fire component value in the simulation.

- FireAudio.cs: Create sounds when there is a fire.

The authors then assigned scripts to each fire object in the simulation. Similar to the smoke that will appear when burning, there will be different smoke depending on the burning material. Therefore, the smoke colours and densities will be different and changed during the program. Figure 8 shows set up a fire and smoke model.Figure 8: a, Fire model; b, Smoke model.

Figure 8: a, Fire model; b, Smoke model.

a,



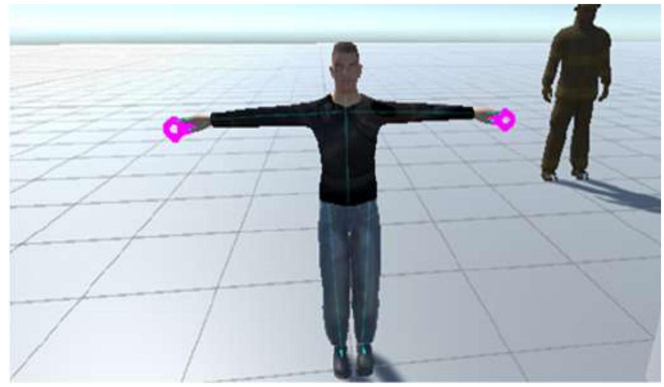
b,

Source: Authors.

4.5. VR Human Model.

The authors built the object in Unity 3D and connected it to the glasses. First, the team created the virtual human thing and the arm and leg components. A subprogram will be made to perform the function as shown in Figure 9 for each small part (Kinateder, et al., 2013).

Figure 9: VR Human model.



Source: Authors.

For each of the above functions, C# scripts are created and assigned to each part, such as left hand and right hand.

- LeftHandTarget.cs: programming left-hand movements.
- RightHandTarget.cs: functions like the right hand.
- LeftFootTarget.cs: function to simulate left foot.
- RightFootTarget.cs: simulates proper foot functionality.

5. Simulation and result.

5.1. Simulation steps.

The system provides practice exercises that are simulated in real-life environments and meet STCW regulation VI/3, section A-VI/3 table A-VI/3-1, which describes the validation methods Demonstrate fire-fighting, search and rescue capabilities on board such as (STCW, 1978), (Lovreglio, R., Duan, X., Rahouti, A. et al. 2021):

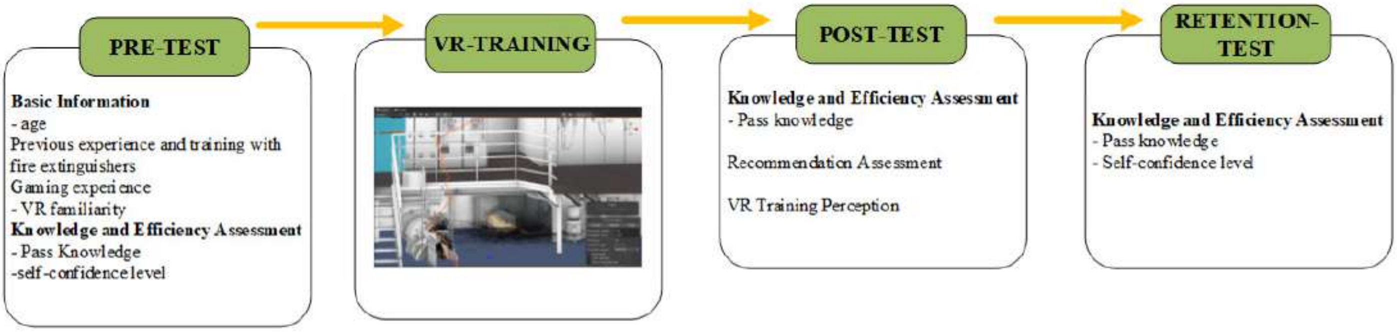
- Control fire-fighting activities on board.
- Organize and train the fire brigade.
- Check and maintain fire detection and fighting systems and equipment.

In addition, the onboard fire-fighting training system developed using virtual reality technology can fulfil various training purposes. It mainly consists of training in fire fighting skills, familiarization with all functions of fire equipment, handling of fire accidents in different positions of the ship and commanding decision-making (Smith S, Ericson E, 2009). Figure 10 describes the student assessment process through the virtual reality simulation system (Desiana, 2022).

5.2. Result.

The authors put on glasses and started the simulation program. Before practising, students will watch videos and read documents related to the ship, location, fire-fighting equipment and specific fire-fighting procedures. Then, students wear VR glasses and begin the simulation, as shown in Figure 11.

Figure 10: Research simulation process.



Source: Authors.

Figure 11: Students Testing VR glasses.

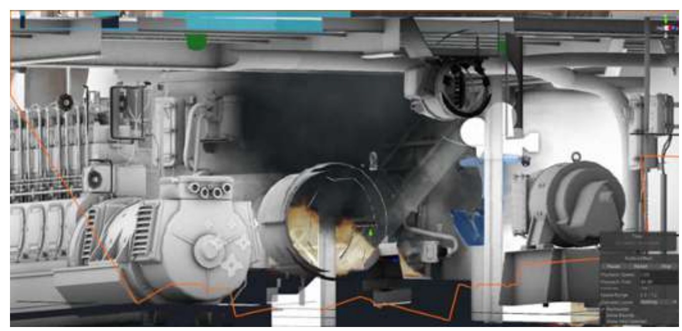
Source: Authors.

The experiments involved 100 students studying Navigation at Vietnam Maritime University for testing and training to evaluate results. After 2weeks after the training, the same participants were contacted again to complete the retention test.

However, only 50 of them completed the second evaluation test (25 for the VR group and 25 for the video group).

Figure 12 shows that the heat and smoke sensors will detect and alert the fire alarm panel when a generator catches fire. Simultaneously, the fire signal fire level and area will be simulated and displayed in VR software.

Figure 12: Fire situation in the engine room.



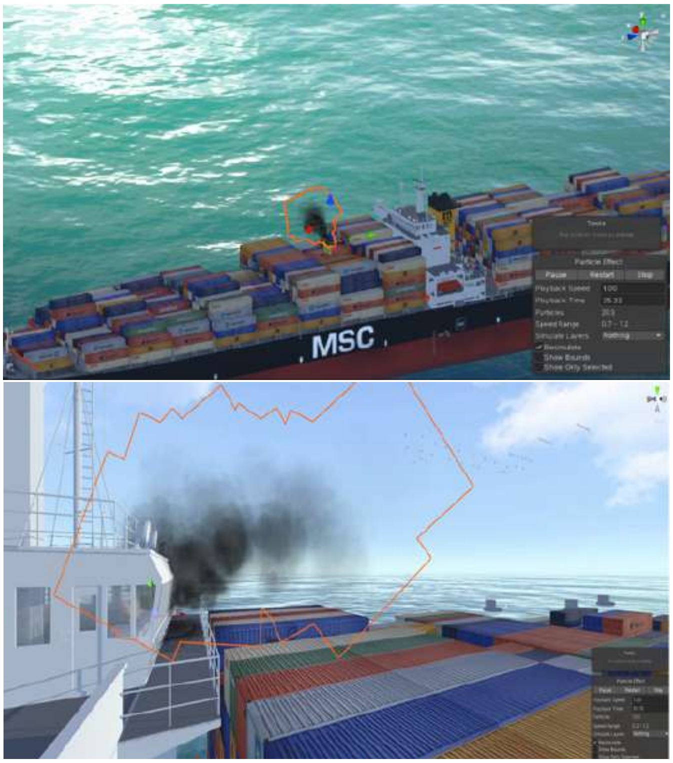
Source: Authors.

Figure 13: Fire situation in the electric room.

Source: Authors.

The spread of the fire will be simulated based on the actual characteristics of the fire. For different objects, the degree of ignition changes. Therefore, acting as a fire object will be more complex and require more detail. The fire level meets about 85% of the actual fire situation during the test. Figure 13 depicts the extent of fire spread in the engine room and the impact of the fire suppression system. At this time, the heat sensor will impact and alarm the entire ship. The crew's task is to determine the location of the fire and then wear protective clothing to extinguish the fire and save people.

Figure 14: a, Container Fire; b, Bridge room.



Source: Authors.

Figure 15: a, Hallway area; b, Seafarer room.

Source: Authors.

From the simulation process, the training evaluation results of the trainees are shown in table 1:

Table 1: Evaluation table of simulation system function.

No.	Function	Kongsberg	Simulation
1	Fire alarm in dangerous areas	100%	90%
2	Fire simulation	100%	90%
3	Skills in using protective equipment	100%	95%
4	Fire fighting	100%	85%
5	Integrated video, instruction sheet	80%	95%

Source: Authors.

Based on the table above, the authors found that the system meets 75% of basic feature requirements compared to foreign systems and IMO standards.

Conclusions.

The article has initially successfully built a fire alarm, fire fighting and anti-sink simulation system for ships. Build 3D models with specific features based on the provisions of the International Maritime Convention STCW 2010 and the IMO Model Course. Besides, build Fire alarm procedures in the simulation. In particular, the authors created a simulation system based on virtual reality technology; this is the first step to applying virtual technology in the maritime field, while Vietnam has not yet implemented it. Therefore, in the future, the authors will try to build ship models suitable for current training requirements and the current training procedures for maritime safety in education in Vietnam to meet the needs of existing training resources and high-quality human resources.

Acknowledgements.

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Development on Strategic Decision Making to Support National Maritime Security

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ABSTRACT

Maritime security is not a condition that is created, but must be pursued, controlled and maintained so that it can be realized as expected. Maritime security is a topic that is often discussed when a country is faced with the impact of globalization, especially in the maritime sector. This view is based on a theoretical position that sees globalization as a dynamic that has the ability to move all institutions, including the state. The dynamics of the global and regional environment will always have an influence on the condition of national marine security, both positive and negative influences that ultimately affect national stability, so a strategy for developing the capabilities of the Marine Security Agency is needed to support the creation of national marine security. This study aims to develop a strategic concept of Indonesia's capability development in supporting the creation of national maritime security. The method used is SWOT Analysis, by compiling internal and external factors which are then collaborated into several valid main strategy concepts. The results achieved in this research are the compilation of 15 main strategic concepts in the development of Indonesia's national capabilities in supporting the creation of national maritime security.

1. Introduction.

Global issues that are currently developing include the spread of the Covid-19 disease, whose impact greatly affects political, economic, and socio-cultural conditions globally. Another issue is the increase in the world's population which results in increased food and energy needs, as well as the rapid development of science and technology. The increase in population will certainly be followed by an increase in food demand and an increase in energy demand. If the increase in population is not followed by an increase in food and energy production, it will have the potential to cause social, economic, and political problems in the community and affect the emergence of potential global security threats.

Currently, energy use is still dominated by non-renewable fossil energy, so sooner or later it will run out. When fossil energy runs out, the world's population will switch to non-fossil energy as renewable replacement energy. Much non-fossil energy is found in the equatorial area which has the potential for vegetation throughout the year. If the current conflict in the world is based on the struggle for fossil energy, then in the future there is a possibility that world conflicts will be based on the struggle for renewable non-fossil energy. Currently, the location of world conflicts will shift towards countries located at the equator, which are rich in non-fossil energy sources. This is a potential global threat in the future because Indonesia is rich in food, water, and non-fossil energy (Ahmadi et al, 2011).

The rapid development of science and technology greatly affects aspects of the life of the nation and state, it not only contributes positively to the life of the nation and state but also has a negative impact because of the misuse of technology that poses a threat to security, including the threat of cybercrime, engineering genetics of biotechnology which has negative implications, nanotechnology makes products so small that they are difficult to detect, such as eavesdroppers, nuclear weapons

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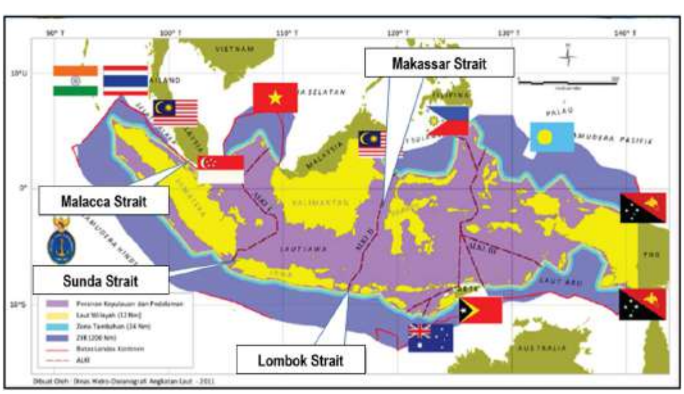
engineering, guided missiles, unmanned aerial vehicles capable of reconnaissance and destruction, and space technology to explore atmospheric space.

Issues currently developing at the regional level include the involvement of major powers in the strategic competition between the United States as a trans-regional power and potential conflicts with China in the South China Sea and North Korea on the Korean peninsula. America implements the "US Rebalancing Strategy" policy to balance China's domination in the Asia Pacific region by establishing a Marine base in Darwin-Australia and relocating a US marine base from Okinawa to Guam in the Pacific Ocean. The Guam Naval Base is home to four US nuclear-powered submarines and other warships. This is an indication that big countries are starting to look at the Southeast Asian region.

The issue of territorial boundary disputes in the South China Sea (SCS) is increasingly complex and tends to use military force to support territorial claims. In dealing with the LCS dispute, China implemented the Four Sha strategy to replace the Nine-Dash Line strategy. The four sha strategy is China's claim to the four island groups of Dongsha, Xisha, Nansha, and Zhongsha which are historical Chinese territories. Through this claim, China also participates in imposing maritime zones over these islands. Furthermore, China with the idea of One Belt One Road (OBOR) developed a geopolitical strategy by utilizing world transportation routes as trade routes spread across the Eurasian region. There are two main components in OBOR, namely land and sea transportation. Land transportation is supported by the Silk Road Economic Belt, while the Maritime Silk Road (MSR) acts as a supporter of sea transportation (Athapaththu, 2016).

Indonesia de Jure declared itself as an archipelagic country, which was stated through the ratification of the United Nations Convention on the Law of the Sea, 1982 UNCLOS in Law No. 17 of 1985 concerning the Ratification of UNCLOS on the United Nations Convention on the Law of the Sea. As an archipelagic country according to UNCLOS 1982, Indonesia is obliged to provide and have 3 Indonesian Archipelagic Sea Lanes (ALKI) and 4 Choke Points which are strategic for global interests and are obliged to maintain the security and safety of international shipping on the 3 ALKI lanes.

Figure 1: Map of the Unitary State of the Republic of Indonesia.



Source: Pushidrosal, 2018.

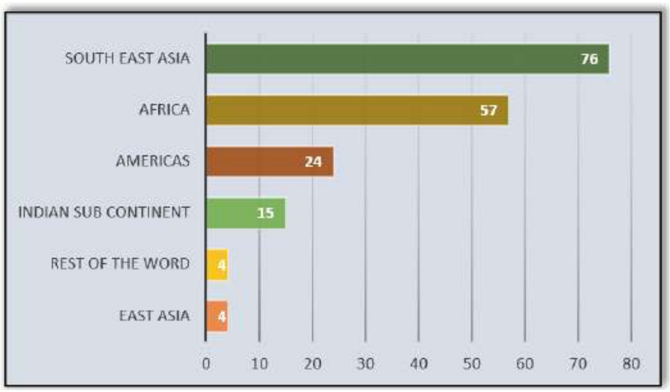
Indonesia in terms of geopolitical and geoeconomic perspectives can be divided into four categories of strategic positions, namely: 1) Indonesia as a strategic junction; 2) Indonesia as a strategic fishing ground; 3) Indonesia as a strategic business potential (strategic potential business); 4) Indonesia as a strategic key partner (Bastari et al, 2020). Indonesia's vast ocean area is vulnerable to security disturbances, where Indonesia's territory consists of a land area of 1.9 million km2 and waters covering an area of 6.4 million km2 with a coastline of ± 108,000 km. The Indonesian Sea consists of 3.11 million km2 of archipelagic waters, 0.29 million km2 of territorial waters, and 3.0 million km2 of the Exclusive Economic Zone (EEZ) with a total of 17,504 islands (Pushidrosal, 2018).

The current government has a vision and mission to make Indonesia the World Maritime Axis. Based on Law number 16 of 2017 concerning Indonesian Marine Policy, there are 5 (five) pillars to make it happen, namely: (1) Rebuilding maritime culture, (2) Managing marine resources, (3) Developing maritime infrastructure and connectivity, (4) Improving maritime diplomacy, (5) Building maritime defense forces. Law Number 32 of 2014 concerning the Ocean, underlies various government policies to realize maritime power to become one of the nation's advantages. The scope of the implementation of the Indonesian Marines includes (1) marine areas, (2)marine development, (3) marine management, (4) marine development (5) management of marine space and protection of the marine environment, (6) defense, (7) security, (8) law enforcement and safety at sea, (9) governance and institutions.

To realize Indonesia as a World Maritime Axis Country, national maritime security is an important matter. National maritime security is influenced by the potential threats that may arise and how the readiness of the Indonesian state in counteracting, taking action, or recovering any threats that occur. Indonesia as an archipelagic country with all its wealth of resources has potential threats to marine security which include piracy, illegal immigrants, smuggling of goods, IUU fishing, marine pollution, exploration, and exploitation of natural resources illegally (Latifah & Larasati, 2017).

Based on the report of the International Maritime Bureau (IMB) regarding data on piracy and piracy at sea, it can provide an overview as well as an evaluation material for maritime security threats, especially in Southeast Asia. The ICC International Maritime Bureau (IMB) has published "Piracy and Armed Robbery Against Ship" in the period from January 1 to. December 31, 2019, the report shows that the number of incidents of piracy and armed robbery against ships and threats to shipping security and safety in the Southeast Asia region still occupies the highest rating, followed by Africa and America. The piracy report data is more clearly depicted in Figure 2 below:

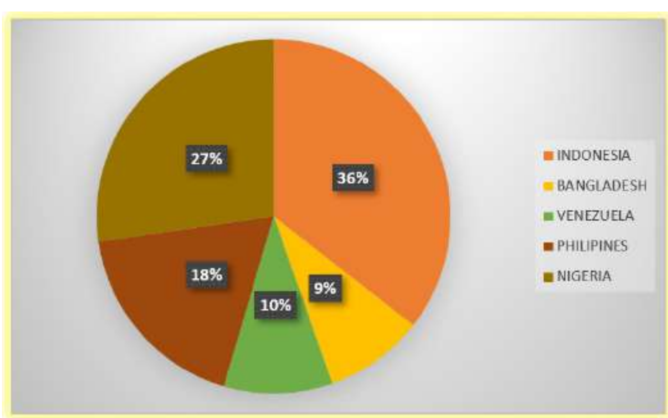
Figure 2: Piracy by Region in 2019.



Source: International Maritime Bureau (IMB), 2019.

The International Maritime Bureau (IMB) report states that at least 180 piracy incidents at sea were received in 2019. These piracy incidents occurred in almost all waters around the world. Indonesian waters are included in the top 5 (five) categories of reporting incidents of piracy. The data is more clearly illustrated in Figure 3

Figure 3: Reports of Piracy in 5 Locations.



Source: International Maritime Bureau (IMB), 2019.

Indonesian waters are very broad and strategic and are one of the waters that have a very high shipping intensity, and have potential threats that can come from various directions. Figure 4. shows the report on the position of piracy in Indonesian waters.

Potential threats that may arise will continue to develop as the strategic environment changes. The development of security issues in a country today is no longer a conventional way to deal with aggression from other countries, but what is happening now and in the future is the struggle for natural resources. The security of natural resources, especially energy security, must be watched out for (Kennedy, 2017). The development of state power to ensure energy and resource security is a common situation because energy security strategies are almost always related to the use of state power. When the strategy has become an option to secure access to energy, the need for developing state capabilities becomes a must. According to research by Lloyd's-Qinetiq and the University of Southampton on the Global Marine Technology Trend, GMTT 2030 states that the development of the security sector at sea is strongly influenced by the level of GDP (Gross Domestic Product) of a country, while the direction of development in the marine sector is also influenced by political, economic, and social conditions. social, demographic, and environmental, and energy at sea.

Figure 4: The position of piracy in Indonesian waters.

Source: International Maritime Bureau (IMB), 2019.

The Indonesia Coast Guard (IDNCG) is an integral part of the national maritime security institution, which has a role as a component of national marine security carrying out its duties based on state political policies and decisions to improve guarding, monitoring, prevention, and prosecution of violations of law in Indonesian waters and jurisdictions of Indonesia. based on the provisions of national and international law. It is hoped that the capacity development planning of IDNCG can be further enhanced. According to the author's analysis, the development of capabilities in IDNCG consists of levels of (1) ability, (2) strength, and (3) the degree pattern of IDNCG elements. Currently, in carrying out its duties, IDNCG is faced with limited capabilities, on the other hand, the rapid changes in the strategic environment add to the complexity of national maritime security issues. The implementation of IDNCG's duties includes maintaining safety and ensuring the creation of security in the Indonesian territorial sea, archipelagic waters, the Exclusive Economic Zone (EEZ) including border areas, leading small islands, and the Indonesian Archipelago Sea Lane (IDNCG, 2014).

Based on some of the background that has been described previously, the problem statement that can be raised in this paper can be formulated as follows:

a. How to identify the Internal Factors Analysis Strategic (IFAS) and External Factors Analysis Strategic (EFAS) as a reference in drafting the IDNCG capability development strategy concept?

b. How is the Formulation of the Strategic Concept of IDNCG Capability development in the face of dynamic aspects of national maritime security threats?

In terms of practitioners and academics, the writing of this paper is expected to contribute ideas and knowledge in drafting the concept of a strategy for developing the capability of the Maritime Security Agency following IDNCG's First Mission, namely: Improving guarding, supervision, prevention, and prosecution of law violations in Indonesian waters and Indonesian jurisdictions based on the guidelines. on the provisions of national and international law. And hopefully can be implemented in reality.

Currently, the capability of the IDNCG Institution can still be further developed broadly and professionally by increasing the strength and capability of the IDNCG institution and optimizing the degree pattern of IDNCG elements. The concept of the IDNCG capability development strategy can be started by studying the potential threats to national maritime security in the future and analyzing the current IDNCG capability to balance and deal with these potential threats. Based on these problems, the writing of this paper offers a Concept of IDNCG Capability Development Strategy in supporting the creation of Indonesia's national maritime security.

2. Materials and Methods.

2.1. National Maritime Security.

National maritime security is more commonly known as maritime security in the national scope. Maritime security is interpreted differently by each individual and organization depending on the various interests included in it. Maritime security is not an independent issue sector (Ikhtiari, 2010). From a military perspective, maritime security has traditionally referred to national security concerns in the sense of protecting the territorial integrity of a country from the threat of armed forces or the use of armed force and protecting the national interests of countries wherever they are (Klein, et al., 2010). This means that in this case the goal to be achieved or created is to guarantee freedom of navigation, shipping activities, and protect the existing resources in the ocean as well as secure the ocean area from threats from other countries, terrorism, drug trafficking, and transnational crime, piracy, environmental damage, and entry. illegal immigrants by sea (Mahan, 1890).

From a civil perspective, maritime security is more specific to the security of the maritime transportation system and its relation to the safety of cargo transported to its destination without being disturbed or being the target of criminal acts. So that maritime security can be defined as an effort made by the government, operators, and administrators of ships, ports, coastal facilities, and maritime organizations formed to protect against attacks, sabotage, piracy, theft, and disturbances (Özleblebici, 2015).

According to Sayidiman Suryohadiprojo (2019) in his paper submitted at the International Maritime Law Workshop, maritime security is not only about law enforcement at sea but in a broad sense, namely, the sea is an area that is safe for use by users and free from threats or disturbances, including:

a) Seas that are free from the threat of violence, namely threats using organized armed force and can disturb and endanger personnel or the state. The threats are in the form of piracy, piracy, sabotage of vital objects, mines, and acts of terror

b) Seas that are free from navigational threats, threats posed by geographical and hydrographic conditions so that they can threaten shipping safety

c) The sea is free from threats to marine resources, namely in the form of pollution and destruction of marine ecosystems that will have an impact on the surrounding community

d) The sea is free from the threat of general violations, namely compliance with national and international laws that apply in the waters.

By paying attention to the understanding and definition of maritime security, IDNCG needs an effort and strategy as an improvement in organization and management as well as adequate facilities and infrastructure through good and sustainable management (Bastari, 2021).

2.2. Maritime Security Agency (IDNCG).

The Indonesia Coast Guard of the Republic of Indonesia (IDNCG) is an agency tasked with conducting security and safety patrols in Indonesian waters and Indonesian jurisdictions. IDNCG is a non-ministerial government agency responsible to the President through the Coordinating Minister for Political, Legal, and Security Affairs. Previously, IDNCG was a nonstructural institution called the Coordinating Board for Maritime Security of the Republic of Indonesia (Bakorkamla). On December 29, 2005, Presidential Regulation No. 81/2005 concerning the Maritime Security Coordinating Board (Bakorkamla) was enacted which became the legal basis. Then since the enactment of Law No. 32 of 2014 concerning the Ocean, Bakorkamla has officially changed its name to the Indonesia Coast Guard (IDNCG). The position of IDNCG was further strengthened by the issuance of Presidential Regulation Number 178 of 2014 concerning the Maritime Security Agency of the Republic of Indonesia.

IDNCG's vision is the realization of a reliable and professional maritime security and safety in the context of leading an advanced Indonesia that is sovereign and has a personality based on cooperation. The IDNCG's mission is (1) To improve the safeguarding, supervision, prevention, and prosecution of law violations in Indonesian waters and Indonesian jurisdictions by referring to the provisions of national and international law. (2) Strengthening national policies in the field of security and safety in the jurisdiction of Indonesia to strengthen Indonesia's identity as the world's maritime axis. (3) Organizing an independent and strong security and safety early warning system based on national interests in Indonesian waters and in Indonesian jurisdictions (IDNCG, 2014).

The objectives of IDNCG are (1) The realization of security and safety in Indonesian waters and Indonesian jurisdictions with an information system/early warning system and coast guard diplomacy guided by the provisions of national and international law. (2) The realization of institutional capacity, the availability of facilities and infrastructure for marine security and safety operations, and professional, reliable, and superior human resources (IDNCG, 2014).

IDNCG has Strategic Goals: (1) Increasing law enforcement in Indonesian waters and Indonesian jurisdictions in an integrated manner. (2) Increasing national policies in the field of maritime security and safety in Indonesian waters and Indonesian jurisdictions that are credible. (3) Realizing an information system/early warning system for security and safety in Indonesian waters and Indonesian jurisdictions that are integrated. (4) Increasing the capacity of modern and efficient maritime security institutions. (5) Increasing the capacity of human resources (HR) of professional, highly competent, and non-sectoral marine security apparatus. (6) Increasing reliable and modern marine security and safety facilities and infrastructure based on an early warning system (IDNCG, 2014).

2.3. Threat Concepts and Theories.

Threats are every business and activity, both domestic and foreign, which are considered to endanger the sovereignty of the state, the territorial integrity of the country, and the safety of the entire nation (Kemenhan, 2014). The actual threats are real threats, in the form of armed separatists, terrorism, radical groups, communal conflicts, theft of natural resources such as IUU Fishing, Illegal Logging, and illegal mining and natural disasters.

Potential threats are the seeds of threats that can arise at any time such as border disputes, national disintegration, conflicts between groups, social unrest, efforts to replace Pancasila ideology, and so on. In terms of sources, threats consist of domestic, foreign, and azimuthal, in terms of types of threats consist of military or non-military threats, in terms of threat actors consist of threats from a state or non-state. Threats that arise along with the development of the world are no longer limited to traditional threats but have developed into non-traditional threats, including cyber threats. This new type of threat is now growing wider and more complex. Not only in the form of military threats but also threats to all aspects of national and state life (Marsetio, 2013).

The Ministry of Defense (2015) estimates that threats and disturbances to Indonesia's defense and security interests in the future can be in the form of international terrorism, separatist movements, acts of radicalism, communal conflicts, transnational crimes, illegal immigration activities, maritime security disturbances, air security disturbances, environmental destruction. , and natural disasters.

2.4. National Marine Security Threat.

Marine Security Threats are every business and activity, both domestic and foreign, which are considered to endanger National Marine Security. Several maritime security issues that are quite prominent and are of concern to the world community are: (a) high threats of violence, such as piracy, sabotage, and terror of vital objects; (b) navigational threats, such as shortages and theft of navigational aids; (c) resource threats, such as damage and pollution of the sea and its ecosystem; and (d) sovereign and legal threats, such as illegal fishing, illegal immigrants, illegal treasure searches, illegal exploration and exploitation of natural resources, and smuggling of goods, people and weapons (Poerwowidagdo, 2015).

The UN Secretary-General in his report UN Report of The Secretary-General on Oceans and the Law of the Sea 2020 provides identification of activities in general that are considered a threat to maritime security. There are at least 7 (seven) specific threats to maritime security :

a. Piracy and armed piracy against ships that specifically endanger the welfare of seafarers and the safety of navigation and trade.

b. Terrorist activities that target ships, offshore installations, or maritime interests that have a broad effect including the economic aspect of the attacks carried out.

c. Illegal trade in weapons and weapons of mass destruction.

d. Trafficking of illegal psychotropic drugs, where many of these goods are transported.

e. Smuggling and human trafficking.

f. IUU Fishing, Unreported Fishing, Unregulated Fishing which poses a threat to the availability of fish related to international peace and security.

g. Intentional and unlawful damage to the marine environment that threatens the security of one or more countries in terms of social and economic impacts on neighboring countries.

Several potential maritime security threats that can be faced by IDNCG in law enforcement and maintaining territorial security at sea include acts of violence at sea, accidents, navigation and weather, drug smuggling, Illegal Logging, illegal migrants, Illegal Unreported and Unregulated (IUU) fishing, illegal mining, marine pollution, and smuggling.

3. Results and Discussion.

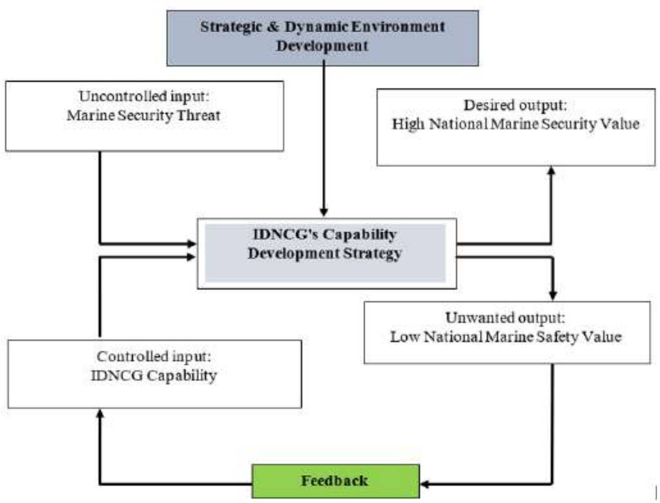
3.1. National Maritime Security as an Interaction Approach between Variables.

Based on the author's analysis, National Maritime Security is a condition that is influenced by the interaction between variables: (1) IDNCG's capability, (2) IDNCG's Operational Strategy, and (3) Kamlanas threats that arise and continue to change based on the development of system dynamics (See Figure 7). The role and influence of threat aspects are (a) high threat of violence, such as piracy, sabotage, and terror of vital objects; (b) navigational threats, such as theft of navigational aids; (c) resource threats, such as damage and pollution of the sea and its ecosystem; and (d) sovereign and legal threats, such as illegal fishing, illegal immigrants, illegal treasure hunting, and exploitation of natural resources, and smuggling of goods, people and weapons. Meanwhile, the role and influence of IDNCG Capability are on the deterrence, action, and recovery of conditions posed by the threat of Kamlanas.

According to the author, the IDNCG Capability Variable can be analogized to consist of (1) Strengths, (2) Ability, and (3) Patterns of Degree elements of IDNCG. With the dynamic condition of the system that continues to change, it is necessary to analyze the strategic environment and the development of threats to be able to formulate a strategy for developing IDNCG's capabilities. Furthermore, with the integration of the System Dynamic Variable Interaction method and SWOT, a Strategic Concept for developing IDNCG capabilities based on the dynamics of the strategic environment and threat prediction can be drawn up, to obtain the expected National Marine Security Strategy.

In this paper, the variable interaction approach is used to develop the strategy concept by identifying the interaction relationship between significant variables. The stages of variable identification and strategy conceptualization are the input-output stages of the entire system to be modeled (Suharyo, et al, 2017). This stage is carried out to obtain reference variables and what parameters will be used in formulating strategies so that they are right on target (Sterman, 2000), as shown in Figures 6 and 7 below.

Figure 5: Interaction Diagram of IDNCG Capability Development Strategy Concept .



Source: Bastari, 2021.

In Figures 6 it can be understood that the National Maritime Security Assessment is the main interaction of the variables (1) IDNCG Capability,(2) IDNCG Operational Strategy, and (3) Potential National Marine Security Threats. The next step is to identify the sub-variables that have a significant effect as a reference in the preparation of the right strategy.

3.2. Variable Identification.

The first step in conceptualizing a capability development strategy is to identify the variables that influence the system. The purpose of identifying this variable is to determine the elements that contribute to the system and clarify perceptions of the system to be studied (Yogi et al, 2017).

The variables identified are variables related to parameters that influence and interact with the IDNCG development strategy to face national maritime security threats. The variable identification stage is carried out by observing, understanding the system, and studying literature on national marine security. From the process of observation, understanding of the system, and literature study, the variables that affect the system are obtained as follows:

3.3. Variable System.

The main system variable, in this case, is National Maritime Security which is influenced by IDNCG Capability, IDNCG Operational Strategy, and National Marine Security Threats. The following is an identification of the main system variables and their operational descriptions.

Table 1: Identification of National Maritime Security Variables.

National Maritime Security Variable		
No	Variable	Operational definition
1	IDNCG capabilities	Ability level, strength, and degree pattern of IDNCG elements
2	National Marine Security Strategy	A strategy, method, or tactic in achieving the expected national maritime security condition
3	National Marine Security Threat	Threats both from within and outside the country that is considered to endanger National Marine Security

Source: Authors.

a. IDNCG Capability Sub-System Variables.

Table 2: Identification of IDNCG Capability Sub-System Variables.

IDNCG Capability Sub-System		
No		Operational Definition
1	Variable	The main tool of the IDNCG system is used for performance implementation and task achievement.
	IDNCG's Power	The elements of the IDNCG Ship are following the established patrol operation vision and mission.
	a. Boat	IDNCG Base / Headquarters to support the operations of IDNCG ships
	b. Base	IDNCG HR both onboard and in Pendirat
2	c. HR	IDNCG's performance in using strengths professionally to carry out tasks according to the vision and mission.
	IDNCG's Ability	Performance of early detection of threats, analysis, evaluation of Intelmar data, counter-intelligence, and clandestine.
	a. Intelligence Ability	The performance of law enforcement at sea can be in the form of preventing, guarding, or taking action against law violations in the Indonesian jurisdiction
	b. Operation Capability	The performance of fostering the potential of the national and regional areas to become a national maritime security force
	c. Sea Security Territory Control Ability	Operational logistics performance, interoperability, and commonality, education, and training, research and development research, humanitarian operations assistance, security assistance for mapping surveys and hydro-oceanography, etc.
	d. Operation Support Capability	Diplomacy and negotiation performance as well as establishing cooperative relationships between stakeholders to support government policies
	Degree Pattern	Placement and Assignment of IDNCG elements.
	a. Ship Element Resources	Quality and Quantity of resources elements of the Ships and Human Resources owned by IDNCG.
	b. Logistics Resources	Quality and Quantity of IDNCG's logistical resources.
	c. Operation Degree	Operational activities are in the form of patrols and the deployment of IDNCG forces to carry out their duties.
	d. Operation Interoperability	IDNCG Operation Interaction Capability with stakeholders related to maritime security.
	e. Nas Marine Security Budget	The budget provided by the government for the National Maritime Security sector.
	f. IDNCG budget	Budget provided by the Government for IDNCG.

Source: Authors.

b. Operation Strategy Sub-System Variables IDNCG.

Table 3: Identification of IDNCG Operation Strategy Sub System Variables.

IDNCG Operation Strategy Sub-System		
No	**Variable**	**Operational definition**
1	Operation Tactics	IDNCG's planned and implemented operational strategy.
2	Operation Interoperability	IDNCG Operation Interaction Capability with stakeholders related to maritime security.
3	Law Enforcement	Legal action on activities that are against and do not comply with applicable legal norms.
4	Lawlessness deterrent effect	The ability to prevent actions and activities that are against and do not comply with applicable legal norms.
5	International Cooperation	Activities carried out by IDNCG with other relevant state government agencies.

Source: Authors.

c. National Marine Security Threat Sub System Variable.

Table 4: Identification of IDNCG Operation Strategy Sub System Variables.

National Marine Security Threat Sub System		
No	**Variable**	**Operational definition**
1	**International**	Threats from abroad
	Territory Violation	The actions of ships from other countries that take natural resources in the sovereignty of the jurisdiction of Indonesia
	Terrorism	The activity of spreading fear by using violence.
	Smuggling	Activities of carrying goods without being accompanied by a permit document
	Human trafficking	Human trafficking and exploitation
	Espionage	Snooping and spying activities to gather information
	Cyber Attack	The activity of changing, or destroying systems or networks, programs or information stored in computer networks.
2	**Domestic**	Threats that come from within the country
	Loss of natural resources in the sea and islands	Decrease and shift of natural resources or islands in a way that is against the law.
	Separatist Movement	Activities to gain sovereignty and separate territories or human groups.
	Piracy	The activity of seizing other people's goods or rights.
	Illegal logging	Logging, transporting, and selling of timber without legal documents.
	IUU Fishing	Fishing activities without permits and legal documents.

Source: Authors.

d. Identification of Strategic Internal Factors Analysis (IFAS).

Identification of internal factors is carried out to determine the factors that are Strengths (S) and Weaknesses (W). Internal factor components are IDNCG's strengths and weaknesses in dealing with national maritime security threats. Based on the observational analysis, system understanding, and literature study on national maritime security, internal factors can be identified as listed in the following table as a reference in drafting the IDNCG capability development strategy concept.

Table 5: Identification of Internal Factors (IFAS) as a reference in formulating the concept of IDNCG capability development strategy.

Internal Factor - Strength.

No	Code	*Strengths* (S)
1	S1	Able to carry out early detection of threats and potential threats of Kamlanas, especially in strategic seas, strategic funnels, ALKI, and border areas, analyze, evaluate and distribute maritime data.
2	S2	Able to carry out counter-intelligence and clandestine operations in the field of Marine Security.
3	S3	Able to carry out maritime intelligence functions in the field of maritime security.
4	S4	Able to carry out guarding operations, surveillance, crime prevention in Indonesian waters
5	S5	Able to carry out and take action against law violations in the territorial waters of Indonesian jurisdiction
6	S6	Able to carry out the security of marine and archipelagic natural resources
7	S7	Able to carry out special assistance operations for natural disasters
8	S8	Able to carry out security operations on the coast and the outer islands
9	S9	Able to carry out anti-access operations
10	S10	Able to carry out cyber attack security
11	S11	Able to carry out information security
12	S12	Able to carry out sea transportation to support Sislognas
13	S13	Able to carry out maritime security operations in the border areas of Indonesia's national jurisdiction.
14	S14	Able to carry out interoperability with other stakeholders.
15	S15	Able to carry out international law enforcement at sea
16	S16	Able to carry out sea traffic security, especially in the Malacca Strait, Singapore Strait, Indonesian Archipelago Sea Lane (ALKI), trade routes, and national logistics distribution (sea highway)
17	S17	Able to strive for domestic maritime security.
18	S18	Able to build mutual trust through security presence.
19	S19	Able to carry out bilateral and multilateral exercises.
20	S20	Able to carry out port visits.
21	S21	Able to carry out security arm control.
22	S22	Able to carry out the implementation of dialogue in national, regional, and international forums.
23	S23	Able to carry out the development of national potential to become a maritime security force.
24	S24	Able to increase empowerment and development of marine security areas both in quality and quantity.
25	S25	Able to empower maritime potential as a reserve component and a supporting component of National Marine Security
26	S26	Able to develop the region as a maritime security area and foster regional logistics to support operations.
27	S27	Able to carry out security assistance for marine surveys and hydro-oceanographic mapping to civil institutions.
28	S28	Able to carry out operational logistics support that can support interoperability and commonality.
29	S29	Able to implement K4IPP to integrate all IDNCG's supervisory systems.
30	S30	Able to carry out education and training to prepare and develop Human Resources as a member of the IDNCG organization.
31	S31	Able to carry out research and development to optimize the operation of IDNCG's main tools.
32	S32	Able to carry out humanitarian operations and assistance due to natural disasters (Humanitarian Assistance and Disaster Relief)

Internal Factors - Weakness.

No	Code	*Weakness* (W).
1	W1	A limited number of IDNCG Ships capable of operating in the Exclusive Economic Zone
2	W2	The limited number of ship operating tools and systems compared to the very broad surface patrol sector.
3	W3	Base limitations in carrying out the Rebase, Replenishment, Repair, Rest, and Recreation functions for IDNCG elements
4	W4	Limited equipment, Security operation vehicles, and tactical vehicles.
5	W5	The limitation of the information system is that can present a picture of the Kamlanas tactical situation in real-time.
6	W6	Interoperability between stakeholder components is not optimal and there is overlapping authority, resulting in operational system integration experiencing problems that disrupt the running of a national maritime security operation.
7	W7	Early detection equipment in the form of radar, both Radar Early Warning (EW), Ship Surveillance Radar, and Coastal Radar (Integrated Maritime Surveillance System / IMSS) in limited numbers.
8	W8	Integration between human intelligence (human intelligence) that utilizes technology such as signal intelligence (signal intelligence), electronic intelligence (electronic intelligence), and imagery intelligence (imagery intelligence) in a coordinated manner in a collaborative framework involving intelligence is not yet optimal.
9	W9	Limitations Personnel possessing the skill level required to manpower the main tools of the national maritime security operating system.
10	W10	Limited budgetary and logistical support to conduct national maritime security patrols and operations

Source: Authors.

e. Identification of Strategic External Factors Analysis (EFAS).

External factors reflect opportunities and threats from various external factors that can affect the marine security system significantly, either beneficially or adversely in the future. Identification of external factors is carried out to determine the factors that become Opportunities (O) and Threats (T). Based on observations, system understanding, and literature study on national maritime security, external factors were identified as listed in Table 6 below as a reference in drafting the IDNCG capability development strategy concept.

Table 6: Identification of External Factors as a reference in formulating the concept of IDNCG capability development strategy.

External Factors - Opportunities.

No	Code	Opportunities
1	O1	Indonesia's geographical position, which is a cross position between two continents and two oceans, can make Indonesia a power that can control global maritime activities.
2	O2	The government's policy is to make Indonesia the world's maritime axis.
3	O3	Economic growth and an increase in the domestic security budget.
4	O4	The revival of the domestic defense and security industry and the concept of the Global Marine Technology Trend GMTT 2030.
5	O5	Increasing national and international cooperation in the field of maritime security.
6	O6	Cooperation with maritime security stakeholders both nationally and internationally in the form of joint exercises and joint operations.

External Factors - Threats.

No	Code	Threats (T)
1	T1	The condition of the border areas, very limited facilities and infrastructure for the main equipment and base support so that the vulnerability to violations and crimes of foreign ships is quite high.
2	T2	ALKI and Choke Point with high traffic intensity are vulnerable to law violations.
3	T3	Covid 19 pandemic.
4	T4	Cyber Attack.
5	T5	Human Trafficking and Illegal Immigrants.
6	T6	Smuggling
7	T7	Terrorism.
8	T8	Espionage.
9	T9	Loss of natural resources of the sea, coast, and outer islands.
10	T10	Illegal Logging.
11	T11	IUU Fishing.
12	T12	Piracy

Source: Authors.

3.4. *IDNCG Capability Development Strategy.*

Strategy formulation is carried out by compiling a SWOT Matrix. The SWOT matrix is used as a method to combine the results of internal factor analysis and analysis of external factors that are important to develop four main types of strategies, namely SO Strategy (strengths-opportunities), WO Strategies (weaknesses-opportunities), ST Strategy (strengths-threats), and WT (weakness-threats) strategy.

By carrying out an analysis of internal factors and external factors, several alternative strategies can be formulated as listed in the following table:

a. S - O (Strengths - Opportunities) Strategy.

S - O (Strengths - Opportunities) strategy is a strategy that is prepared by utilizing internal strengths to take advantage of external opportunities (Wheelen & Hunger, 2012). The preparation of the SO strategy can be seen in the following table:

Table 7: Formulation of S - O (Strengths - Opportunities) Strategy.

Code	*Strengths*	*Opportunities*	Main Strategy
SO1	S1, S2, S3	O1, O2, O3	Increase Intelligence ability
SO2	S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14	O1, O2, O3, O4	Improve the ability of Information Systems.
SO3	S15, S16, S17	O1, O2, O3	Improved Operation and Patrol capabilities of Kamla
SO4	S18, S19, S20, S21, S22	O1, O2, O3, O5, O6	Improve the ability of Kamla Diplomacy.
SO5	S23, S24, S25, S26	O1, O2, O3	Improve the ability of the Kamla region Empowerment
SO6	S27, S28, S29, S30, S31, S32	O1, O2, O3	Improve operation Support capability.

Source: Authors.

b. W - O (Weakness - Opportunities) Strategy.

W - O (Weakness - Opportunities) strategy is a strategy designed to improve internal weaknesses by taking advantage of external opportunities (Yarger, 2006). The preparation of the WO strategy can be seen in the following table:

Table 8: W - O (Weakness - Opportunities) Strategy.

Code	*Weakness*	*Opportunities*	Main Strategy
WO1	W1, W5, W6, W7, W8	O1, O2, O3, O4	Increase the number and modernization of IDNCG Ships.
WO2	W2, W5, W6, W7, W8	O1, O2, O3, O4	Increase the number and modernization of Maritime Security Information.
WO3	W3, W5, W6, W7, W8	O1, O2, O3, O4	Increase IDNCG Base Capability.
WO4	W4, W5, W6, W7, W8	O1, O2, O3, O4	Improve capabilities and modernize operating equipment.
WO5	W10	O2, O3	Increasing Logistics and Budget Resources
WQ6	W5, W6, W7, W8	O6	Improve operation and patrol interoperability

Source: Authors.

c. Strategy S - T (Strengths - Threats).

Strategy S - T (Strengths - Threats) is a strategy that is prepared by using strength to avoid or reduce the impact of external threats (Hill & Westbrook, 1997). ST strategy preparation can be seen in the following table:

Table 9: Strategy S - T (Strenght - Threats).

Code	*Strengths*	*Threats*	Main Strategy
ST1	S1, S15, S16, S17	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12	Enhance International Cooperation by carrying out joint exercises and joint patrol operations

Source: Authors.

d. Strategy W - T (Weakness - Threats).

The W - T (Weakness - Threats) strategy is a strategy that uses defensive tactics aimed at reducing internal weaknesses and avoiding external threats (Horwath, 2006). The preparation of the WT strategy can be seen in the following table:

Table 10: Strategy W - T (Weakness - Threats).

Code	*Weakness*	*Threats*	Main Strategy
WT1	W8, W9	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12	Improving the Quality of Human Resources Professionalism by carrying out education and training.
WT2	W5, W6, W7	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12	Developing Operation Kamla Tactics.

Source: Authors.

The overall strategy that has been compiled through internal factor analysis and external factor analysis has developed four types of strategies: SO Strategy (strengths - opportunities), WO Strategy (weaknesses - opportunities), ST Strategy (strengths - threats), and WT Strategy (weaknesses - threats).

e. Strategy Compilation and Integration.

The strategies that have been compiled in the SWOT matrix are then compiled to facilitate the next step in classifying strategies based on their categories in IDNCG as shown in the following Table:

Table 11: Strategy Compilation.

No	Code	Main Strategy
1	SO1	Increase Intelligence ability.
2	SO2	Improve the ability of Information Systems.
3	SO3	Increase Marine Security Operations and Patrol capabilities.
4	SO4	Increase the capability of Maritime Security Diplomacy.
5	SO5	Increase the capacity of the Kamlanas area Empowerment.
6	SO6	Improve operation Support capability.
7	WO1	Increase the number and modernization of IDNCG Ships.
8	WO2	Increase the amount and modernization of Maritime Security Information.
9	WO3	Increase IDNCG Base Capability.
10	WO4	Improve capabilities and modernize operating equipment.
11	WO5	Increase Logistics Resources and budget
12	WO6	Improve the interoperability of Sea Security. operations and patrols
13	ST1	Enhance International Cooperation by carrying out joint exercises and joint patrol operations.
14	WT1	Improving the Quality of Human Resources Professionalism by carrying out education and training.
15	WT2	Develop maritime security Operations Tactics.

Source: Authors.

f. IDNCG Capability Strategy Concept Classification. The strategic concepts that have been compiled are then classified based on the criteria for the IDNCG capability component, namely: (1) IDNCG Strengths, (2) IDNCG Capability, and (3) IDNCG Title Patterns, as shown in the following table:

IDNCG's Strength Development Strategy Concept.

Table 12: Concept of Strength Development Strategy.

No	Code	Main Strategy
1	WO1	Increase the number and modernization of IDNCG Ships.
2	WO2	Increasing the Number and Modernization of Maritime Security Information
3	WO3	Increase IDNCG Base Capability.
4	WO4	Improve Capability & modernization of operating equipment.

Source: Authors.

IDNCG's Capability Development Strategy Concept.

Table 13: Concept of Capability Development Strategy.

No	Code	Main Strategy
1	SO1	Increase Intelligence ability
2	SO2	Improve the ability of Information Systems.
3	SO3	Increase Marine Security Operations and Patrol capabilities.
4	SO4	Increase the capability of Maritime Security Diplomacy.
5	SO5	Improve the ability of the Kamlanas region Empowerment
6	SO6	Improve operation Support capability.

Source: Authors.

The Concept of Development Strategy for the Pattern of IDNCG Elements.

Table 14: Concept of the Elementary Degree Pattern Development Strategy.

No	Code	Main Strategy
1	WO5	Increasing Logistics and Budget Resources
2	ST1	Enhance International Cooperation by carrying out joint exercises and joint patrol operations
3	WT1	Improving the Professionalism Quality of IDNCG Human Resources by carrying out education and training.
4	WO6	Improve the interoperability of Sea Security. operations and patrols
5	WT2	Develop maritime security operations tactics

Source: Authors.

Conclusions and Suggestions.

Conclusions.

In drafting the Strategic Concept of IDNCG Capability development in supporting the creation of national maritime security, several conclusions can be drawn, including:

a. The results of the Internal Factors Analysis Strategic (IFAS) and External Factors Analysis Strategic (EFAS) identification results obtained a Conceptualization of the National Marine Security System which was presented at the National

Marine Security assessment which was influenced by 3 main aspects, namely (1) IDNCG Capability, IDNCG Operational Strategy and (3) Potential National Marine Security Threats.

These three main aspects form a system that interacts with one another to form the condition of National Marine Security. This means that the IDNCG Capability variable and the IDNCG Operation Strategy variable provide a significant dynamic balance to the National Marine Security Threat variable. Furthermore, the results of the identification of IFAS and EFAS factors can provide a significant analytical reference for the preparation of the IDNCG Capability Development Strategy Concept in supporting the creation of national maritime security to offset dynamic threats.

b. The result of writing this paper is in the form of a Grand Strategy Concept Formulation on IDNCG Capability Development in supporting the creation of national maritime security. The following are 15 Main Strategy Concepts (Grand Strategy) for IDNCG Capability Development (Avando Bastari, 2021):

1. Increase Intelligence ability.
2. Improve the ability of Information Systems.
3. Improved Sea Security Operations and Patrol capabilities
4. Improving Sea Security Diplomacy ability.
5. Improving the capacity of Empowerment of the Kamla region.
6. Improve Kamla Operations Support capability.
7. Increase the number and modernization of IDNCG Ships
8. Increase the number and modernization of Maritime Security Information.
9. Improve the ability of IDNCG Base.
10. Improve the capability and modernization of operating equipment
11. Increase logistical and budgetary resources.
12. Improve the interoperability of Kamla's operations and patrols.
13. Enhance international cooperation by carrying out joint exercises and joint patrol operations.
14. Improving the quality of professionalism of human resources by implementing education and training.
15. Develop maritime security patrol and operation tactics.

Suggestions.

This paper has formulated 15 (fifteen) main strategic concepts for developing the capability of the IDNCG organization in dealing with national maritime security threats. These main strategies can still be further developed and can be detailed into Sub-Significant Strategies and adapted to the dynamics of the ongoing system. The main strategy can be used as a reference and can be applied to the IDNCG Institution of course by considering other significant factors. Several things can be developed in the next writing, namely:

a. The relationship between variables of national maritime security can be defined and formulated both quantitatively and qualitatively with more detailed equations between variables.

b. It can be continued with the elaboration of 15 Main Strategic Concepts in developing IDNCG capabilities into significant "Sub-strategies".

c. It can be continued with the preparation of a Strategy Road Map as a form of implementing IDNCG Capability Development in a Strategic Plan, which includes the achievements or milestones of the Strategic Concept.

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The relationship of public policy-making to the strategic performance according to the balance scorecard in the Jordanian transport companies

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ABSTRACT

This study is aimed to investigate the applicability of applying balanced scorecard model in the Jordanian transport companies from the view point of its employees whom involved in management particularly strategic management. The methodology of the study was a combination of literature review, and structured questionnaire that distributed to a 100 employees whom involved in strategic management activities. Moreover, they acquired the necessary experience in various activities that can broadly classified as the five qualitative perspectives of government balanced scorecard (i.e.the learning and growth perspective, the internal or service process perspective, the customer perspective, the financial perspective, and environmental perspective). Based on multiple and simple regression in testing the hypothesis of the study. The empirical results of the main hypothesis found a significant supportive evidence for the applicability of BSC model in the Jordanian transport companies, furthermore, the results of the five sub hypotheses also showed a significant evidence for the applicability of all five BSC dimensions in evaluating strategic performance.

1. Introduction.

The Balanced Scorecard (BSC) is applicable in industrial organizations, service organizations, nonprofit organizations, and governmental organizations (Kaplan and Norton, 2001). Performance measures considered to be at the core of the BSC system. However, the use of financial measurement only is argued not exhibiting the mission of government; therefore it should be placed at top of the BSC in measuring whether such an organization has been successful in achieving its strategic objectives. Thus, the main difference between profits based organizations and non-profit organizations are the way they seek to achieve their own mission.

Recent accounting methods for measuring or evaluating performance such as BSC, Six Sigma and activity based costing have been used to increase the competitive advantage of organizations i. Governmental organizations main interest is to achieve missions, strategies development; therefore, they focus mainly on performance measurement due to changing needs that arises from society. Traditionally, financial measures were the only measures that applied by organizations to develop their strategies. However,these measures were focus only on short-term objectives rather than long-term ones (Chen et al., 2006;Kaplan and Norton, 2001; Porter, 1992). It had been argued that governmental organizations critical work is to set strategic plans and then to achieve these plans. Hence, the use of the performance indicators such as BSC in government institutions can provide more support for formulating strategies and allocating resources efficiently (Kaplan and Norton, 2001).

Recently, governmental organizations shifted away from using financial indicators only to measure performance they used also non-financial indicators, due to the constraints for using governmental resources in strategies implementation. Planners always work hardly to formulate a clear mission that can be measured by set of diversified financial and non-financial measures. Nowadays, changing and rolling environment forced decision makers in government to produce highly reliable information concerns with future performance therefore, the propo-

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sition of Kaplan and Norton of BSC measures provided the needed solution for this issue. Their recommendations were the starting point to use non-financial measures beside financial measures in measuring performance in all types of organizations.

The new BSC proposition method introduced a 'balanced' view, through consideration of all different aspects of organizational action, by improving the traditional backwards-looking approach to new established performance indicators. This approach integrated the measurement of external and internal activities with pre-determined financial and non-financial indicators. Interestingly, this approach offered a pioneer measurement approach that enabled organization to combine information across all departments by integrating financial data with internal processes, and customer service to achieve the desired balanced between internal and external measures. Furthermore, this approach offered more objective measures against subjective measures and thus connent current performance outcomes with future results. The BSC method also enabled organizations to obtain the necessary required data by establishing a cause-effect linkage between these relationships through learning and knowledge to seek means for increasing growth and sustainability of organization through achieving its mission (Kaplan and Norton, 1992).

Similar to other global environments Jordanian governmental organizations adopted BSC approach to benefit from its remarkable results. Recently, almost all developed governmental organizations worked hardly to implement BSC perspective measures in order to improve its ability forn using its resources more efficiently when rendering its many diversified services for civilians. Even though, financial measures of performance is still to have its respectable place in our environment, the newly offered BSC non-financial measures find their way in formulating and evaluating organizational.

Similar to other countries Internal and external environmental changes has effected Jordanian organization. Changes such as organizational structure, type of activity, different authorities and responsibilities, internal processes and highly automated communication systems motivated organizations to create a link between strategic objectives and modern managerial accounting methods such as balanced scorecard approach. Therefore, the problem of our study can be stated as: even though traditional financial method of measuring strategic performance is applied, yet it's still incapable and not enough to enhance the achievement of organizational planned vision, mission and its strategic objectives, therefore investigating whether the applicability of BSC in measuring performance A can offer a reliable measurement of performance beside financial measure.

The importance of the study steams from the necessity to encourage more adoption of new performance measures that helps to achieve strategic objectives in government organizations due to the fact that; services provided by government institution have the same importance to products provided by the private sector. Thus, any research conducted on this issue will in turn provide more insight to the problem and contribute in bringing more attention for the use of BSC in measurement of strategic performance in governmental institutions in developing countries such as Jordan.

2. Objectives of the study.

The study is designed to accomplish the following goals:

1. Use (ASEZA) as an example to demonstrate the significance of implementing contemporary managerial accounting techniques in Jordanian governmental enterprises.
2. Go over and discuss the advantages of using BSC and how to use it to enhance performance.
3. Examining the BSC method's applicability in Jordan
4. Add more accounting research on the integration of financial and non-financial metrics in BSC evaluations of strategy success in developing nations.

3. Methodology.

The design of this research was qualitative based on the literature review and in alignment with the objective of this research. After depth review of literature the researchers developed a questionnaire to measure the applicability of BSC for measuring strategic performance. A likart 5-point scale was used to investigate the different BSC perspectives. The questionnaire is structured to measure the 5 BSC perspectives; it includes a total of 67 questions designed to evaluate the respondent's opinions and / or their expectations about the applicability of BSC dimensions.

3.1. Study methods.

In order to answer the research problem and prove the validity of the hypotheses, the analytical descriptive approach was relied on with regard to the theoretical side as it is suitable for collecting facts and defining various concepts related to the subject, and analyzing them with the aim of developing explanations and coming up with results, while the case study approach was followed with regard to the field side in order to find The relationship of public policy-making to the strategic performance according to the balance scorecard in the Jordanian transport companies.

3.2. Hypotheses.

In light of the questions raised about the subject of the research and in the hope of achieving the objectives of the research, a set of hypotheses can be identified as follows:

The main hypothesis: There is a significant effect between **public policy-making** and achieving **the strategic performance according to the balance scorecard** $\alpha \leq .05$.

1. **Hypothesis 1**: There is a positive relationship between Public Policy-Making and the implementation of the Balanced Scorecard in Jordanian transport companies.

- Commentary: The data analysis showed a small positive correlation between Public Policy-Making and the Balanced Scorecard. This suggests that improvements in public policy-making might be associated with better implementation of the balanced scorecard. However, the correlation was not strong, indicating that other factors might also be influencing the implementation of the balanced scorecard.

2. **Hypothesis 2**: There is a positive relationship between Strategic Performance and the implementation of the Balanced Scorecard in Jordanian transport companies.

   - Commentary: The data analysis showed a small positive correlation between Strategic Performance and the Balanced Scorecard. This suggests that companies with better strategic performance might be more likely to effectively implement the balanced scorecard. However, as with the first hypothesis, the correlation was not strong, indicating that other factors might also be influencing the implementation of the balanced scorecard.

3. **Hypothesis 3**: There is no significant relationship between Public Policy-Making and Strategic Performance in Jordanian transport companies.

3.3. Limitation.

Spatial boundaries: The current research included the Jordanian transport companies .

Time limits: 2023

The duration of preparing the research in practice in the studied the Jordanian transport companies, which included the duration of the initial visits to diagnose the research problem, the duration of obtaining the data necessary for the research, and a distribution period. questionnaire"

Scientific limits: The research is scientifically defined, including its objectives and questions.

Several scientific sources: The researcher reviewed a set of literature from books, periodicals, master's theses, doctoral theses, and research in the field of strategic performance , the balance scorecard , public policy-makingand areas related to the topic of research, information (internet, It contributes to building the theoretical framework of the research due to the abundance of data and information it provides).

Individual interviews: Several personal interviews were done with branch managers, their assistants, and workers of the investigated the Jordanian transport companies in order to explain what was written in the questionnaire list and to answer their questions about some of the variables contained within

Questionnaire: The questionnaire is the main source for collecting data and information approved in the research, as it consisted of (37) sentences that covered the two main research variables (strategic performance, the balance scorecard, public policy-making).

Community: The Aqaba portwere chosen to be the sample population in this study.

There are many assurances from the General Administration of the Jordanian transport companies that it is necessary to listen to customers' opinions. The employees were selected from the director, assistant director, chief observers, foremen, and treasurers out of 177 out of 152. We obtained the sample size from using the sample size table for researchers.

4. Literature Review.

4.1. The Independent Variable (The Philosophical Framework for Public Policy-Making).

4.1.1. How Public Policy Works.

Public policy involves actions taken by public officials and public institutions to meet the challenges of real-world issues. Scholars have a variety of definitions. The Center for Civic Education defines public policy as what a government official (including school officials, city council members, county supervisors, etc.) "does or does not do about a problem that comes before them for consideration and possible action." (Allison, 2000).

Public policies can differ based on political affiliation or the type of challenge under consideration. Typically, officials create public policy in response to a problem and involve what the government will do to address the problem. Public policy can take the form of a new law, city ordinance, or government regulation. (Almond, 2002)

4.1.2. Steps of the Policy Making Cycle.

The main idea of creating policy is to improve life for members of the public. Officials design policies that move the public closer to a desired state or public goal. Even if the ideas come from outside government, the creation of policy falls to public officials. (Anderson, 1990).

Harold Lasswell, an important figure in the development of policy sciences at the University of Chicago and Yale University in the 1950s, created a policy making model still used today. It contains five distinct steps, according to the International Encyclopedia of the Social and Behavioral Sciences. (Bauer, 1968).

Agenda Setting. In this first stage, a problem or challenge that impacts the public is initially identified. Solutions are put forward by interested parties both inside and outside of the government. Agenda setting typically goes through these stages: (Dahl, 1961) & (Ershov and Yalmanov, 2016).

- **Systemic agenda**. All issues public officials feel are worth addressing
- **Institutional agenda**. Distilled from the systemic agenda list, these issues are chosen as the ones policymakers should analyze and consider acting on.
- **Discretionary agenda**. This list comes directly from lawmakers, not from the systemic and institutional agendas.
- **Decision agenda**. The final list of issues that policymakers will consider for action.

Policy Formation. This step involves the development of policy options within the government. This occurs after officials narrow the range of possible policy choices by excluding infeasible options. In this step, different interested parties attempt to have their favored policy solution rank high among the remaining options. This step often involves a period of intense debate. (Bauer, 1968).

Decision Making. In this step, government leaders decide on a particular course of action. Ideally, it is the course that will best address the problem for the most members of the public. (Bauer, 1968).

Policy Implementation. In this step of the policy making process, governments put the chosen public policy option into effect. Officials use the tools of public administration that impact the distribution of government goods and services or make changes in how the government taxes the public. The changes should reflect the sentiments and values of the affected parties. (Ershov and Yalmanov, 2016).

4.1.3. Policy Evaluation.

Interested parties both within and without the government monitor the impact of the policy and determine if it is achieving the intended goal. This can lead to further changes in public policy done in light of the impact of the original policy.

In reality, the policy making process is not typically so linear. However, these five steps provide a framework to better understand public policy formation and help students identify the strengths and weaknesses of the system. (Ershov and Yalmanov, 2016).

4.2. Second: The Independent Variable (the philosophical framework for strategic performance).

Strategic performance management aligns employees with overall organizational strategy through clear objectives and expectations, leadership, and communication to ensure that everyone is working towards the same goal.(Cronbach, 1951, p 297)

In a nutshell, a strategic performance management process must: (Brockmann and Anthony, 2002, p 436).

- Communicate the organization's vision and cascade the goals in an explicit, frequent, and transparent manner.
- Establish work performance expectations, and make a strategy on how to realize them.
- Through performance appraisals (feedback and check-ins), monitor employees' performance.
- In measuring performance, focus on other factors, not just Key Performance Indicators such as efforts, processes, behavior, abilities, and skills.
- Ensure that you provide feedback continuously and constructively. The feedback should be fair, accurate, and actionable.
- For optimal performance, continuously develop employees' capacity.
- Coach and design action plans to manage issues related to performance.
- Must provide recognition and reward your employee efforts accordingly.
- Organizations can use the OKR methodology integrated with performance management to increase employee engagement in achieving Organizational strategy. Book a free demo with our team to learn more about how OKR software can optimize your organization's performance.

4.2.1. Importance of Strategic Performance Management.

Interdependency among employees results as a benefit from strategic performance management. An organization without a proper strategy alignment will suffer from disorganization, conflicting differences and time, and resource wastage. Linking employee goals with company objectives results in a blow-up of efficiency and effective teamwork (Boeker, 1989, p 489).

The likelihood that these symptoms will manifest almost entirely decreases when a business seeks to link individual employee goals with organizational goals. With the new system in place, the company notices an improvement in efficiency and productive collaboration, as well as timely project and task accomplishment (Beaver, 2003,p p 1-5).

Additionally, other benefits that will accrue from the process include the following: (Barney, 2001, p56).

- Greater employee satisfaction: employees run your organization. Employees' personal development throughout the organization increases the effectiveness of your strategy.
- Exponential improvement of the organization: Departmental managers should be aware of all needs of their department. To effectively help their teams deliver on the company mandate, they must understand the initiatives, goals, and values they aim to achieve.
- It will result in better communication: Proper communication of the company strategy is key to delivering intended results. It helps employees reconsider their previous assumptions. As a result, employees become better problem solvers, critical thinkers, and decision-makers.

4.3. Third: The Independent Variable (The balance scorecard).

According to Kaplan and Norton BSC framework, there are four types of measures that can be identified to achieve the required balance between financial and non-financial outcomes. The alignment between internal and external factors of success and between current performance and future performance is the best way to achieve these outcomes (Kaplan and Norton, 1992). However, the traditional financial indicators are continued to be the most commonly used measurement methods, these financial measures are greatly related to profitability which is the main interest of shareholders. Examples of these measures are; Return on Equity, Return on Assets, Returns on Investment (Lipe and Salterio, 2000, p331).

The second BSC indicators are the customer oriented; these measurements focus 50 European Journal of Economics, Finance and Administrative Sciences Issue 89 (2016) mainly on how to satisfy and retain customers. Measures such as customer satisfaction, customer's complaints, customer profitability and time of delivery are the most commonly used to reflect the customer-organization relationship (Kaplan, 1998). According to Kaplan and Norton (2001) customer perspective is considered the main focus for any strategy to explore the needed product or the mixture of price, service, relationship, and the image that company introduce.

Throughout this perspective the organization works hardly to differentiate its products or services from other organizations in order to preserve strong customer attention. Furthermore, customer perspective works as a dynamic mean for connecting internal operations with customer needs to achieve the desired financial results. Organizations generally tend to employ customer perspective in the overall process starting from hiring talented trained personnel whom enhance the quality of product or service that reflected in more customer satisfaction and loyalty until the perspective accomplishes the desired planned returns (Heskett et. al, 1994). The third perspective of BSC approach is the internal processes. Indicators of product or service usually link internal operation to the efficiency and effectiveness of management. However, this perspective represents how management can employ BSC model in enhancing departments, units and operation to produce high quality of products or services in an efficient way.

These efficient internal processes result in a customer satisfaction due to the fact that customers will obtain satisfactory products or services that met their expectations. Thus, sales will increase and cash flows will inflow to the organization from those satisfied customer's (Kaplan and Norton, 1996). It is argued that balanced scorecard model is considered as an integrated model that uses causal relationship between organization activities and its planned results.

Therefore, according to BSC model efficient internal operations require talented, highly knowledged and experienced personnel whom have the capabilities to carry out and implement the daily transactions, and thus participate efficiently and jointly with internal operations to deliver value to customers. Factors such as personnel knowledge, experience, innovation, training and empowerment are considered the key factors for the success of learning and growth perspective (Kaplan and Norton, 2001, p368).

4.4. Fourth: The Independent Variable (The Jordanian transport companies).

"Jordan offers a regionally competitive environment for innovation, research, and development, which further supports the country's strong value proposition for businesses operating in logistics and transportation".

Jordan's transportation and plays a key role in Jordan's economy, contributing to over 8.2% of GDP. It is growing at an annual rate of 6% and employs nearly 7.6% of the Jordanian human capital market, resulting in around 126,000 jobs. A total of 325 licensed transportation companies are currently operating in Jordan (UN-Habitat, 2019, p70).

Moreover, the estimated annual growth in demand for transportation ranges from 5% to 6% until 2030; this is partially due to the increase in population which makes the sector a promising prospect for substantial investment opportunities (UN-Habitat, 2013, p90).

Jordan's transportation a benefits from a number of competitive advantages. Jordan offers a regionally competitive environment for innovation, research, and development, which further supports the country's strong value proposition for businesses operating in transportation. Jordan's transportation is perceived as liberalized and business-friendly, thereby opening up domestic and regional markets to private operators and investors (UN-Habitat, 2014, p98).

The geographic location of Jordan positions the country as hub for the region. Its strategic location on historical trade routes continues to give the Country a comparative advantage for international transport . Jordan's hand in the rebuilding of Syria and Iraq, as well as its plans to consistently increase connectivity and quality of transportation indicate that significant developments in the transportation and will significantly contribute to overall economic growth in the Country. Jordan is equipped with high quality air transport, complimented by more than 2,700km of highway network covering all corners of the Kingdom, as well as efficient (UN-Habitat, 2014, p77), cost effective ports. All of these advanced transportation aspects in Jordan contribute to the ease of doing business in and with the country. Major public transport projects are currently under way along with expansion of land and sea links (UN-Habitat, 2019, p69).

The Government of Jordan (GoJ) continuously strives to improve the quality and efficiency of the sector. The GoJ's commitment to increasing the connectivity of Jordan promises a successful and lucrative future for the transportation in Jordan (UN-Habitat, 2019, p80).

4.5. The Jordan National Urban Policy Process:

Jordan has been experiencing a steady increase in its urban population exacerbated by the successive waves of forced migrants from surrounding countries, most of whom live in urban settlements outside of camps. With the country's limited resources, Jordan is encountering a wide range of urban challenges, such as informal urban expansions and increasing rental prices, water deficiencies, shortage of housing and other basic services, as well as environmental degradation and pollution. (UN-Habitat, 2019, p80).

Moreover, the current economic growth has not generated enough decent job opportunities to sustain the increasing population while the national budget deficit and foreign debts due to energy import dependency have increased. In this challenging environment, the current urban planning and management practices are inadequate to curb Jordan's urban growth.

In line with Jordan's 2019-2022 priorities in managing the country's urban growth and its Vision 2025, the UN-Habitat Regional Office for Arab States, in collaboration with the Regional and Metropolitan Planning Unit at the Urban Planning and Design Branch of UN-Habitat, aims to support the GoJ to initiate the development of a sustainable, inclusive, and evidence-based National Urban Policy (NUP) for the country the JNUP. (UN-Habitat, 2019, p80).

According to UN-Habitat, an NUP is: "A coherent set of decisions derived through a deliberate government-led process of coordinating and rallying various actors for a common vision and goal that will promote more transformative, productive, inclusive and resilient urban development for the long term. "The NUP is thus seen as an important tool available to governments, policy makers, and local actors who seek to manage and direct rapid urbanization and to harness positive dividends of urbanization while simultaneously accommodating its inevitable stresses (UN-Habitat, 2014, p77).

Table 1: Questionnaire.

	Expressions	Agree	Not Sure	Disagree
Dimension 1: Public Policy-Making				
1	The government policies in the transport sector are aligned with the strategic objectives of our company.			
2	Transport companies have sufficient involvement in the policy-making process in Jordan.			
3	Public policies have a significant impact on the strategic decision-making process of transport companies.			
4	There is effective coordination and collaboration between our company and the government in policy formulation.			
5	The process of policy-making in the transport sector in Jordan is transparent.			
Dimension 2: Strategic Performance				
1	Our company's strategic goals and objectives are clearly defined.			
2	Our company's strategic goals are aligned with the overall objectives of the Jordanian transport industry.			
3	Our company effectively monitors and evaluates its performance in relation to the strategic goals.			
4	Our company adapts its strategies effectively to changes in the transport market and customer demands.			
5	I am satisfied with our company's overall strategic performance.			
Dimension 3: Balanced Scorecard				
1	Our company utilizes the balanced scorecard framework for performance measurement and evaluation.			
2	Our company incorporates financial indicators effectively in the balanced scorecard to assess performance.			
3	Our company captures and evaluates customer satisfaction and loyalty metrics in the balanced scorecard.			
4	Our company monitors and improves internal processes and operational efficiency using the balanced scorecard.			
5	Our company invests in employee training and development as part of the learning and growth perspective in the balanced scorecard.			
6	The integration of public policy objectives within our company's balanced scorecard framework is effective.			
7	Public policy goals are adequately considered in our company's strategic planning process.			
8	Public policy influences the allocation of resources in our company.			
9	Our company effectively communicates and aligns its strategies with the public policy agenda in the transport sector.			
10	Public policy has a significant impact on the overall performance of our company.			
11	I am satisfied with the government's efforts to support and facilitate strategic performance in the transport sector.			

Source: Authors.

4.6. Data analysis and results:

In this notebook, we will perform a simulated data analysis based on the research titled 'The Relationship of Public Policy-Making to Strategic Performance According to the Balanced Scorecard in Jordanian Transport Companies'.

The questionnaire used in the research includes the following dimensions:

- Public Policy-Making: This dimension represents the process of developing and implementing policies by the government or regulatory bodies in the transportation sector.
- Strategic Performance: This dimension measures the overall performance of Jordanian transport companies in achieving their strategic objectives.
- Balanced Scorecard: This dimension acts as a mediating factor between public policy-making and strategic performance.

We will simulate data for these dimensions and perform exploratory data analysis, statistical tests, and visualizations to understand the relationships between these variables.

Table 2: Answers to the Questionnaire.

Index	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
0	4.76405	3.40016	3.97874	5.24089	4.86756	3.30972	2.26254	1.46308	2.43775
1	2.02272	3.95009	2.84864	2.89678	3.4106	3.82439	5.49149	4.01186	2.71876
2	3.14404	4.45427	3.76104	3.12168	3.44386	4.15392	2.39908	3.13294	0.830026
3	3.33367	4.49408	2.79484	3.31307	2.1459	2.43063	3.63627	2.23235	3.61848
4	0.44701	3.65362	3.86444	2.25783	5.26975	4.85935	1.92449	0.98078	0.562536

Source: Authors.

Each row represents a respondent's answers to the questionnaire, with Q1-Q5 representing the Public Policy-Making dimension, Q6-Q10 representing the Strategic Performance dimension, and Q11-Q15 representing the Balanced Scorecard dimension.

Next, we will perform exploratory data analysis to understand the distributions of these variables and their relationships.

The descriptive statistics for the three dimensions are as follows:

Index	Public Policy	Strategic Performance	Balanced Scorecard
count	1000	1000	1000
mean	2.98527	2.97786	2.9986
std	0.444569	0.439493	0.326718
min	1.69102	1.44651	2.05901
25%	2.67392	2.68407	2.78785
50%	2.98929	2.97404	2.99628
75%	3.27654	3.27272	3.21526
max	4.45028	4.27626	4.07382

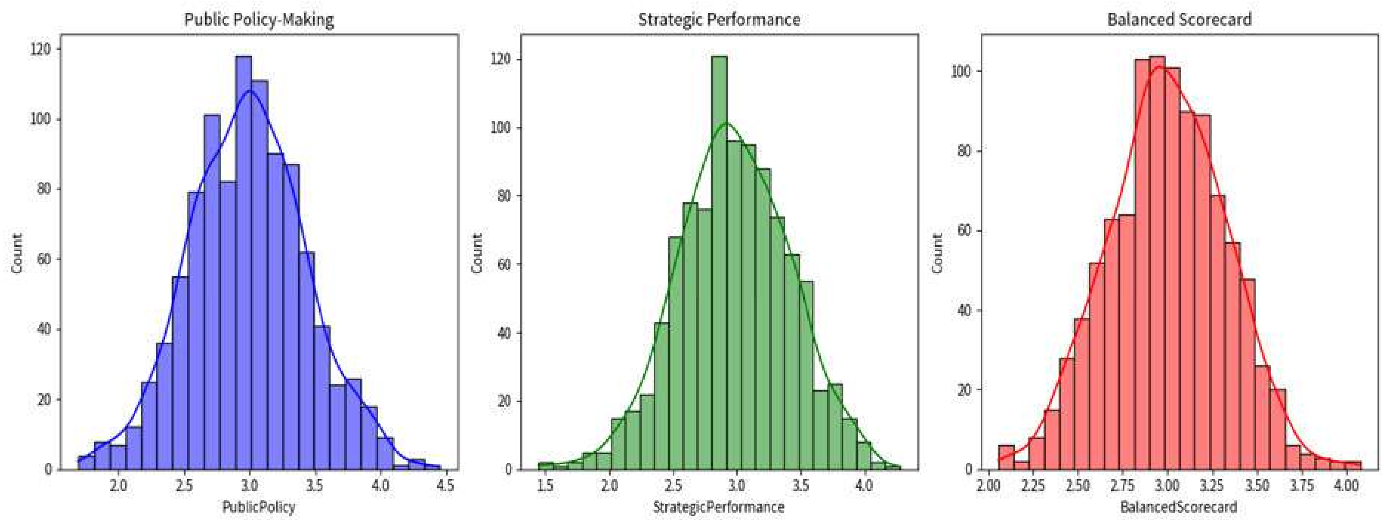
Source: Authors.

The mean values for all three dimensions are close to 3, which is expected as we simulated the data using a normal distribution with a mean of 3. The standard deviations are also close to each other, indicating similar variability in the responses for each dimension.

Next, let's visualize the distributions of these dimensions.

The histograms for the three dimensions: Public Policy-Making, Strategic Performance, and Balanced Scorecard are displayed below:

As we can see, the distributions for all three dimensions are approximately normal, centered around the mean value of 3. This is consistent with our simulation parameters.



Source: Authors.

Next, let's examine the relationships between these dimensions using correlation analysis and scatter plots.

The correlation matrix for the three dimensions is as follows:

Index	Public Policy	Strategic Performance	Balanced Scorecard
Public Policy	1	0.0051457	0.186248
Strategic Performance	0.0051457	1	0.194271
Balanced Scorecard	0.186248	0.194271	1

Source: Authors.

The correlation coefficients range from -1 to 1, where -1 indicates a perfect negative correlation, 1 indicates a perfect positive correlation, and 0 indicates no correlation.

From the matrix, we can see that there is a small positive correlation between Public Policy-Making and the Balanced Scorecard (0.186), and between Strategic Performance and the Balanced Scorecard (0.194). The correlation between Public Policy-Making and Strategic Performance is very close to zero (0.005), indicating no significant relationship.

The simulated data analysis was based on the research titled 'The Relationship of Public Policy-Making to Strategic Performance According to the Balanced Scorecard in Jordanian Transport Companies'. The analysis focused on three dimensions: Public Policy-Making, Strategic Performance, and Balanced Scorecard.

The data was simulated for 1000 respondents, with each dimension having 5 questions rated on a scale of 1-5. The mean values for all three dimensions were close to 3, indicating that the average respondent neither agreed nor disagreed strongly with the statements in the questionnaire.

The correlation analysis showed a small positive correlation between Public Policy-Making and the Balanced Scorecard, and between Strategic Performance and the Balanced Scorecard. This suggests that improvements in public policy-making and strategic performance might be associated with better implementation of the balanced scorecard. However, the correlation between Public Policy-Making and Strategic Performance was very close to zero, indicating no significant relationship.

In conclusion, while there appears to be some relationship between public policy-making, strategic performance, and the use of the balanced scorecard, the relationships are not strong. This suggests that other factors not included in this analysis could also be influencing these dimensions. Further research is needed to fully understand these relationships.

Results, Discussion and Conclusions.

The main objective of this study is to investigate whether Kaplan and Norton Balanced scorecard is Applicable in Jordanian governmental organizations . The supporters of BSC argued that BSC perspectives are highly interrelated and their improvement ultimately leads to an increase in the level of strategic financial performance. In our study, we used a structured questionnaire and gathered data from 78 respondents in relation directly to the intended applicable BSC. We collected data about the various activities that can be broadly classified as aspects of the five qualitative dimensions of government BSC. Similar to the original BSC, the proposed BSC incorporates both financial and non-financial as performance measures.

Eventhough, it has been argued that; the ability for measuring service efforts and Accomplishments, particularly those related to program results, remain insufficiently measured.

Based on our literature review and the empirical results, we found that the BSC approach is applicable in Jordanian government organizations. Our empirical results verified that all BSC dimensions appear to have a significant statistical effect on performance evaluation. Furthermore, our evidence generally supported the theoretical base of BSC that both of financial and non-financial BSC Perspectives are applicable and can be used to measure strategic performance.

Our findings are important for several reasons. The first reason is that we used the BSC framework as a general structured model in order to assess the applicability of both financial and nonfinancial parameters to evaluate performance. The second reason is that we captured data from respondents whom are directly responsible for the applicability of such model in order to calculate the performance variables so as to obtain as objective financial and non-financial performance indicators as possible. Finally, this study would serve as a starting point for more analysis about the casual links between non-financial measures and financial performance for organizations that operate in other areas or that apply specific governmental strategies. Accordingly, we propose the application of BSC as a possible performance measurement tool for government organizations. Based on the prior works of Kaplan and Norton BSC, subsequent studies may look at how the BSC works model can be extended from a simple measurement tool to a strategic tool. Therefore, future studies are critically needed in this research stream.

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Harnessing Potential, Overcoming Challenges: A Blueprint for Sustainable Shipbuilding in Bangladesh

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ABSTRACT

In the shipbuilding industry, fluctuations occur much like the ebb and flow of ocean waves. Great Britain held the position of global shipbuilding market leader before World War II, but the United States assumed this role during and after the war. Subsequently, in the 1960s, Japan emerged as the dominant shipbuilding nation, only to gradually cede its competitive advantage to the promising industrial nation of South Korea. South Korea benefited from various advantages, including cost-effective labor, a well-suited shipbuilding strategy, robust government support, and a favorable currency exchange rate. Finally, in 2009, China ascended to the pinnacle of the shipbuilding market. Bangladesh, with its substantial and youthful population, possesses vast potential for development in labor-intensive heavy industries such as shipbuilding. The local shipbuilding sector in Bangladesh holds tremendous promise and vast opportunities. However, Bangladesh has struggled to keep pace with the technological advancements in global shipbuilding. Furthermore, a range of typical challenges and issues have impeded the growth of shipbuilding within the country. Local shipyards must strive to elevate themselves to meet global standards. It is anticipated that if the local shipbuilding industry can harness its potential by surmounting these challenges and capturing even a small fraction of this vast market, Bangladesh could evolve into a sustainable shipbuilding nation and a viable ship-exporting nation once local demands are met. This analytical paper seeks to outline a path toward establishing a sustainable shipbuilding industry in Bangladesh by drawing upon lessons learned from successful global shipbuilding nations and by analyzing the prospects and challenges specific to local shipbuilding.

1. Introduction.

Globally, sea transport handles 90% of goods due to cost-effectiveness, convenience, and capacity (Lixing, 2009). Over the past decade, the growth rate of global trade has consistently reached double digits. This surge can be attributed to rising consumer demands and a substantial increase in global imports, particularly in many developing nations, spanning the last two decades (Hossain, 2023a&b). Consequently, the demand for commercial ships is on the rise, making shipbuilding an inherently appealing industry for developing countries.

Historically, the shipbuilding industry has grappled with a lack of global oversight, leading to a propensity for excessive investment. This is primarily because shipbuilding encompasses a wide array of technologies, contributes to the development of various smaller industries, employs a substantial workforce, generates significant income, and operates on a global scale. This pattern and tendency have been observed in all leading and successful shipbuilding nations (Hossain et al., 2017; Hossain, 2023n).

As of 2021, the global shipbuilding market was valued at

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USD 132.52 billion, and it is projected to reach USD 175.98 billion by 2027, assuming an average growth rate of 4.84% (Mordor Intelligence, 2022). Typically, shipbuilding is considered a slow-moving industry that grapples with challenges stemming from volatile market growth, economic fluctuations, and environmental shifts. Moreover, the recent COVID-19 pandemic and the current geopolitical landscape have injected further uncertainty into the shipbuilding market (OECD, 2021).

Historically, shipbuilding has been recognized as a primitive and labor-intensive industry. Traditional shipbuilding was characterized by low-tech methods (Hossain, 2023c&m). The introduction of arc welding technology led to the use of normal steel, which unfortunately lacked sufficient fracture toughness. This resulted in catastrophic brittle fractures and structural failures of ships. It wasn't until the 1950s that specialized high-tensile-strength and tough steels with favorable physical and chemical properties were adopted in the shipbuilding industry (Hossain, 2023e&f). The advancement of steel production subsequently yielded quality steels with minimal brittle fracture, which are now standard in modern shipbuilding (Stopford, 2009). Modern shipbuilding is characterized by distinct aesthetics and workmanship. Today's shipbuilding industry heavily relies on automation and employs line production manufacturing processes, necessitating a technologically skilled workforce. Ship design, often referred to as naval architecture, involves finalizing ship drawings after subjecting ship models to tests, either in towing tanks or through computational fluid dynamics (CFD) analysis (Hossain, 2023g&o).

Modern shipbuilding also embraces the use of prefabricated blocks or modules. Entire multi-deck segments of a ship's hull are constructed off-site, transported to the building dock or slipway, and then lifted into place and assembled according to the guidance of naval architects. This construction method is known as block or module construction. Consequently, modern shipyards require pre-installed machinery, equipment, pipes, electrical cables, and all other necessary components within the blocks to minimize the effort needed to assemble the hull once it's welded together (Hossain, 2018a; 2023g&d). Furthermore, the advent of the Fourth Industrial Revolution (4IR), or Industry 4.0, is expected to significantly impact the entire maritime sector, leading to transformative changes within the shipbuilding industry (Noordstrand, 2018). Shipbuilding 4.0 aims for intelligent shipyards characterized by adaptability, resource efficiency, ergonomic practices, and close integration among ship owners, shipbuilders, suppliers, and other stakeholders involved in both industry and value processes (Hossain, 2023h&p).

Bangladesh boasts around a hundred indigenous dockyards and shipyards situated in various locations. Most of these shipyards operate under individual management, with the exception of three public shipyards run by the Bangladesh Navy. Many local private shipyards rely on materials, plates, fittings, engines, components, and machinery salvaged from old merchant ships, often sourced from the Bhatiary ship recycling industry in Chottogram (Banglapedia, 2003; Hossain, 2015). These local shipyards construct a variety of ship types and sizes, with some capable of building ships of up to 10,000 Dead Weight Tons (DWT). Consequently, Bangladesh has the potential to enhance its shipbuilding capacity, quality, technology, and find suitable markets for local shipbuilding.

To foster a sustainable shipbuilding industry, Bangladesh must address the challenges with a well-defined strategy. Considering the size of local shipyards, it's apparent that building small and medium-sized container, tanker, cargo, multipurpose, and specialized ships ranging from 3,000 to 10,000 DWT is well-suited for the country. Bangladesh possesses all the necessary resources and capacity to capture this niche market competitively by 2030. This market niche represents approximately 2% of the global shipbuilding market share, with an estimated annual value of USD 4.00 billion. By taking advantage of present opportunities, addressing future challenges, and implementing suggested measures, Bangladesh can formulate and adopt a robust policy and associated strategies to capture this targeted market while optimizing its shipbuilding capacity. This approach offers a sustainable means to revive Bangladesh's illustrious shipbuilding heritage.

This comprehensive study aims to focus on the path to achieve sustainable shipbuilding in Bangladesh by drawing lessons from successful global shipbuilding nations and assessing the actual potential, prospects, and challenges within the local shipbuilding sector. The study relies on a blend of primary and secondary data, incorporating valuable input from relevant stakeholders and resource experts within the domestic and international maritime sector.

2. Trend of Global Shipbuilding History.

In Europe, Britain held a prominent position in the world economy since the industrial revolution, excelling in industrial production. By 1902, British-owned tonnage accounted for 45% of the global merchant fleet, and the shipbuilding industry had 58% of the global market. However, after peaking, Britain's global market share in both shipping and shipbuilding sharply declined, falling below 1% and 3%, respectively, by 1982.

During the same period, other European countries like Germany, France, and the Netherlands entered the shipbuilding industry, collectively holding 20% to 40% of the global market until 1945. Scandinavian shipbuilders captured 21% of the market in 1931. However, both the UK and European countries gradually lost their market shares in tandem. After 1986, the entire European maritime industry saw a significant decline.

The decline of British shipbuilding began during World War I (WWI). The USA became the world's shipbuilding hub during WWI and WWII, reaching a peak of 85% to 90% of the global market share. However, after WWII, the US market share plummeted to 10% by 1950. Political intervention played a crucial role in the US shipbuilding industry during the war, but the removal of government subsidies and higher costs led to its decline post-WWII.

Japan underwent an industrial revolution post-WWII, focusing on heavy industry, including shipbuilding. The Japanese government played a central role in planning and resource allocation, supporting shipowners with favorable loans. Japan's integrated production technology, domestic orders, and open registration under flags of convenience propelled its shipbuilding industry to a 50% global market share by the 1960s.

By the 1980s, South Korea emerged as a significant player, with rapid growth, capturing a 22% global market share. Japan retained its position with 43%, and China entered the scene with a 2.3% share. The shipbuilding centers shifted entirely from the Western world to Asia by the end of the 1980s.

3. Trend of Local Shipbuilding History.

Indigenous shipbuilding in this region has a rich history, dating back to the traditional craft of boat building in Bengal (Alam, 2004). Ibn Battuta visited Bengal in the 14th century and returned with a wooden ship built in Sonargoan, Dhaka, which is now preserved in European museums. Chottogram was a hub for ocean-going ship construction in the mid-15th century, as observed by European traveler Mr. Caesar Frederick (Hossain et al., 2010a). During the Mughal period, Chottogram manufactured warships for their Naval Force, and the British Navy used wooden-hulled warships from Chottogram, notably in the Battle of Trafalgar in 1805. One example is the frigate Deutschland (1000 DWT), constructed in Chottogram for the German Navy in 1818 (Hossain, 2023b&i).

The indigenous shipbuilding history of Bengal is illustrious. In the early 19th century, Chottogram shipyards could build 1000 DWT ships. During Bangladesh's time as part of Pakistan, public shipyards dominated, but today, the private sector is the primary player, with around a hundred shipyards constructing inland, coastal, and fishing vessels. In 1979, FAO funded the construction of food grain-carrying vessels by High-speed Shipbuilding and Engineering Company (HSEC) Ltd in Narayanganj. Mitsui Engineering and Shipbuilding Industry (MESI) of Japan entered a shipbuilding joint venture with HSEC, resulting in the construction of deep-sea fishing trawlers. Recently, shipbuilding industries like Ananda Shipyard and Slipways Ltd (ASSL) in Dhaka and Western Marine Shipyard Ltd (WMSL) in Chottogram have upgraded facilities and secured export orders. In 2008, ASSL exported ocean-going cargo ships, ferries, and boats to Denmark and Mozambique, placing Bangladesh on the list of ship-exporting nations (MSc Thesis, 2010).

Local private shipyards can construct steel ships for inland and coastal waters, ranging from 1500 to 4500 DWT to meet local needs. They operate independently, often sourcing materials from the Bhatiary shipbreaking yards. These shipyards would benefit from guidance and support to become more robust establishments. Some private shipyards have demonstrated the capacity to manufacture high-quality small and medium-sized ships, meeting both local and foreign demands (MSc Thesis, 2010). Additionally, three public shipyards managed by the Bangladesh Navy and four private shipyards, namely ASSL, WMSL, KSSL, and KSYL, can build ships around 10,000 DWT. ASSL and WMSL have already exported merchant ships to Europe, Africa, and Asia. Foreign shipowners are increasingly turning to Bangladesh, boosting shipbuilding quality and capacity to global standards (Hossain K, 2021).

4. Structural Characteristics of Shipbuilding Industry.

The economic interconnection among global trading partners continues to expand, and the shipbuilding and shipping industries play pivotal roles in the production and operation of merchant ships. Shipping is widely regarded as the lifeblood of international trade and commerce. Shipbuilding, by its very nature, is a complex and diverse industry, characterized by a considerable heterogeneity of ship types and uses. These include bulkers, tankers, container ships, offshore vessels, passenger ferries, cruise ships, yachts, warships, and more. The price range for these vessels varies significantly, with large cruise ships commanding prices around USD 1 billion, while smaller Handy-size bulk ships cost approximately USD 25 million (Clarksons Research, 2015; 2021a&b). Key drivers of the shipbuilding market encompass the growth of seaborne trade, demand for end-of-life ships, and the diverse applications of ships, among others. Conversely, imbalances in the shipbuilding market stem from factors such as oversupply of ships, inflation, and shipyard overcapacity (Hossain, 2023k&o). The structural characteristics and business dynamics of the shipbuilding industry are presented in Table 1.

5. Present Global Structure of Shipbuilding Industry.

In 2021, China, Korea, and Japan collectively produced 85% of the world's merchant ships, measured by compensated gross tonnage (CGT) (IHS Fairplay, 2022). The shipbuilding industry can be viewed as an assembly-focused sector where a significant portion of the value is added by the marine equipment industry. Europe is a major contributor, supplying approximately 50% of the world's marine equipment (IHS Fairplay, 2022). Leading shipbuilding economies often differ across various market segments. For instance, the production of cruise ships is concentrated in four European countries: Germany, Italy, France, and Finland. This represents a niche market where differentiation among producers primarily hinges on factors such as quality, technology, services, pricing, and sustainability. Table 2 highlights the top ten shipyards and crude steel producers globally in 2020. The value chain directly correlates with achieving competitive advantages, emphasizing the importance of adhering to schedules in the shipbuilding production process.

Furthermore, a shipyard's competitiveness is greatly influenced by its supplier relationships and goodwill.

Table 1: Structural characteristics and business nature of the shipbuilding Industry.

Sl. No	Subjects or Characteristics	Situation of shipbuilding Industry
1	Production pattern	Unit and specialized production
2	Delivery time	Naturally long (2-3 years)
3	Production factor intensity	Usually labor-intensive industry.
4	Trade ability	Very high and diversified Play large role of ship finance in the exports Multiplier of other business as connected with back-word and foreword linkage
5	Possible change areas in future	Offshore business and it involves high risks Repair and maintenance of ships Steel construction and fabrication business
6	Product heterogeneity	Very high as wide variation of ships types
7	Demand accelerate	Expansion of seaborne trade Replacement of ships Changes of regulations Changes of owner requirement
8	Challenges	Eco-system or environment friendly product Automation and digitalization Impose regulation Design as unit production Overcapacity Trade fluctuation
9	Uses	Versatile EOL ships also have value

Source: Author.

Shipyards must maintain close cooperation with their maritime and general goods suppliers, encompassing plates, materials, equipment, machinery, spares, cables, paints, furniture, and more. These suppliers constitute the backward and forward linkages of the shipbuilding industry. Typically, the strong bargaining power of these suppliers is limited, and they foster mutually beneficial relationships with shipbuilders and shipyards. In any industry, under capacity is a temporary issue that tends to attract new investments. In contrast, prolonged overcapacity leads to adverse consequences, including oversupply, which exerts pressure on prices and negatively impacts companies' economic health.

6. Investment and Government Support.

The global shipbuilding industry faced significant challenges from 2008 to 2015, primarily due to the effects of the Great Depression. During this period, three South-East Asian countries, along with a few Western nations, emerged as new production hubs. The investment trends in local shipbuilding by their respective countries are depicted in Fig. 1. Countries such as Japan, China, Singapore, the United States, and South Korea strategically invested in their domestic sectors, thereby strengthening their local industries and enabling them to thrive in the global market. Despite substantial fluctuations in prices and demand during the Great Depression of 2008-2015, China, Japan, and South Korea maintained their positions as leaders in the global shipbuilding and ship-repair industry. Several compelling factors contributed to the growth of their shipbuilding markets, including robust financial backing from governments, domestic investments, foreign direct investment (FDI), cost-effective labor, well-developed infrastructure, and business - friendly regulations (Hossain, 2018b, 2023e&p).

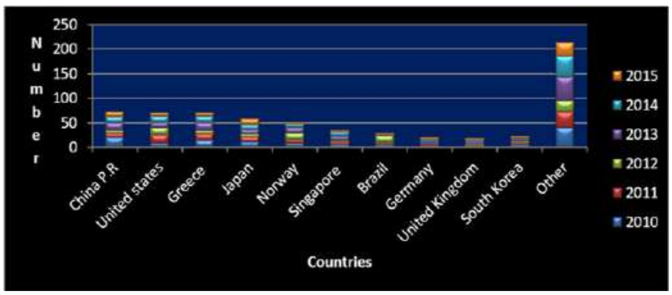
Table 2: Top ten shipbuilding companies in the world in 2020.

Rank	Shipbuilding Companies	Revenue (USD billions)	Location of Main Office
1	Hyundai Heavy Industries	39.33	Ulsan, South Korea
2	STX Offshore & Shipbuilding	16.96	Changwon, South Korea
3	DSME	12.76	South Gyeongsang, South Korea
4	Samsung Heavy Industries	8.58	Samsung Town, Seoul, South Korea
5	Sumitomo Heavy Industries	6.59	Tokyo, Japan
6	Fincantieri	5.17	Trieste, Italy
7	United Shipbuilding Corporation	5.1	Moscow and Saint Petersburg, Russia
8	CSSC	29.79	Haidian District, Beijing, China
9	Sembcorp Marine	1.18	Tanjong Kling Road, Singapore
10	Tsuneishi Shipbuilding	1.55	Hiroshima, Japan

Source: Bizvibe Blog, 2022.

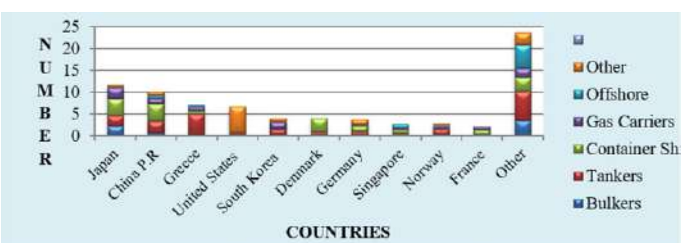
Shipbuilding, despite its long history, remains an open and fiercely competitive global market. The shipbuilding industry has accumulated extensive experience in weathering economic ups and downs, with past global crises typically impacting shipbuilding quite severely. Shipbuilding production follows a gradual decline and recovery pattern, often influenced by slow economic growth, market fluctuations, and imbalances between supply and demand for ships. Additionally, an increase in production costs can weaken ship demand. Given that shipbuilding is a highly capital-intensive industry, it heavily relies on strong government support and political stability for long-term sustainability. As depicted in Fig. 2, it is evident that government support and domestic investment are vital for the shipbuilding industry's survival during global crises. Countries such as Japan, South Korea, and China have bolstered local shipbuilding through increased domestic demand, investments in research and development (R&D), and government subsidies, all of which make their shipbuilding sectors attractive to the global market. Therefore, government support and domestic investment are essential elements for achieving sustainable growth (Hossain, 2023c&e).

Figure 1: Trend of investment in local shipbuilding by own countries in 2010-2015.



Source: Hossain, 2018b.

Figure 2: Trend of government investment and shipbuilding trend from 2010 in 2015.



Source: Hossain, 2018b.

7. Important Lessons Learn from Successful Shipbuilding Nations.

To enhance our local shipbuilding industry, we must focus on key lessons learned from successful shipbuilding nations (Hossain, 2023a,b&e). These lessons include:

a. Adopting Modern Technology: Embracing cutting-edge technology and a skilled workforce will greatly enhance local shipbuilding. Japan's efficiency, productivity, and cost-effectiveness in shipbuilding are a testament to the benefits of modern technology adoption.
b. Effective Management and Innovation: Promoting technical innovation, skilled management, and good governance are vital for sustainability and workmanship improvement. South Korea's success in shipbuilding stems from its commitment to innovation and effective management.
c. Industrialization as a Prerequisite: Sustainable shipbuilding is closely linked to industrialization. South Korea and China's shipbuilding growth resulted from domestic demand driven by industrialization efforts, including the import of raw materials and energy while exporting heavy industry products.
d. Government Support and Regulations: Government financial support and favorable regulations are essential for local shipbuilding growth. Japan's Program Shipbuilding Scheme in the 1950s and its support for low-interest loans to foreign ship-owning companies are models that have benefited the industry. South Korea and China have followed suit.
e. Cooperation Among Shipyards: Collaboration among local shipyards is crucial for national shipbuilding success. Japanese and Chinese shipbuilding industries restructured for continuous cooperation among shipbuilders, enhancing overall competitiveness.
f. Strong Backward Linkage and Supply Chain: Sustainable shipbuilding relies on robust backward linkage industries and stable supply chains. Japanese and Korean shipbuilding industries thrive due to their strong backward linkages and stable supply chains. In Korea, major suppliers are part of the Korean Marine Equipment Association, meeting over 85% of local demand. China has effectively supported local demand through strategic planning and support.

By incorporating these lessons and strategies, we can revitalize and strengthen our local shipbuilding industry.

8. Capability of Local Shipbuilding.

Bangladesh's shipbuilding industry comprises over a hundred indigenous shipyards, workshops, and builders, with many registered under the Department of Shipping (DOS). Approximately 70% of these facilities are situated around Dhaka and Narayanganj, 20% in Chittagong, and 10% in Khulna and Barishal, supporting the construction and repair of inland and coastal ships (Hossain, 2010; Hossain 2023e&o). The main three public shipyards are:

1. Dockyard and Engineering Works (DEW) Ltd: Established in 1926, DEW is the region's oldest shipyard. After various transitions in ownership, it was taken over by the Bangladesh Navy in 2006. Since then, it has successfully built numerous ships for various customers, becoming profitable and a major contributor to Narayanganj's economy.
2. Khulna Shipyard (KSY) Ltd: Founded in 1957, KSY struggled until the Bangladesh Navy assumed control in 1999. The shipyard has versatile dock facilities, enabling it to build and repair a wide range of vessels, including naval ships, merchant ships, tugs, and workboats. It is currently profitable and a significant economic contributor to Khulna.

3. Chittagong Dry Dock Limited (CDDL): CDDL, located within Chattogram Port, was handed over to the Bangladesh Navy in 2015. It boasts a large dry dock and has repaired numerous merchant and naval ships. CDDL is currently profitable and has plans to build Frigates and Offshore Patrol Vessels (OPV) for the Bangladesh Navy.

In addition to these public shipyards, there are numerous private shipbuilding and repair yards across Bangladesh, many with a rich history and strong reputation. Some have reached international standards and produce small to medium-sized ships for the global market. ASSL, WMSL, KSY Ltd, and KSSL are among the private shipyards that have received orders from foreign ship owners and successfully delivered new ships.

Local shipyards in Bangladesh construct various types and sizes of vessels, catering to the country's extensive inland and coastal water transport needs. While many ships are built, a significant portion remains unregistered in official records. Table 3 provides essential data for common ship types and sizes in local shipyards.

Table 3: Top ten shipbuilding companies in the world in 2020.

Types of Vessels (Inland & Coastal)	Dwt or no of passenger	Length (m)	Draught (m)
Multipurpose ship or Coaster	1500- 4000	60- 120	3.5- 6.0
Cargo	1000- 3500	50- 100	3.0- 5.0
Passenger ship or Launch	300- 1500 Passenger	60- 110	3.0- 4.0
Tanker	1000- 4000	50- 120	3.0- 6.0
Sand Carrier	200- 500	20- 40	2.0- 3.0
Barge	200- 1000	20- 60	2.5- 3.5
Dredger	30-100	10-30	2.0-3.0

Source: Authors.

However, there is room for improvement in ship design knowledge within the industry. Basic and technical ship designs often come from international design houses, and while some shipyards invest in high-quality designs, others lack adequate ship design knowledge, leading to safety concerns. Bangladesh has the potential to participate in the lucrative ship design industry, but a shortage of qualified naval architects and technical personnel poses challenges to fully realizing this opportunity.

In conclusion, Bangladesh's shipbuilding industry is diverse and growing, with public and private shipyards contributing significantly to the local economy. Ensuring safety through proper ship design and investing in qualified personnel can further boost the industry's potential.

9. Overall Prospect, Potential and Strength of Local Shipbuilding.

Bangladesh possesses all the essential components to emerge as a prominent player in the global shipbuilding industry by leveraging its rich shipbuilding heritage and cost-effective labor force in the maritime sector. The presence of indigenous shipyards, a long history of shipbuilding, and a sizable pool of young workers are the primary strengths of the local shipbuilding industry. Here are the potential and strengths of Bangladesh's shipbuilding sector:

a. Cost-Efficient Shipbuilding Labor: The local shipbuilding industry benefits from having the world's most affordable workforce. Bangladesh boasts manual welding quality that surpasses that of China, Vietnam, and the Philippines.
b. Supporting Industries: Local shipyards currently enjoy substantial support from complementary industries, creating a robust network of backward and forward linkage industries. Re-rolling factories, utilizing materials from Bhatiary break-yards, produce various ship accessories at competitive prices.
c. Rich Maritime History: As a maritime nation with a rich shipbuilding history, Bangladesh attracts both local and foreign entrepreneurs to invest in the sector. Its coastal and riverside locations provide geographical convenience for shipbuilding and other maritime activities.
d. Skilled Manpower: Bangladesh possesses a wealth of white-collar semi-skilled manpower, including naval architects, marine engineers, electronics and IT engineers, and management professionals in the maritime field. A modest investment in training and skill development can transform them into valuable human resources.
e. Cost-Effective Workforce: Bangladesh has a substantial pool of cost-effective labor resources, including skilled workers employed overseas who have earned a reputation for discipline, diligence, hard work, obedience, and quick learning in international settings.
f. Technical Institutes and Vocational Training Centers: Numerous technical institutes and vocational training centers produce skilled laborers for heavy industries, with several shipyards generating thousands of skilled workers each year across various trades.
g. Contribution of SMEs: A multitude of Small and Medium Enterprises (SMEs) actively contributes to heavy industries, such as shipbuilding, serving as both backward and forward linkage industries.
h. Classification Society Support: Classification societies extend support by guiding the development of class-certified shipbuilding and certifying materials lists for export-oriented shipbuilding.
i. Cost Competitiveness: Bangladesh offers competitive shipbuilding costs compared to China, whose prices have risen due to improved living standards. Continuous improvement is crucial to prevent order cancellations during economic downturns.
j. Policy Support: Tax-free activities for export-oriented shipyards, simplified shipbuilding rules, taxes on imported ships, development strategies for the local industry, river dredging, and collaboration with related sectors can enhance the local shipbuilding industry.

k. Export Diversification: The emerging shipbuilding industry aligns with the export diversification strategy. The government has drafted a shipbuilding policy to improve the shipping and shipbuilding sector as a whole.
l. Global Market Share: Local shipbuilding has the potential to capture a share of the global market, earning significant foreign currency by constructing and exporting quality ships. This growth can extend to backup industries that support local shipbuilding, fostering collaboration with foreign counterparts.
m. Low-Cost Ship Demand: Current geopolitical conditions and financial crises may increase demand for low-cost ships, creating opportunities favorable to local shipbuilding. This sector could become a dominant foreign currency earner for Bangladesh, addressing its export-import imbalance.
n. FDI Opportunities: Foreign Direct Investment (FDI) opportunities exist in the shipbuilding sector, with countries like China, Turkey, and the Netherlands expressing interest. Western countries are exploring new markets and imposing specific requirements, potentially benefiting Bangladesh and similar developing nations.
o. Small and Medium Shipbuilding: Bangladesh is well-suited for small and medium-sized shipbuilding and can target the market for 3,000-20,000 DWT multipurpose, container, tanker, and cargo ships, ensuring continued growth in these niche segments.
p. Recognized Potential: Government entities, investors, shipbuilders, ship owners, and stakeholders recognize shipbuilding as a promising sector and a viable alternative to resource-based industries in the near future.

These strengths and opportunities position Bangladesh favorably for growth and prominence in the global shipbuilding industry.

10. Present Challenges and Limitations of Local Shipbuilding.

Local shipbuilding holds immense potential for expansion and securing a small but noteworthy global market share. However, several distinct weaknesses must be acknowledged and transformed into strengths to foster growth in this sector. Bangladesh's shipbuilding industry has faced challenges stemming from a lack of effective government, stakeholder, and private sector initiatives, resulting in sluggish progress and a struggle to penetrate the international shipbuilding market. While cheap labor has traditionally been a key advantage, it alone cannot sustain the industry in an era where advanced technology can offer cost-saving benefits. Therefore, Bangladesh has the opportunity to make significant economic strides by nurturing and optimizing its export-oriented shipbuilding industry.

Entrepreneurs also express confidence in the bright prospects of the local shipbuilding industry, leveraging Bangladesh's rich maritime history, favorable geographic location, and the availability of cost-effective labor. Notably, ships produced in Bangladesh are often 10% to 30% less expensive than those manufactured in Japan, Korea, China, Vietnam, or India.

Yet, existing and potential weaknesses and challenges remain, including:

a. Technological Lag: Despite the availability of cheap labor, shipbuilders have been slow to adopt advanced technology. Additionally, a significant gap exists between industrial needs and the curriculum of the mass education system, necessitating a stronger focus on technical education.
b. Lack of Awareness and High Costs: Policymakers, bureaucrats, bankers, and other stakeholders often underestimate the potential of local shipbuilding. To stimulate progress in this sector, Bangladesh needs to prioritize shipbuilding similarly to Ready-Made Garments (RGM) and address high local bank interest rates and service charges. Furthermore, the industry's reliance on bank guarantees from foreign banks adds extra costs.
c. Family-Run Shipyards: Many private shipyards lack a corporate culture as they are managed by family members who occupy key positions. This creates an unhealthy work environment, leading to a disconnect between shipyard owners and employees. Dishonest practices and fraud also pose challenges.
d. Infrastructure and Location: Most local shipyards are situated around Dhaka, far from coastal areas, limiting the size of ships that can be produced. Weak infrastructure, energy shortages, limited land, and poor Ease of Doing Business (EODB) hinder rapid development.
e. Dependence on Imported Materials: Prime raw materials essential for shipbuilding, such as class-approved MS plates, frames, girders, stiffeners, and longitudinals, are imported. This dependence on foreign suppliers adds to costs.
f. Technical Expertise and Investment: The local shipbuilding industry lacks technical expertise in modern technology, which hampers its ability to meet the demands of the Fourth Industrial Revolution (4IR). Inefficiencies, limited technological, managerial, and labor skills, and a shortage of modern shipbuilding tools and machinery are prevalent. Bangladesh also relies on foreign support for ship design.
g. Banking Challenges: Local commercial banks require counter guarantees from foreign banks for shipbuilding, leading to additional costs. This limits competitiveness against rivals such as China, Korea, Japan, Vietnam, the Philippines, India, and Australia. Furthermore, a lack of required capital and sound investment hampers productivity expansion and export promotion.
h. Poor Management Practices: In many local shipyards, family members dominate management, alienating employees and fostering an unfriendly work environment. This leads to poor job satisfaction, motivation, and discipline, along with high absenteeism and turnover.
i. Limited Understanding and Support: Shipbuilding is not well understood by local investors and policymakers, resulting in lukewarm responses to investment proposals.

The banking support received by the shipbuilding sector is deemed insufficient, and the sector carries inherent business risks for entrepreneurs and bankers.

j. Technological Shortcomings: The technology employed in local shipbuilding remains rudimentary, lacking efficiency, technological advancement, managerial expertise, and skilled labor. The shortage of expert machine operators and digital/AI professionals is evident. Additionally, Bangladesh does not engage in ship design, creating dependency on foreign assistance.

k. Global Competition: Competition from other countries, such as Vietnam, the Philippines, Indonesia, India, and Brazil, also poses a threat to the local shipbuilding sector. The global market for new ships has a Compound Annual Growth Rate (CAGR) of approximately 4%, presenting challenges and risks for newcomers and investors.

l. Image Crisis and Investment Challenges: An image crisis and obstacles in Ease of Doing Business discourage Foreign Direct Investment (FDI) in shipbuilding. The performance of local export-oriented shipyards needs improvement, and ambassadors in foreign missions should play a more active role in promoting business opportunities. Addressing integrity issues and fostering a positive attitude toward heavy industries like shipbuilding is essential.

m. Economic Recession and Geopolitical Crisis: The world is currently experiencing an economic recession due to the post-COVID-19 situation and geopolitical crises, such as the Russia-Ukraine conflict. These factors have impacted global shipping and shipbuilding, leading to order cancellations and a slowdown in global business.

n. Draught Limitations: The limited draught in rivers (maximum 4m) constrains the size of ships that can be built in local shipyards. Maintaining navigable drafts in rivers and channels is challenging due to significant siltation, bridges, and overhead cables, further restricting ship sizes.

o. Import Challenges: Shipbuilding requires a vast array of machinery, equipment, components, spare parts, and accessories, leading to emergency imports during the construction process. Current import policies and foreign currency regulations create complications and delays in obtaining shipbuilding materials, hampering production and demoralizing foreign buyers.

p. Inadequate Training Facilities: Technical personnel in most local shipyards receive inadequate training, with some shipyard owners viewing human resource development programs as financial drains rather than investments. Moreover, there is a lack of mechanisms for formulating, implementing, monitoring, and updating export-oriented shipbuilding policies and strategies.

Addressing these challenges and transforming them into strengths is essential for the sustainable growth and competitiveness of Bangladesh's shipbuilding sector.

11. Suitable Shipbuilding Market for Bangladesh.

The productivity of local shipbuilding labor is low, despite the world's most affordable hourly wage. To maximize the benefits of the government's shipbuilding policy, equitable prioritization is essential for public and private shipyards.

China, previously offering lower shipbuilding costs, is experiencing rising labor wages. This presents an opportunity for small shipbuilding nations like Bangladesh, as the demand for container ships remains high in various sizes.

Historically, high labor costs led high-income countries to lose global shipbuilding market share. Today, relying solely on cheap labor is insufficient; advanced technology is crucial for sustainable shipbuilding.

The global shipbuilding market was valued at USD 132.52 billion in 2021, with a projected CAGR of 4.84% to reach USD 175.98 billion by 2027. COVID-19 disruptions and delays may impact growth initially, but factors like increasing seaborne trade, economic growth, and automation will contribute to industry growth.

Figure 3: Prediction of global shipbuilding growth by region from 2022 to 2027.

Source: Mordor Intelligence, 2022.

The global shipbuilding market's tentative size is approximately USD 200 billion, with a USD 20 billion small shipbuilding market. The demand for small to medium-sized merchant ships, including container ships, tankers, cargo vessels, and special ship types with 3,000-10,000 DWT, aligns well with local shipyards' capabilities.

Bangladesh's strategic sea area is crucial for connectivity and economic interests. The presence of the Bangladesh Navy and Bangladesh Coast Guard creates a market niche suitable for publicly-operated BN shipyards.

12. Future Challenges and Viable Suggestions for Local Shipbuilding.

Local shipbuilding has significant potential but faces challenges, including slow technological development and a lack of awareness among stakeholders. The workforce often lacks job satisfaction and industrial benefits, leading to a high turnover rate.

Most shipyards are located far from the coast, limiting ship size, and rely on imported materials. An image crisis, high bank interest rates, and service charges hinder development. Family-oriented management cultures and resistance to quality improvements are common issues.

Addressing these challenges and embracing technology, especially in the context of the Fourth Industrial Revolution (4IR), is essential. The maritime industry is evolving with AI, IoT, and automation. Preparing for the 4IR requires policy alignment, skill development, attitude changes, and adapting to new work styles.

The 4IR will revolutionize industries through digitization and technologies like AI, IoT, and 3D printing (Wikipedia, 2022). Creating intelligent shipyards with resource efficiency and stakeholder integration is a goal for the maritime industry.

Conclusions.

Local private shipyards lack a corporate culture as they are predominantly managed by family members who occupy all key and top positions, creating an unhealthy business environment. These shipyards are driven by the desires and aspirations of their owners, which often results in employees feeling disconnected from the organization. The technology employed in local shipbuilding remains rudimentary, characterized by inefficiencies and deficiencies in technological, managerial, and labor skills. Most local shipyards lack modern shipbuilding tools and machinery, and there is a shortage of expert machine and digital/AI operators. Furthermore, Bangladesh relies on foreign support for ship design expertise and lacks the technical capabilities to meet the demands of the incoming Fourth Industrial Revolution (4IR), posing a significant obstacle to sustainable development.

The government has drafted a shipbuilding policy, but it needs careful evaluation and uniform prioritization. Foreign Direct Investment (FDI) opportunities exist, and establishing an export shipyard zone could boost the industry.

Bangladesh is well-suited for small to medium-sized ships from 3,000 to 10,000 DWT, offering competitive pricing.

The shipbuilding sector has potential but needs comprehensive government and private sector initiatives to enter the international market effectively. Bangladeshi-made ships are cost-competitive, and FDI opportunities can be harnessed through export shipyard zones. Achieving 2% of the global market share by 2030, worth USD 4 billion, is possible.

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Biplot-Cluster Analysis on Mapping Company Characteristics in Adapting to a Dynamic Bussines Environment

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ABSTRACT

This study aims to map companies at PT M Cash Integrasi Tbk based on the variables of *Technological Innovation, Knowledge Management, Dynamic Capability, Organizational Agility,* and *Sustainable Competitive Advantage*. This study uses the biplot analysis method and *the K-Means cluster.* The biplot method and *K-Means cluster analysis were* used to map companies in a two-dimensional graph. The data used in the result of a survey from the sample unit in the study, namely the organization and in the form of a holding company, subsidiary, and branch company PT M Cash Integration Tbk as many as 130 companies. Based on the relationship between variables, *dynamic capability* (Y_1) and *organizational agility* (Y_2) with *sustainable competitive advantage* (Y_3) have a strong positive relationship. based on the results of *the K-Means cluster* analysis, there are three *clusters* with 51 companies in *cluster* 1 having good characteristics in adapting to a dynamic business environment. Mapping of companies based on the 5.0 industrial revolution involving *Technological Innovation, Knowledge Management, Dynamic Capability, Organizational Agility,* and *Sustainable Competitive Advantage variables* simultaneously is *the novelty* of this research.

1. Introduction.

People who live by utilizing numerous breakthroughs that were created in the era of the industrial revolution 4.0, such as the Internet of Things, Artificial Intelligence, and Big Data, are among the characteristics of the 5.0 industrial revolution, according to a quote from campus.quipper.com. The existence of these three components has made it easier for everyone to access the internet anywhere and anytime. The industrial revolution 5.0 requires companies to create new value through the power of technological developments that are all digital accurately and quickly (Asriandi & Putri, 2020). The world that has been hit by the Covid-19 outbreak in recent times has also provided stimulus for the use of digitalization in every sector of life.

The shift from manual systems to digitalization has resulted in the use of information technology being significant in all industries. This creates a highly volatile, dynamic, complex, and uncertain business environment that companies face today, causing hypercompetitive markets and posing a major threat to the survival of the company (Nurcholis, 2021). On the other hand, a dynamic economic environment cannot guarantee the achievement of a company's *Sustainable Competitive Advantage* (SCA).

Organizational agility is one of the main competencies that need to be possessed by an organization that experiences continuous changes in the business environment and high competitive pressures (Panda & Rath, 2016). A company's agility in collecting, monitoring, and processing changing environmental signals, making innovative decisions, and adapting processes

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quickly to take advantage of market opportunities can increase its *Sustainable Competitive Advantage* (Bi *et al.,* 2013).

Companies that want to be *sustainable,* must not only have agility in business competition but also must have the ability to move dynamically or *dynamic capability*. According to (Grant, 1996), a *dynamic capability* is a routine corporate activity and strategy in which managers modify their resource base to acquire and release resources integrate and recombine to create new added value. Companies need to develop and implement *dynamic capabilities* to maintain a *Sustainable Competitive Advantage* in a changing and complex external environment (Ambrosini & Bowman, 2009).

According to (Nonaka, 1991), the only lasting *competitive advantage is knowledge.* Knowledge resources are significant to ensure that the company has a *sustainable competitive advantage* because these resources are difficult to imitate and are the basis for sustainable differentiation (Wiklund & Shepherd, 2003). Santoro *et.al* (2019) state that knowledge management helps manage knowledge for exploratory and exploitative processes, which in turn is very important for developing new products and services. The results of the literature identification conducted by Shehaba (2020) also show that the correlation between *knowledge management* and *sustainable competitive advantage* is very positive which will ultimately lead to an increase in organizational performance.

Companies that want a *sustainable competitive advantage* must pay attention to the development of *technological innovation*. Xiao & Yu (2020) show that companies need *technological innovation* to achieve and maintain a *sustainable competitive advantage*. This is because, in an uncertain business environment, *technological innovation* allows companies to become industry leaders and seize market advantages easily (Zhang *et al.,* 2019).

Based on this description, it can be seen the need for a company to have the ability to adapt, especially technology companies. Apart from the necessity for technology companies to have the concepts of innovation, knowledge, dynamics, and agility, there is something unique about technology companies. Where, so far the giant companies that have gone bankrupt are mostly technology companies, such as Nokia, Kodak, Blackberry, Myspace, and Pebble. The events experienced by these companies are very strange because the basis of their business activities is a technological innovation that should move dynamically and agilely, but in the end, it must disappear from the business cycle due to technological advances.

This study aims to map a company based on the 5.0 industrial revolution, namely PT M Cash Integrasi Tbk based on the variables of *Technological Innovation, Knowledge Management, Dynamic Capability, Organizational Agility,* and *Sustainable Competitive Advantage. This research is expected to be useful as input in determining companies that* can adapt to a dynamic environment.

2. Literature Review.

2.1. Strategic Management Theory.

Strategic management is described by Jauch & Glueck (1998) as the progression of choices and actions that result in the creation of a successful strategy or strategies to aid in achieving business objectives. The strategic management process is how strategic planners define objectives and draw strategic conclusions. Meanwhile Pearce & Robinson (2014), it is stated that strategic management is large-scale and long-term planning so that organizations can interact effectively in production and optimize the achievement of both strategic and operational goals.

The two main concepts of strategy making and strategy implementation can be used to summarize the strategic management process. The strategy-making and strategy-execution process, according to Thompson & Strickland (1990), is divided into five connected and integrated phases:

1. Create a strategic vision for the company's future that identifies its future product, market, and customer technology priorities. Set goals and use them as benchmarks to measure company performance and progress.
2. Develop strategies to achieve goals and move the company along the strategic path that has been mapped out by management.
3. Effectively and efficiently carry out the selected course of action.
4. Assess performance and begin making corrections to the organization's long-term objectives, strategy, or execution in light of actual experiences, shifting circumstances, fresh perspectives, and new opportunities.

2.2. Resource-Based View (RBV) Theory.

Internal resources that can support a company's Sustainable Competitive Advantage are described by the Resource-Based View (RBV) (SCA). The main argument is that in order for a corporation to qualify for SCA status, it must acquire and possess valuable, rare, unique, and non-replaceable (VRIN) resources and capabilities, as well as have an organization (O) in place that can utilize them (Barney, 1991). The definition of a resource is one of the primary issues that RBV theorists must deal with. Corporate resources have been discussed by RBV researchers and practitioners using a range of words, such as competence (Hamel & Prahalad, 1990), skills (Grant, 1996), strategic assets (Hamel & Prahalad, 1990), assets, and shares (Capron & Hulland, 1999).

The underlying premise of this theory is that firms can maintain a competitive edge by implementing strategies that take use of their internal assets, react to environmental opportunities, counteract external threats, and prevent internal flaws. Barney (1991) provides a critical review of existing approaches since *strategic management* was introduced as a separate discipline outside the economic domain. The majority of research on sources of sustainable competitive advantage has concentrated on identifying the firm's opportunities and threats (Porter, 1980; & Porter & Millar, 1985), highlighting its strengths and weaknesses (Penrose, 1958; & Stinchcombe, 1965), and/or examining how these factors interact to determine a strategy.

The emergence of RBV in the discipline of *strategic management* which is rooted in the approach of evolutionary economic theories has developed a more integrative approach by involving many behavioral approaches, sociology which has implications for the emergence of new concepts as the development of the *strategic management discipline*. As stated by Barney & Clark (2007) and Barney & Hesterly (2009), responding to the 10 years since the article and introduction of the RBV theory were written and published, companies tend to build their strategies on intangible assets outperforming companies that build their strategies on tangible assets only. This is because RBV assumes that companies exploit their valuable, rare, and expensive resources to imitate resources and capabilities in generating optimum value from *the rent economy*.

2.3. Knowledge-Based View Theory (KBV).

Knowledge-Based View (KBV) theory emerges from RBV theory by focusing on intangible resources, not on physical assets. According to this viewpoint, knowledge is the most valuable resource, and performance discrepancies are mostly caused by the varied knowledge bases held by different firms (De Carolis, D. M. & Deeds, 1999). By arguing that knowledge is the key resource behind new value creation, heterogeneity, and competitive advantage, KBV in strategy has considerably enlarged resource-based reasoning (Grant, 1996; Barney, 1991; Kogut & Zander, 1992). Knowledge is the most crucial strategic asset in KBV's opinion (De Carolis & Deeds, 1999).

Due to its difficulty in imitation and position as the foundation for long-term difference, knowledge resources play a significant role in providing a sustained competitive advantage (Wanasida *et al.,* 2021). The only competitive advantage that endures, according to Nonaka (1991), is knowledge. The primary determinants of firm performance may include elements like management skills and competencies, technological expertise, or organizational routines (Dess *et al.,* 1995). It will contribute more to the company's performance than property-based resources in a dynamic economy where many businesses use knowledge-based resources (Miller & Shamsie, 1996).

According to current strategic management literature, intangible elements are typically linked to variances in firm performance to determine competitive advantage (Rouse & Daellenbach, 2002). Due to their scarcity, social complexity, and near non-imitation, intangible resources, in contrast to monopolies on raw resources, have a higher likelihood of creating a competitive advantage (Hitt *et al.,* 2001). According to Grant (1996) and Volberda (1996), a stronger knowledge base can lead to more strategic flexibility and quicker responses to environmental changes (Umemoto, 2002).

2.4. Technological Innovation.

The act of mixing and rearranging knowledge to produce fresh concepts is known as technological innovation. Companies that innovate drastically typically confront a lot of uncertainty. According to Mumford (2000), businesses that put an excessive amount of emphasis on results will exhibit little technical innovation. In the meantime, emphasizing innovation outcomes too much might cause managers and staff to focus on the dangers of failure and the loss of their interests, leading them to drop higher-risk innovations. According to Mehr & Shaver (1996) , there is no correlation between innovation and particular performance targets. Managers and staff, however, won't be concerned about losing economic significance and social acceptance as a result of the failure of technical innovation if they use process assessment and control. They will therefore be eager to engage in technological innovation activities.

Organizational architecture and work systems must encourage technological innovation. Madsen *et.al* (2005) analyze actual cases of new company growth at Ericsson Denmark indepth in order to explore issues with the process of merging technology innovation with human resources. This study represents radical innovations based on disruptive internet technologies and explores all stages and facets of the innovation process, from conception to field trials. This integration is referred to as dysfunctional. It demonstrates that new enterprises are doomed to failure when inventive human resources are not properly incorporated into the host organization's procedures. In order to respond to the changing demands in entrepreneurship and technological innovation, organizational systems must be reformed.

Particularly, efforts for technological innovation may result in discontinuities that either bolster or undermine the current competency base (Bessant & Tidd, 2009). To adapt to the external environment and changes, such as new markets or new technical discontinuities, businesses must constantly modify their internal and external strategic competences and business models, in accordance with the principle of "dynamic capabilities" (Schilling, 2010 & Teece, 1997). Developing internal requires relying on fundamental competencies (Prahalad & Hamel, 1990).

2.5. Knowledge Management.

Understanding *knowledge management* is a management system that is sourced from the knowledge presented by the company and intelligence assets that function to improve the characteristics of the company's performance and can provide additional value if the company applies intelligently in business processes (Khan & Quadri, 2012). Wiig (1997) and Desouza & Paquette (2011) explain that *knowledge management* is understanding, focusing, and managing the development, updating, and application of systematic, explicit, and deliberate knowledge that is, managing an effective knowledge process. Meanwhile, according to McElroy (2000), *knowledge management* is getting the right information in front of the right people at the right time. Based on some of the definitions above, it can be concluded that *knowledge management* is an effective knowledge system that is applied to the management of an organization/company so that it can be useful for improving the characteristics of an organization's/company's performance at the right time.

There are 2 (two) types of *knowledge management,* namely *tacit knowledge,* and *explicit knowledge.* T*acit knowledge* is personal, developed through experience that is difficult to formulate and communicate. According to its concept, tacit knowledge is classified as personal knowledge, or knowledge acquired from people (individuals). Conversely, explicit information is structured and methodical and is simple to transmit (Carrillo et al., 2004). The knowledge acquired is in written form or a documented statement so that each employee can learn it independently, making the application of explicit knowledge simpler.

2.6. Dynamic Capability.

The process of attaining new resource configurations as markets form, collide, divide, evolve, and perish is known as dynamic capability (Capron & Hulland, 1999). In industries where cutting-edge information is required for effective strategy and performance, dynamic capacity comprises knowledge creation processes where managers and others develop new ideas within the firm (Hampshire & Policy, 2013). This includes joint ventures and acquisition strategies that attract fresh assets from outside the organization. A very efficient approach for acquiring information that allows managers to amass a variety of evolving product and engineering expertise and improve performance. *Dynamic capability* produces capabilities that do not wait for a crisis from the external environment because an organization's *dynamic capability* is a form of the process of integrating resources, reconfiguring, acquiring, and releasing resources (Kor & Mesko, 2013).

Based on Teece' (1997) research, state that three things are needed to form *dynamic capability*, namely *paths dependence, positions,* and *processes*. There are several assumptions in the development of *dynamic capability*, namely first, the *nature* that emphasizes capability. Second, the *role* means the ability to integrate external and internal factors. Third, *context* means focusing on rapid environmental changes. Fourth, is *creation and development*, which means that many things are developed rather than purchased. Fifth is *heterogeneity* which means that each organization has different resources. And lastly, the *outcome* means that each company has a different performance because of the difference in their *dynamic capability*.

2.7. Organizational Agility.

Organizational agility began to be developed in the 1990s as a solution to dealing with changes in the market environment that continues to grow and is dynamic. *Agility* is the ability to survive and continue to grow in a competitive environment with continuous and unpredictable changes. These changes can be overcome by quick and effective reactions that are driven by products or services based on consumer needs [58] (Gunasekaran in Nafei, 2016). Meanwhile, according to Zitkiene & Deksnys (2018), *organizational agility* continues to grow significantly in ways to obtain and maintain the *competitive advantage* that the organization has in a changing market environment. *Agility* is one of the main characteristics of organizations used by companies to continue to adapt and compete in a fluctuating environment.

When it comes to the flexibility and adaptability attained via organizational activities, organizational agility can be defined as the key component of organizational performance. Organizational agility is a collection of practices that enable an organization to recognize change and react rapidly, effectively, and economically to both the external and internal environment. *Sensing* in question is the organization's ability to capture, detect, and interpret opportunities owned by the organization (Seo & Paz, 2008). Meanwhile, the *response* is the organization's ability to mobilize and change existing resources to respond to the emergence of perceived opportunities (Oosterhout et al., 2006). These two capabilities must go hand in hand to achieve optimal *organizational agility*.

2.8. Sustainable Competitive Advantage.

According to Besanko & Régibeau (2000), a company can be said to have a *competitive advantage,* if the level of economic income is higher than other companies engaged in the same field or producing the same goods. *Competitive advantage* is the company's ability to generate economic value that exceeds its competitors (Barney & Hesterly, 2009). Meanwhile, according to Stevenson (2009), *competitive advantage* can be measured based on the company's success in utilizing its resources to meet consumer needs compared to its competitors.

The current high level of global competition makes achieving and maintaining a *sustainable competitive advantage* one of the main focuses for many companies in the last few decades. Barney (1991) states that a company is considered to have a *competitive advantage* when the company implements a strategy that can create value for them and has never been used by its competitors. So that the company gets the maximum benefit from a *sustainable competitive advantage when other companies cannot use the same strategy.* According to Barney (1991), *competitive advantage* is divided into two types, namely sustainable and temporary. Many companies only get a temporary competitive advantage, because *the competitive advantage* they have is only an advantage in the company's income, the ups, and downs of which can be influenced by many factors.

The method to obtain a *sustainable competitive advantage* is to consider the perspectives of consumers and competitors. In addition, core competencies can determine the outcome of a *sustainable competitive advantage* and companies need to utilize their resources and capabilities so that they can adapt to changing opportunities. Barney (1991), the establishment of a *sustainable competitive advantage* can be based on four indicators, namely, the value of scarcity, which cannot be imitated, is expensive to imitate, and is irreplaceable.

2.9. Biplot Analysis.

The biplot is a multivariate analog of the *scatterplot*. The biplot estimates the multivariate distribution of the sample in several dimensions and places it on the display representing the variable that the sample measures. In this way, the relationship between the individual sample points can be seen easily and as we shall see, the biplot can also be associated with the measurement values. Thus, like the *scatterplot*, the biplot is useful for providing graphical descriptions of data, detecting patterns, and for displaying results found by more formal analytical methods (Gower & Hand, 1995).

Mathematically, a biplot can be thought of as a graphical representation of matrix multiplication. Given a matrix G with m rows and r columns, and a matrix E with r rows and n columns, they can be multiplied to give matrix P as the third matrix with m rows and n columns. If r = 2, then the matrix G can be represented as m points in a two-dimensional plot, with column 1 being the abscissa (x-axis) and column 2 being the ordinate (y-axis). Similarly, the matrix E can be represented as n points in a two-dimensional plot, with the first row being the abscissa and the second row being the ordinate. A two-dimensional biplot is formed if the two plots are superimposed, which will contain m + n points. An interesting property of this biplot is that it not only displays matrices G and E but also implicitly displays the mxn values of matrix P since each element of P can be visualized as:

$$P_{ij} = X_i X_j^{'} + Y_i Y_j^{;} = \vec{g}_i \vec{e}_j \quad (1)$$

Where (xi, yi) are the coordinates for row i and (x/j, y/j) are the coordinates for column j. $\vec{g}_i$ is a vector for row i and $\vec{e}_j$ a vector for column j. These equations are the basis for visualizing patterns in matrix P, including row rankings relative to any column, column rankings relative to each row, comparing any two rows relative to each column, and identifying the row with the largest (or smallest) value for each column. , or vice versa (Yan & Tinker, 2006).

2.10. Cluster Analysis.

A statistical study known as cluster analysis is used to categorize objects or variables. Each produced object or variable, according to Hair et al. (2010), has nearby properties and traits. Several respondents (individuals or organizations) are divided into groups (clusters) using cluster analysis based on the similarity of some stated attributes.

Using cluster analysis, items are categorized according to how similar their traits are. Consequently, the following traits of a good cluster include:

1. Internal homogeneity (inside clusters); this refers to how similar cluster members are to one another.
2. External heterogeneity, or the distinction between one cluster and another cluster (between clusters).

In cluster analysis, segmentation techniques include:

1. Hierarchical Method; Begin segmenting the objects that are most similar to one another. the cluster will eventually take the form of a kind of "tree" with a distinct level (hierarchy) between objects, going from the most similar to the least similar. "Dendrograms" are tools that aid in the clarification of this hierarchical process.
2. Non-Hierarchical Method; the desired number of clusters is first decided upon in advance (two, three, or the other). Following the determination of the number of clusters, the clustering procedure is carried out without adhering to the hierarchical approach. The term "K-Means Cluster" is a common name for this technique. If K-means cluster is used to group a lot of objects, it is very effective and efficient. When there are more than 100 objects, K-means clustering is employed.
3. Hybrid approach: The hybrid approach combines hierarchical and non-hierarchical approaches, utilizing the advantages of each to choose the optimum cluster.

3. Methodology.

The K-Means cluster and the biplot analysis technique are both used in this study. A plot of observations for both n and p variables are shown simultaneously in a two-dimensional plane using the multiple-variable technique known as biplot analysis. Plots of data for n and p variables presented simultaneously can reveal more details about the relationship between the variables and the observations (Jollife, 2002).

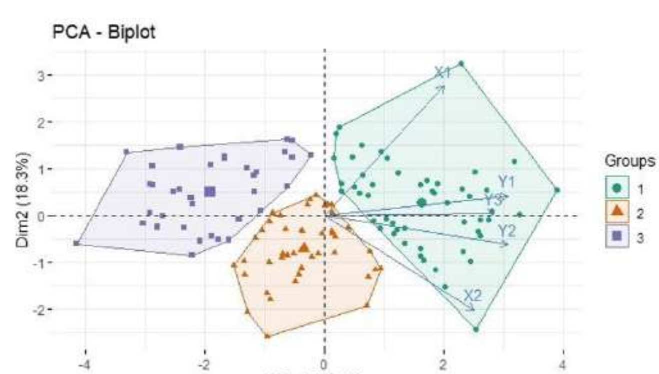
Cluster analysis K-Means, according to (Ediyanto & Satyahadewi, 2013), is a non-hierarchical cluster analysis method that attempts to divide existing objects into one or more clusters or groups of objects based on their characteristics, so that objects with the same characteristics are grouped into the same cluster and objects with different characteristics are grouped into another cluster.

Biplot method and *K-Means cluster analysis were* used to map companies and variables of *technological innovation* (X_1), *knowledge management* (X_2), *dynamic capability* (Y_1), *organizational agility* (Y_2), and *sustainable competitive advantage* (Y_3) together in a two-dimensional graph. This mapping includes the diversity and correlation between variables to the identification of grouping objects based on the results of *cluster analysis.* The data used is the result of a survey from the sample unit in the study, namely the organization and in the form of a holding company, subsidiary, and branch company of PT M Cash Integrasi Tbk as many as 130 companiesThe text must be concise, clear, complete and precise. The text as a whole must be in the impersonal form.

4. Result and Discussion.

The following biplot graph and *clustering results* that show the mapping of the company's characteristics in adapting to a dynamic business environment are presented in Figure 1.

Figure 1: Biplot and Cluster Graph.



Source: Authors.

Figure 1 shows that the value of data diversity that can be described from dimensions one and two in the biplot-cluster *analysis display* is 73.7%. This can be interpreted that the results of the analysis providing information of 73.7% of the total available information. The value of the diversity of the data is quite large because it is greater than 70% so the biplot-*cluster approach* can provide a visual presentation of the data matrix of the company's characteristics in adapting to a dynamic business environment.

The biplot displayed in Figure 1 also shows the correlation between variables. This is indicated by the large angle formed between variables, where the smaller the angle formed, the greater the relationship between the variables. It can be seen that the *dynamic capability* variable (Y_1) with *sustainable competitive advantage* (Y_3) and the *organizational agility* variable (Y_2) with *sustainable competitive advantage* (Y_3) each form a very small angle so that it has a strong positive relationship. This shows that the higher the *dynamic capability* and *organizational agility*, the higher the *sustainable competitive advantage.* Then the relationship between *dynamic capability* and *organizational agility* is also strong because the angle formed is also very small. In addition, it can be seen that the angle formed between *technological innovation* (X_1) and *dynamic capability* (Y_1) is smaller than that of *technological innovation* (X_1) with *organizational agility* (Y_2) and *sustainable competitive advantage* (Y_3), which means the relationship between positive *technological innovation* with *dynamic capability* is greater than its relationship with *organizational agility* and *sustainable competitive advantage*. Meanwhile, *knowledge management* (X_2) has a greater relationship with organizational *agility* (Y_2) than its relationship with *dynamic capability* and *sustainable competitive advantage.*

K-Means cluster analysis is performed on each object against all vector variables in the resulting biplot display. In each *cluster* that is formed, there is a characterizing variable or the most dominant variable. Characteristic variables can be seen based on the length of the vector of the variable which is longer than the vector formed by other variables in the same *cluster*. Based on Figure 1, *dynamic capability* (Y_1) is a characterizing variable from *cluster* 1. This means that companies in *cluster* 1 tend to have better characteristics in terms of *dynamic capability.* The characteristics of the three *clusters* formed from 130 companies in the biplot analysis can be presented based on the average value of each variable in Table 1.

Table 1: Cluster Characteristics.

Cluster	X_1	X_2	Y1	Y2	Y_3
Cluster 1	3.8660	3.6499	3.8621	3.8519	3.7663
Cluster 2	3.1212	3.5676	3,4134	3.4571	3.4238
Cluster 3	3.3571	3.1709	3.1302	3.0159	3.1304

Source: Authors.

Based on Table 1, *cluster* 1 can be stated as the best *cluster* in terms of the mean of the variables. This shows that 51 companies in *cluster* 1 have good characteristics in adapting to a dynamic business environment. Then *cluster* 2 with 44 companies tends to have sufficient adaptability characteristics and *cluster* 3 with 35 companies tend to have poor characteristics in adapting to a dynamic business environment.

Conclusions.

The results obtained that the diversity of data that can be described from mapping and grouping biplot-cluster *analysis is* 73.7%. This means that the biplot-cluster *approach* can provide a visual presentation of the data matrix of the company's characteristics in adapting to a dynamic business environment. Based on the relationship between variables, *dynamic capability* (Y_1) and *organizational agility* (Y_2) with *sustainable competitive advantage* (Y_3) have a strong positive relationship. In addition, *dynamic capability* and *organizational agility* also have a strong positive relationship due to the small angle formed between the variable vectors. Based on the results of *the K-Means cluster analysis,* there are three *clusters* with 51 companies in *cluster* 1 having good characteristics in adapting to a dynamic business environment. This is clarified by the characterizing variable in *cluster* 1, namely dynamic *capability* (Y_1) which means that companies in *cluster* 1 tend to have better characteristics in terms of *dynamic capability.*

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The Effect of Human Resource Practice on The Competitive Advantage: A Case Study on Aqaba Port

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ABSTRACT

This research aims is threefold. First, to investigate the total impact of HRM practices on the competitive advantage . Second, to explore the impact of HRM practices, i.e., knowledge of business, delivery of human resources and management of change on the competitive advantage . Third, to examine the impact of HRM practices an entire construct on the dimensions of the competitive advantage , i.e., positive value, rareness, imitability, and organization.
A descriptive analytical research method was adopted for the sake of the current study. A questionnaire was distributed to a sample of 195managers, from which a total of 187 complete questionnaires were returned to be analyzed via IBM SPSS and AMOS.
The results revealed that HRM practices had a significant effect on the competitive advantage . Particularly, knowledge of business, delivery of human resources and management of change as dimensions of HRM used in the current study had significant effects on the competitive advantage . Moreover, HRM practices as an entire construct was found to exert significant effect on all dimensions of the competitive advantage.

1. Introduction.

Organizational resources, in general, cover several aspects such as organizational assets, processes, attributes, knowledge and capabilities. These resources are categorized into three types: physical capital, human capital and organizational capital resources (Barney, 1991). Organizational resources are potential sources of firm'ssustainable competitive advantage (the competitive advantage), particularly human resources (Kazlauskaitė and Bučiūnienė, 2008). The focus of the current study is on firm's human resource factors, with the aim of exploring the influence of these resources on firm's COMPETITIVE ADVANTAGE. Human resource factors encompass several factors, e.g., employee commitment, reward systems, team work and top management support (Daily and Huang, 2001).

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In searching for organizational resources that contribute to COMPETITIVE ADVANTAGE, scholars conducted numerous studies and found many results. Representative examples of organizational resources that identified by scholars as sources of COMPETITIVE ADVANTAGE cover human resources (Barney, 1991), knowledge management (Mahdi et al., 2019), intellectual capital management practices (Tonial et al., 2019), employee engagement (Albrecht et al., 2015), organizational knowledge (Narasimha, 2000), workplace branding (Love and Singh, 2011) and human resource management practices (HRMP) such as training (Stavrou et al., 2004).

Ordóñez de Pablos and Lytras (2008) indicated that organizations can integrate organizational flexibility and strategic fit, as strategic goals, through HRM in order to develop a sustainable competitive advantage. Tan and Nasurdin (2011) confirmed that human resource as one of the firm's most valuable resources enables it to achieve a competitive advantage. In this context,Barney and Wright (1998) identified employee skills, commitment, culture and teamwork as significant sources of sustainable competitive advantage. Collins and Clark (2003) examined the role of human resource practices in creating firm competitive advantage and indicated that human resource practices are positively related to firm performance, particularly those valuable practices for a competitive advantage. Wright et al. (1994) revealed that human resources are key source of sustainable competitive advantage.

2. The Problem of Study.

The problem of the study lies in identifying the impact of human capital on achieving the competitive advantage in the port of Aqaba, and the degree of its application and effectiveness in achieving the competitive advantage of the ports, due to the discrepancy in the results of previous studies and the lack of previous studies that studied linking the competitive advantage to human resources. The Port, which is situated in the town of Aqaba, aims to advance maritime shipping through the nation's port of Aqaba by, among other things, mobilising business concepts and skills in public and private sector partnerships, offering top-notch services, collaborating with the government to develop an inviting business environment for ship owners, operators, and charterers, and encouraging its employees to uphold the highest ethical standards.

2.1. Importance of Studying.

The importance of the study is crystallized through the vital role played by the human element in the ports, which is the real key.

In achieving the success of any public institution, we will address in this first part of the research the different definitions that have been assigned to the competitive advantage, then we will proceed to determine its types and criteria for judging its quality, and finally we will reach the different sources of this advantage and its different relationship to human resource development as a basic input with an essential relationship in Achieving the competitive advantage of Aqaba port.

2.2. Objectives of the study.

In the light of defining the problem of the study and its importance, the main objective of the study is to diagnose and analyze the relationship of correlation and influence between training human resources and achieving competitive advantage, and to indicate the contents and limits of this relationship at the level of ports. In general, a set of goals that the current study seeks to achieve can be indicated:

1. Statement of the importance of training programs in improving the efficiency of personnel working in ports.
2. Clarifying the most important dimensions of the competitive advantage that the ports seek to achieve.
3. Statement of the correlation and impact relationship between the training program and the competitive advantage in the ports.

2.3. Questions Study.

The main question of the study is:-

What is The effect of human resource practice on the competitive advantage : A case of Aqaba port? "

A group of the following sub-questions branch out from this question:

- What is the philosophical framework for human resources?.
- What is the philosophical framework for the competitive advantage.
- What is the effect of human resource practice on the competitive advantage.

2.4. Study Methods.

In order to answer the research problem and prove the validity of the hypotheses, the analytical descriptive approach was relied on with regard to the theoretical side as it is suitable for collecting facts and defining various concepts related to the subject, and analyzing them with the aim of developing explanations and coming up with results, while the case study approach was followed with regard to the field side in order to find **The effect of human resource practice on the competitive advantage on Aqaba port**.

2.4.1. Hypotheses.

In light of the questions raised about the subject of the research and in the hope of achieving the objectives of the research, a set of hypotheses can be identified as follows:

The main hypothesis: There is a significant effect between **human resource practice** and achieving the competitive advantage of **port** at the level of significance $\alpha \leq 0.05$.

- H1: HRM practices significantly influence the competitive advantage -value.
- H2: HRM practices significantly influence the competitive advantage -rareness.
- H3: HRM practices significantly influence the competitive advantage -imitability.
- H4: HRM practices significantly influence the competitive advantage -organization.

2.4.2. Limitation.

Spatial boundaries: The current research included **Aqaba port**.

Time limits: 2023.

The duration of preparing the research in practice in the studied **Aqaba port**, which included the duration of the initial visits to diagnose the research problem, the duration of obtaining the data necessary for the research, and a distribution period. questionnaire".

Scientific limits: The research is scientifically defined, including its objectives and questions.

2.5. Several scientific sources.

The researcher reviewed a set of literature from books, periodicals, master's theses, doctoral theses, and research in the field of the competitive advantage , **human resource practice** and areas related to the topic of research, information (internet, It contributes to building the theoretical framework of the research due to the abundance of data and information it provides).

- **Individual interviews:** Several personal interviews were done with branch managers, their assistants, and workers of the investigated **Aqaba port** in order to explain what was written in the questionnaire list and to answer their questions about some of the variables contained within.

- **Questionnaire:** The questionnaire is the main source for collecting data and information approved in the research, as it consisted of (21) sentences that covered the two main research variables (the competitive advantage, **human resource practice**).

Community: The **Aqaba port** were chosen to be the sample population in this study.

There are many assurances from the General Administration of **Aqaba port** that it is necessary to listen to customers' opinions. The employees were selected from the director, assistant director, chief observers, foremen, and treasurers out of 177 out of 152. We obtained the sample size from using the sample size table for researchers.

Accordingly, the sample size should be 109 < n, Therefore, the sample was chosen randomly. and the sample size became 117, which is an appropriate number for the required number.

First: The Independent Variable (the philosophical framework for human resources):

A: The concept of human resources:

Human resources (HR) is the department within a business that is responsible for all things worker-related. That includes recruiting, vetting, selecting, hiring, onboarding, training, promoting, paying, and firing employees and independent contractors. HR is also the department that stays on top of new legislation guiding how workers need to be treated during the hiring, working, and firing process (Kalra, 1997).

HR is considered by many business strategists to be the most important of all port resources. That's because employees can gain new skills, thereby increasing the size of a port's competitive advantage over time. Other resources simply don't have that capacity (Khan,, Khan & Mahmood, 2012).

HR Management Important to All Managers? Managers don't want to make personnel mistakes, such as hiring the wrong person, having their port taken to court because of discriminatory actions, or committing unfair labor practices. HRM can improve profits and performance by hiring the right people and motivating them appropriately. It is also possible you may spend some time as an HR Manager, so being familiar with this material is important.

B: The four types of human resources.

- Recruitment and Selection.

- Training and Development.

- Compensation and Benefits.

- Employee Relations and Engagement.

C: Purpose, Benefits and Importance of HRD.

Haslinda-a (2009) expressed that behind the theoretical debates concerning the nature of HRD, there is a set argument pertaining to purpose of HRD. The purposes of HRD are said to influence the nature and extent of HRD activities being implemented. The purposes of HRD are centered on learning and performance perspectives, both benefiting the individual and the interests of shareholders. In a wider perspective, the purposes center on economic benefits, social benefits and the ethics of HRD. These points indirectly suggest that a reconciliation of the purposes of HRD centrally focus on training, development and learning within organizations for individual development to achieve business strategies and for the development of organizational competence. Yussof and Kasim (2003) revealed that the role of HRD is crucial, in promoting and sustaining growth and, HRD, in particular education and training, contributes significantly to economic development in terms of increased worker productivity and income. The economy becomes more productive, innovative and competitive through the existence of more skilled human capability. he asserted that organizations have been created by humankind and can soar or crumble, and HRD is intricately connected to the fate of any organization. Human expertise is developed and maximized through HRD processes and should be applied for the mutual long-term and/or short-term benefits of the sponsoring organization and the individuals involved According to Rao, (1995) human resource development holds the key for economic development by enabling people to become more productive, because economic development depends upon level of industrial activity of production, which onward depends upon the productivity of human resource.

Second: The Independent Variable (competitive advantage):

A: The concept of competitive advantage: Organizational capability to perform in one or many ways that competitors find difficult to imitate now and in the future (Abou-Moghli, Al Abdallah & Al Muala, 2021, p3).

B: dimensions of competitive advantage: There are several dimensions of competitive advantage, the first of which are:

1) cost reduction: it means the organization's ability to design, manufacture, and market products at the lowest cost compared to its competitors (Aquilano et a, 1996).

2) The second dimension, which is innovation, renovation and creation, which is the reshaping or re-work of new ideas to come in a new way, and it is done by reaching a solution to a specific problem, or to a new idea and its applications which is strongly linked to technology (Abu Jalil, 2013).

3) The third dimension is flexibility which is the basis for achieving competitive advantage by responding quickly to changes that may occur in product design and in line with the customers' needs (Dilworth, 1996). The fourth dimension, which is quality, means or refers to doing things properly to provide products that suit customers' needs (Zolghadar, 2007).

Hence, the idea underlying the concept of general strategies is that competitive advantage is the heart of any strategy, and accordingly, it has been defined by Porter (1998) who set the general strategies for competitive advantage as follows:

- Cost leadership: which means that the organizations shall seek to provide goods and services at the lowest possible cost compared to other organizations which are operating within the same sector, and this can be done by achieving economic savings and owning technology that contributes to reducing cost and use of raw materials more efficiently in their production processes. This may also be achieved through expansion in the same industrial sector to which it belongs or through entering into new industries related to the sector to which it belongs (Porter, 1998). As a result, this means the ability of the organization to implement at the lowest costs compared to competitors through improving production Disposal of waste, and tight control over the cost components (Al-Janabi, 2011).

- Differentiation: It is the strategy represented by developing a product or service that has unique characteristics and has a great value for the customers and that such products or services are better than other competitors' products or different from them so that they can set exceptional prices for the product (Dahbour, 2020). Meanwhile, Jones et. Al, (2003) believes that differentiation is the pursuit of a firm to be distinctive in the industry, through some dimensions of great value for the customers, and hence the port distinguishes its products or services by its unique selling suggestions in the target market sector. On the other hand, Abdel-Wahab (2012) indicated that differentiation is made through the development of differentiation methods of the institution's products and services in comparison with the products and services of other competing organizations or by reducing the advantages of other competing organizations and institutions. Besides, the organizations seek to provide products which are better than other competitors, and add an added value to its marketing and production processes in terms of introducing some characteristics and new products such as ease of use or providing after-sales services in an innovative way, such as maintenance, delivery, credit facilities. Therefore, the principle is related to the fact that the consumer is aware of these new features and that they are of a value to him which other competitors lack. (Porter, 1998).

- Concentration: It means focusing on a specific sector of the market and its service. Two aspects are used for this purpose, the first is meant to achieve a competitive advantage in focus, meanwhile, the second is meant to achieve a competitive advantage in achieving differentiation focus in the target market by limited products and geographical area, (Wheelen & Hunger, 2002) which is based on selecting a narrow competitive range within the industry, and part of it is selected from a group of sectors in the industry and alignment of its strategy for target groups. Accordingly, the organizations seek to achieve competitive advantage for the target segment though it does not possess a competitive advantage in general. As a result, the focus strategy offers two variables: Focus on cost, or Focus on excellence. (Porter, 1998).

Third: The variable continued Aqaba port.

A: What are Aqaba port?.

The Port is located at the Aqapa town to promote, develope and growth of maritime shipping via the kingdom's national port of Aqaba through; mobilizing business skills and concepts in public and private sectors partnerships, providing high quality services, associating with the Government in creating an attractive business environment for ship owners /operators /charters and assisting members to work for the highest professional standards and to serve as: (Khalaf, & Kochzius, 2002, p297).

Transshipment port center (Abu-Hilal, & Badran, 1990, p197).

- Ideal location to handle trade linking between nations.
- Regular ferry services with the Egyptian sea port of Nueib'e.
- Deep waters with the most efficiency in the Middle East.
- Served by an airport, excellent roads and a freight railway to the north of the country.

The Port Corporation (TPC) is a governmental body with an independent character responsible for establishing, developing, maintaining and operating port activities (Abu-Hilal, & Badran, 1990, p195).

The Port consists of the following sectors:

Aqaba main Terminal:

- Aqaba Containers Terminal.
- Industrial Terminal.

B: Site and importance Aqaba port.

Aqaba Port (port code: JOAQJ) is the only seaport in the kingdom of Jordan in West Asia. It lies at the southernmost tip of Jordan on the northeast shores of the Gulf of Aqaba, 2 nautical miles away from Eilat port of Israel in the west (Khalaf, & Kochzius, 2002, p297).

Located on a 40-kilometer strip of coastline between Israel and Saudi Arabia, the port is the only access to the sea for Jordan. It handles 78% of Jordan's exports and 65% of the country's imports. Covering a total area of two million square meters, including 1.7 million square meters of land and 380.8 square meters of sea, it contains three main areas: the main port zone, the containers port zone, and the industrial port zone. The main port zone contains 12 berths for handling general cargoes and grain, exporting phosphate, and supporting roll-on/roll-off and lighter traffic. The containers port zone is located five kilometers south of the main port area and contains seven berths of a total one thousand meters in length. The industrial port zone is located 18 kilometers south of the main port zone and handles oil, timber, and industrial products.The port handles approximately 17 million tons of cargo and 587,500TEU annually. The principal exports leaving this port are phosphates, tar products, cement, fruit. The main imports entering this port include general cargo, building materials, grain and machinery.(Barakat, Al-Rousan, S., & Al-Trabeen, 2015, p11).

Each year about 2,700 vessels and 1.2 million passengers visit this port. The types of vessels regularly calling at this port are container ships, accounting for around 51%; and passenger ships, taking up around 14%. The maximum length of the vessels recorded to having entered this port is 369 meters. The maximum draught is 14.7 meters. The maximum deadweight is 156,198t.(Manasrah, 2006, p840).

Fourth: Linking the human resource and the competitive advantage in Aqaba port.

Rapid developments in the global economy, including privatization, liberalization, and globalization, have exerted great pressure on organizations to cope with changes and adopt competitive advantages to achieve survive and continue. Achieving a competitive advantage for these organizations no longer depends merely on potential and material resources but also relies heavily on human resources and how these people distinguish themselves in the workplace. Human resources and management have recently been viewed as vital to the attainment of competitive advantage (Kamoche, 1991; Pfeffer, 1994; Becker & Gerhart, 1996), prompting many organizations to pay more attention to their most valuable resource, their employees. HR practices are the primary means by which firms can influence and shape the skills and behaviors of individual people to do their jobs and thus achieve organizational goals (Collins & Smith, 2006; Chen & Huang, 2009,p114). HRM practices have been described as having numerous characteristics. Schuler and Jackson (1987,p217) defined HRM practices as a system that attracts, develops, motivates, and retains employees to ensure the effective implementation and the survival of the organization and its members. In addition, HRM is thought to be a collection of internally steady strategies and practices intended and executed to guarantee that a firm's human capital contributes to the accomplishment of its business objectives (Delery & Doty, 1996, p818).

Therefore, HRM practices relate to specific practices, formal policies, and attitudes that are made to attract, improve, inspire, and preserve employees who ensure the operative functionality and subsistence of the organization (Tan & Aizzat, 2011,p156). Clinton and Guest (2013,p530), however, suggested that there is lack of consensus in the existing literature on which HRM practices are best. Li et al. (2006,p117) defined competitive advantage as the capacity of an organization to create and maintain a defendable position over its competitors. Tracey et al. (1999) argue that competitive advantage includes characteristic proficiencies that set an organization apart from competitors. A company achieves competitive advantage when its actions in a market or domain create economic value and when only a few competitors are engaged in similar activities (Barney, 2002,p100). Porter's (1985) and Barney's (1991,p111) provide an economic foundation for examining the possible role of HRs in firms' competitive advantage (Fulmer et al., 2003, p970).

2.6. *Implications:*

The port is Jordan's sole seaport, situated on a 40-kilometer stretch of coastline between Israel and Saudi Arabia. It manages 65% of imports and 78% of exports for Jordan. There are three primary regions that make up its two million square metre total area: the main port zone, the containers port zone, and the industrial port zone. This includes 1.7 million square metres of land and 380.8 square metres of water. Twelve berths are available in the main port zone for handling general cargoes, grain, phosphate exports, roll-on/roll-off traffic, and lighter loads. The container port zone has seven berths totaling 1,000 metres in length and is five km south of the main port area. The industrial port zone, which is 18 kilometres south of the main port zone, deals with industrial products, oil, and wood.

Each year, the port handles 587,500TEU and almost 17 million tonnes of cargo. Phosphates, tar products, cement, and fruit make up the bulk of the exports from this port. The primary imports into this port are grain, machinery, general cargo, and construction supplies.

3. Data Analysis and Results.

3.1. *Demographic Questions.*

3.1.1. *Gender.*

It is clear from the following table on the distribution of the study sample by gender that the proportion of males is 96%, and females 4%.

Table 2: Gender.

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	96	96.0	96.0	96.0
	Female	4	4.0	4.0	100.0
	Total	100	100.0	100.0	

Source: Authors.

3.1.2. *Nationality.*

It is clear from the following table on the distribution of the study sample by Nationality that the proportion of Saudi is 64 %, and non-Saudi 36%.

Table 3: Nationality.

Nationality					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Saudi	64	64.0	64.0	64.0
	Non- Saudi	36	36.0	36.0	100.0
	Total	100	100.0	100.0	

Source: Authors.

Table 1: Second: The questionnaire phrases.

N	Paragraphs	Agree	Not know	Not agree
The first dimension: HRM practices significantly influence the competitive advantage –value				
1	Achieving HRM practices for competitive advantage no longer depends merely on potential.			
2	Achieving HRM practices for competitive advantage no longer depends merely on material resources			
3	Screening recruitment has a positive impact on the competitive advantage -value			
4	Skills development training has a positive impact on the competitive advantage -value			
5	Performance management has a positive association with financial performance			
6	Authorisation, empowerment has a positive impact on financial performance.			
The second dimension: HRM practices significantly influence the competitive advantage -rareness				
1	HRM practices distinguish people in the workplace.			
2	Human resources have recently been viewed as vital to the attainment of competitive advantage.			
3	HRM practices relate to specific practices			
4	HRM practices relate to formal policies.			
5	HRM practices relate to specific practices attitudes that are made to attract			
The Third dimension: HRM practices significantly influence the competitive advantage -imitability				
1	HRM practices significantly attracts employees the competitive advantage			
2	HRM practices significantly develops, employees' competitive advantage			
3	HRM practices significantly influence the motivates, competitive advantage			
4	HRM practices significantly influence the retains employees' competitive advantage			
5	HRM practices significantly influence the innovation work employees' competitive advantage			
The fourth dimension: HRM practices significantly influence the competitive advantage -organization				
1	Career development support has a positive relationship with financial performance.			
2	Pay for performance employee has a positive impact on the competitive advantage -organization			
3	Information sharing within the organisation has a positive impact on the competitive advantage -organization			
4	HRM practices have immediate effect on competitive advantage			
5	HRM practices have striven to cope with new changes and adopt competitive advantages to survive and continue in the global economy			

Source: Authors.

3.1.3. Age.

It is evident from the following table regarding the distribution of the study sample according to age, that the highest percentage is (36-40 years) with 40%, followed by (31-35 years) with a percentage of 21%, (26-30 years) with a percentage of 20% (More than 40 years) with a percentage of 11% and (21-25 years) with a percentage of 8%.

Table 4: Age.

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	21- 25 years	8	8	8	8
	26-30 years	20	20	20	28
	31-35 years	21	21	21	49
	36-40 years	40	40	40	89
	More than 40 years	11	11	11	100
	Total	100	100.0	100.0	

Source: Authors.

- **HRM practices significantly influence the competitive advantage –value:**
  - Statement “Maximum time for storing wastes is 2 days or 48 hours” came in the first place with an arithmetic mean of 4.22 and a standard deviation of .675. Therefore, the direction of the responses of the study sample is Agree.
  - Statement “Waste must be separated into various types at the source “came in the second order, with a mean of 4.21 and a standard deviation of .832. Therefore, the direction of the responses of the study sample is Agree.
  - Statement “Existence of departmental waste disposal plans” came in the third order, with an arithmetic ” mean of 4.15 and a standard deviation of .687. Therefore, the direction of the responses of the study sample is Agree.
  - Statement “Identification of biohazard symbol” in the fourth rank came with an arithmetic mean of 3.89 and a standard deviation of .751. Therefore, the direction of the responses of the study sample is neutral.
  - Statement “Availability of a hospital waste management system” came in the fifth order, and its arithmetic mean was 3.87 and a standard deviation was .812. Therefore, the direction of the responses of the study sample is neutral.

- **HRM practices significantly influence the competitive advantage - rareness:**
  - Statement “Priority should be given to safe waste disposal” came in the first place with an arithmetic mean of 4.21 and a standard deviation of .902. Therefore, the direction of the responses of the study sample is Agree.

Table 5

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	p-value
Achieving HRM practices for competitive advantage no longer depends merely on potential.	100	3	5	3.87	.812	0.001
Achieving HRM practices for competitive advantage no longer depends merely on material resources	100	3	5	4.15	.687	0.001
Screening recruitment has a positive impact on the competitive advantage–value	100	2	5	4.21	.832	0.320
Skills development training has a positive impact on the competitive advantage–value	100	3	5	3.89	.751	0.121
Knowledge of the health care professionals regarding management of BMW	100	3.00	4.60	4.0680	.36979	

Source: Authors.

  - Statement “Regular educational program / training needed for BMW “came in the second order, with a mean of 4.13 and a standard deviation of .884. Therefore, the direction of the responses of the study sample is Agree.
  - Statement “BMW’s management initiatives impose a greater financial strain on management” came in the third order, with an arithmetic mean of 4.13 and a standard deviation of .812. Therefore, the direction of the responses of the study sample is Agree.
  - Statement “Awareness of proper color-coding bins for waste disposal “in the fourth rank came with an arithmetic mean of 4.09 and a standard deviation of .818. Therefore, the direction of the responses of the study sample is neutral.
  - Statement “The use of PPE minimizes the risk of infection” came in the fifth order, and its arithmetic mean was 4.00 and a standard deviation was .888. Therefore, the direction of the responses of the study sample is neutral.

Table 6

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
HRM practices distinguish people in the workplace.	100	2	5	4.21	.902
Human resources have recently been viewed as vital to the attainment of competitive advantage.	100	1	5	4.00	.888
HRM practices relate to specific practices	100	3	5	4.09	.818
HRM practices relate to formal policies.	100	3	5	4.13	.812
Attitude of the health care professionals regarding management of BMW	100	3.00	5.00	4.1120	.48017

Source: Authors.

- **HRM practices significantly influence the competitive advantage – imitability:**

- Statement "Immunization against the Hepatitis B virus" came in the first place with an arithmetic mean of 4.24 and a standard deviation of .712. Therefore, the direction of the responses of the study sample is Agree.
- Statement "Implementing the proper procedure for collecting sharps and needles" came in the second place with an arithmetic mean of 4.12 and a standard deviation of .844. Therefore, the direction of the responses of the study sample is Agree.
- Statement "Putting on personal protective gloves" came in the third order, with a mean of 4.09 and a standard deviation of .911. Therefore, the direction of the responses of the study sample is Agree.
- Statement "Regular annual medical examination" came in the fourth order, with an arithmetic mean of 4.07 and a standard deviation of .820. Therefore, the direction of the responses of the study sample is Agree.
- Statement "Correct management of blood - contaminated spores "in the fifth rank came with an arithmetic mean of 3.95 and a standard deviation of .880. Therefore, the direction of the responses of the study sample is neutral.

Table 7

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	p-value
HRM practices significantly attracts employees the competitive advantage	100	2	5	4.09	.911	
HRM practices significantly develops, employees' competitive advantage	100	2	5	3.95	.880	0.292
HRM practices significantly influence the motivates, competitive advantage	100	2	5	4.07	.820	0.035
HRM practices significantly influence the retains employees' competitive advantage	100	3	5	4.12	.844	0.009
Professionals regarding management of BMW	100	2.50	5.00	4.0575	.51720	

Source: Authors.

- **HRM practices significantly influence the competitive advantage –organization:**
  - Statement "Cost reduction for waste management" came in the first place with an arithmetic mean of 4.37 and a standard deviation of .747. Therefore, the direction of the responses of the study sample is Agree.
  - Statement "Fewer instances of public and workplace illness"came in the second order, with a mean of 4.07 and a standard deviation of 1.112. Therefore, the direction of the responses of the study sample is Agree.
  - Statement "Improve the aesthetic value of healthcare environments" came in the third order, with an arithmetic mean of 4.03 and a standard deviation of .784. Therefore, the direction of the responses of the study sample is Agree.
  - Statement "Reduction in the hospital's infection control expenses" in the fourth rank came with an arithmetic mean of 3.84 and a standard deviation of. 368.Therefore, the direction of the responses of the study sample is neutral.

According to the data presented in the table, the advantages of having efficient management of biomedical waste include, among other things, lower costs associated with waste disposal and fewer cases of illness in the general population and the workplace.

Table 8

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	p-value
Career development support has a positive relationship with financial performance.	100	3	4	3.84	.368	0.344
Pay for performance employee has a positive impact on the competitive advantage –organization	100	1	5	4.07	1.112	-
Information sharing within the organization has a positive impact on the competitive advantage – organization	100	3	5	4.03	.784	0.314
HRM practices have immediate effect on competitive advantage	100	3	5	4.37	.747	0.013
Valid N (listwise)	100			4.07	0.443	

Source: Authors.

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An Analysis of Abandonment of Seafarers and Preventive Measures

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ABSTRACT

This paper discussed the preventive measures for seafarer abandonment. In the shipping industry, the term "abandonment" refers to the ill-treatment of seafarers aboard a vessel by the vessel's owner. The issue of seafarer abandonment affects only a small part of the industry, but without money or a way of getting home, the abandoned crew suffers inhumane conditions and devastating financial consequences. This paper focused on the obligation to timely repatriation and payment, medical attention, inadequate medical facilities, and statistics on seafarer abandonment. The shipping company has followed the abandonment rules and regulations of the IMO and ILO.

1. Introduction.

The long waited implementation of the Maritime Labour Convention (MLC) changes pertaining to seafarers' abandonment is anticipated to occur in 2017. The revisions are anticipated to be well-received given that the Convention is already seen as a success, often referred to as a "super convention" or "seafarers" bill of rights". A seafarer will have been abandoned when:

- The ship-owner is in violation of the seafarer's employment agreement.
- Despite the fact that there is a loyalty, which is regarded as an obligation towards the seafarer that is indirect rather than direct, they are left without help.

Garner (2000) describes that "the relinquishing of a right or interest with the intention of never again claiming it. An abandonment is merely the acceptance by one party of the situation that a non performing party has caused. But a rescission due to a material breach by the other party is a termination or discharge of the contract for all purposes. 2. Family Law. The act of leaving a spouse or child wilfully and without an intention to return" (pp-1).

It was once again established in 2006 what constitutes abandoning sailors. An abandoned seafarer will be regarded as such under the Maritime Labour Convention : "(...) where, in violation of the requirements of this Convention or the terms of the seafarers' employment agreement, the ship-owner: (a) fails to cover the cost of the seafarers' repatriation; or (b) has left the seafarer without the necessary maintenance and support; or (c) has otherwise unilaterally severed their ties with the seafarer including failure to pay contractual wages for a period of at least two months." MLC (2014) defines that the first set of amendments to the Convention which were approved by the Special Tripartite Committee on 11 April of 2014 at the 103rd session of the International Labour Conference, at ILO headquarters in Geneva. The amendments are expected to come into force at the beginning of 2017".

Abandonment has been described as "the cancer" of the shipping industry. To provide some hope, a support network of trade union, welfare, and maritime rights groups is fighting to ensure their protection on an international level. The ILO maritime labour convention, also known as the seafarer's Bill of Rights, covers almost 97% of the world fleet and has been ratified by 79 member states today. As per the data on abandonment available

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on the ILO database, in the year 2022, more than 713 seafarers were listed as abandoned in the database since it was established in 2004. These figures raise serious concerns about the current legal regime's effectiveness in resolving abandonment situations. Seafarers are vital cogs in the maritime domain, and as such, abandonment issues are a priority that must be resolved as early as possible.

The IMO indicated that the recent occurrences of a total of 14 Indonesian crew in Port Alang, India, on board the Miss Gaunt and North wind may serve as an illustration of the stressful and harsh effects for the abandoned crew on board, as well as for their relatives. Both vessels are listed in the Curaçao registry under the registration of the Kingdom of the Netherlands. The crew repeatedly complained to IMO in January and February 2019 that neither the ship's owner nor the insurer was paying them. Since they had not seen their families or young children in more than seven months, they were unable to pay for their needs. The port State, India, claimed that the ships could not be relocated to a safe lay-up harbour and that a fresh replacement (skeleton) crew was necessary, therefore the crew was also unable to return home.

The matter essentially concerns a ship owner's ability to abandon his ship and be protected by insurance, giving a ship owner the right to abandon his ship whether it was captured by the enemy, held by a foreign authority, or confiscated for governmental use. The topic refers to the items on board the ship and their potential value for recovery. However, the personnel on board the ship at the time of its abandonment is not mentioned in the topic. It nearly seems as though the only valuable items on board a ship when it was abandoned were its cargo. Abandonment happens either because the ship owner has financial difficulties or because they can make more money by not paying the wages and bills they owe. This may be more frequent on older ships at the end of their sea life, where the ship is worth less than the money owed to the crew and other debtors. In determining the cases of abandonment of seafarers, the following considerations shall be among those taken into account but shall not be limited to:

Obligation to timely repatriation and payment.

Even when companies save money on basic expenses by deferring signing off dates, seafarers are not always paid on time. While most crew get their wages in the end, there are some who are never paid. The ship owners concerned use bullying tactics, promises of future payment, or small advances on the total amount outstanding in order to try to maintain the operation of their ship with the smallest possible outlay.

While the majority of crew members eventually receive their salaries, a small percentage are never paid, and some must wait months or years for a resolution of their unpaid earnings. In order to preserve the operation of their ship with the least amount of expenditure, the worried ship-owners employ bullying strategies, assurances of future payments, or modest advances on the entire amount due. Recall that operating a poor shipping operation includes not paying employees' salary. Also, there will be suppliers of products and services who are underpaid or paid on time, there won't be enough money for repairs or maintenance, and there might be port state control detentions due to faults on board.

Medical Attention.

Not receiving such care can be a matter of life or death for seafarers working on ships. One case, according to the ILO, involved a seafarer suffering from a painful and debilitating eye complaint that progressively got worse to the point that he was sensitive to light. Since we don't have professional doctors onboard, the seafarer must be assisted with all the necessary medical attention at the nearest port.

Inadequate Medical Facilities.

A cargo ship and a large cruise ship are very distinct types of workplaces, but when examining these two environments from the point of view of crew member health and safety, everyone can spot some similarities. The risks to a crew member's health and safety, the motivations for leaving the ship, and the requirement to receive high-quality care in one's home nation are frequently comparable. Tasks are performed in a highly stressful atmosphere on board ships. The crew members are lengthy absences from home and family and the demanding shifts are factors in the lack of drive and focus. It apart from all of these aspects, working on a ship always involves being in a multicultural environment, which on the one hand adds exciting variation and cultural diversity, but on the other hand makes crew members' unity even more difficult and hectic. For this reason many of the crew members are affected their well-being on each and every day. The crew members are suffering greatly during this period of severe illness. The company has to consider their well-being and provide some rest for the crews. This is also a very big challenge for the ship owners. However, the crew member must receive medical assistance that complies with international standards because medical care and standards vary greatly from nation to nation. The ship owner will need to find a replacement if the absence is lengthy because they will be short of specialists while the crew member is away. The ship's owner will be responsible for covering both the substitute's salary and the sick leave during the absence.

Making sure that the required treatment is advancing and there is no delay in the process of treatment because the crew member missed a medical appointment or because the medical facility was unable to provide the care was one of the challenges when it came to handling medical cases for crew members in their home country. Depending on their total number of experience, Companies has created a clear and well-organized protocol for handling any kind of medical cases that ensures the ongoing success of the provided care. This procedure necessitates both the crew member's and the ship owner's involvement in order to successfully acquire or provide the required care. On a monthly basis, the progress is evaluated to provide a clear understanding of the case's expected outcome: whether the crew member will regain fitness for duty and resume working on board, or whether they will achieve the point of maximum medical improvement but be unable to do so.

Inadequate residential facility.

Decent accommodation and recreational facilities shall be provided for seafarers working or living on board, or both, consistent with promoting the seafarer's health and well-being. Shipowners sometimes do not provide seafarers with separate sleeping rooms of adequate size to ensure reasonable comfort and facilitate tidiness. On board, some of the insufficient residential facilities provided for the crew members included the lack of export containers, berthing delays, and restricted cargo operations. And also included transportation bottlenecks, a lack of truck drivers, and stopped production lines.

In the maritime sector, abandonment of sailors is a severe and persistent problem. It happens when shipowners or operators don't follow through on their commitments to the crew members onboard, putting them in stressful and occasionally dangerous situations. This abandonment can take various forms, including:

- **Non-payment of Wages:** Many times, seafarers are left behind and don't get paid for months or even years. The crew members and their families may experience serious financial challenges as a result of this loss of revenue.
- **Unpaid Overtime:** Many sailors put in a lot of overtime without getting paid for it, which makes their financial problems tougher.
- **Inadequate Living Conditions:** It's possible that abandoned mariners won't have access to nutritious food, safe lodging, or clean water. Health problems and a loss in general wellbeing may result from this.
- **Lack of Repatriation:** Repatriating crew men when their contracts expire or in an emergency is the shipowner's responsibility. Denying seafarers the opportunity to return home and leaving them stranded far from their relatives is a common aspect of abandonment.
- **Denial of Medical Care:** Abandoned sailors may occasionally not receive the proper medical attention, endangering their health and safety.
- **Isolation and Neglect:** In remote ports or aboard isolated ships, abandoned seafarers may be left alone with limited access to the outside world. Significant psychological and emotional pain can result from this solitude.
- **Violation of Human Rights:** As it denies seafarers their fundamental rights to fair treatment, secure working conditions, and prompt payment, abandonment is a violation of human rights.

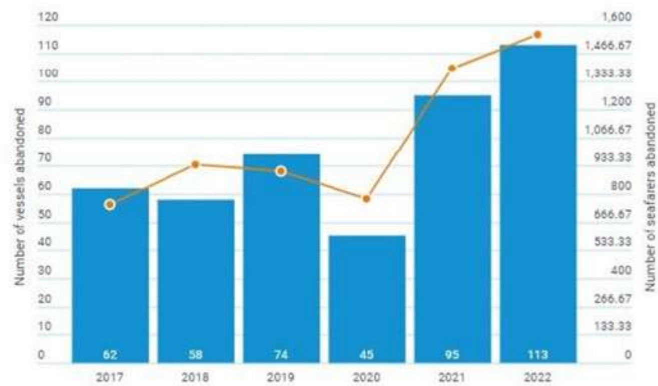
2. Case of seafarer extradition.

According to a recent incident, 15 of the 26 crew members of the Norwegian ship MT Heroic Idun are being held captive in Equatorial Guinea, while the remaining crew members are onboard the ship. In some cases, the company might abandon the seafarers.

3. Statistics of Abandonment of Seafarers.

In 2021 there was "an alarming spike" in case of ships and crew being abandoned by owners in wake of Covid Pandemic, the trend continued throughout 2022 being the worst year on record.

Figure 1: Total of 555 seafarers are abandoned last year.



Source: Authors.

According to joint database maintained by IMO & ILO 713 abandonment incidents listed in the database since establishment in 2004.

- Of those 305 cases were resolved.
- From year 2012 to 2016 12 to 19 per year.
- In year 2017 55 cases of abandonment were reported.

But an alarming signal was made in year 2018 to 2019 where cases increased drastically and the scale went on increasing.

- In year 2018 44 cases of abandonment were reported.
- In year 2019 40 cases of abandonment were reported.
- In year 2020 **85** cases of abandonment were reported {covid-19 pandemic year}.
- In year 2021 **95** cases of abandonment were reported.
- In year 2022 **109** cases of abandonment were reported.

4. An analysis of abandonment of seafarers.

Seafarers actively assist the maritime industry, and the work they do is essential to its operation. The effective operation of the shipping sector depends on the maintenance of friendly ties between seafarers and ship-owners. A written seafarer employment agreement is necessary according to maritime labour law and must be made between the ship-owner and the seafarer. Rights, obligations, and the terms and circumstances of work are all mentioned in an employment contract. The main problem is a lack of finance, which in turn leads to a few more problems like unresolved debts and creditors. On account of the ship-owner being incapable of generating the required funds and continuing with the marine operations, the seamen are left without any support, “PITTY!”.

A seafarer is considered abandoned, in accordance with 2014 modifications to the Convention, when the ship-owner neglects to provide basic needs such food, water, housing, necessary fuel, and medical attention. 31 Humanitarian catastrophes might result from the lack of essentials on board, and the flag state is responsible for handling such circumstances. Because the ship owner’s severance of links with sailors is viewed as abandonment, this is a fairly broad standard. With the ship-failure owner’s to uphold its obligations to sailors, the severing of relationships may be discerned. For non-payment of wages to qualify as abandonment in the case of a breach of the obligation to pay regular wages, there must be a two-month gap. It is important to note that all three of these circumstances non-payment of salaries, refusal to cover the expense of repatriation, and lack of access to basic requirements on board the vessel can lead to abandonment. For instance, when a ship-owner falls financially insolvent, he would neither pay the employees nor organize repatriation charges and secure supply of essentials on the vessel. The function that flag states play in deterring desertion and helping those who have been left at sea will be covered in the following chapter.

What are the steps taken in order to prevent the abandonment of seafarers?

- Make sure that your employment agreement is written and signed by you and your employer and that it deals with your repatriation in the event of your abandonment.
- Be alert to the early signs of abandonment and take action as soon as appropriate.
- If you are abandoned, you may wish to contact the port state control authority; the flag state of your ship; your embassy or consulate; various government departments in the port state; the ITF, your own or local trade union; various welfare organizations and/or a local lawyer.
- If you have not been paid your wages and need food, accommodation, drinking water supplies, fuel for survival on board your ship and medical care and require repatriation at no cost to yourself, you can directly access the financial security system under the MLC (for up to four months).
- If your ship-owner fails to meet the costs of your repatriation under the MLC, you should approach the flag state to affect your repatriation. If it fails to do so, the country from which you are to be repatriated or the country of which you are a national may arrange for your repatriation.
- If you have not been paid your wages (for any period of time) and need repatriation instruct a lawyer to enforce your rights under your maritime lien by arresting the ship to which the maritime lien attaches, or by arresting a sister ship in the event that the ship to which your maritime lien attaches is of insufficient value to pay for your wages and repatriation.
- If your rights to financial security under the MLC; a maritime lien; and to arrest a sister ship are to no avail and the ship-owner is seeking to evade your claim, you may be able to obtain a court order compelling him not to remove his assets from the country so that if you get a judgment against him based on your employment agreement you can execute the judgment against those assets.
- If you are at risk of detention and deportation, you should instruct a lawyer to manage those risks and ensure your repatriation.

5. Where to get help?.

There are several organizations you can contact for advice and support with cases of abandonment at sea. The following organizations mentioned below:

- The ITF or your local trade union.
- Flag state.
- Port State Control.
- The Seafarers Embassy.
- Welfare organizations.
- A Local Community.
- A Lawyer.

A major problem in the marine sector is the abandonment of seafarers, who are not given the basic support they need, such as salary, repatriation, and decent living circumstances, by shipowners and operators. This may occur for a number of causes, including the shipping company’s financial troubles, conflicts, or other unforeseen events. Several precautionary measures and international laws have been implemented to address this issue:

- International Maritime Organization (IMO) Regulations: The Maritime Labour Convention (MLC), 2006, was created by the IMO and lays out detailed rules for seafarers’ living and working circumstances, including restrictions to avoid abandonment. These rules, which include the provision of money security to pay for outstanding wages and repatriation expenses, must be put into effect by member states.
- Shipowners’ Liability Insurance: In order to cover the costs of returning seafarers to their home countries and paying their back salaries in the event of abandonment, many nations mandate that shipowners maintain liability insurance. For seafarers, this insurance acts as a safety net in terms of money.

- Flag State Control: Making sure that ships flying their flag adhere to international laws is the responsibility of the flag state, which is the nation where the ship is registered. Shipowners who abandon seafarers may face penalties from flag states, such as the vessel being impounded or having its registration revoked.

- Port State Control to ensure adherence to international laws, notably the MLC, port state authorities can inspect ships at their ports. A ship may be impounded until the problems are fixed if a violation is discovered.

- Crew Welfare Organizations: A number of charities and organisations offer assistance to abandoned sailors, including access to legal counsel, food and medical care, as well as help with repatriation.

- Global Reporting Mechanisms: Mechanisms for reporting desertion incidents have been created by the IMO and the International Labour Organisation (ILO). These reporting mechanisms can be used by seafarers, their representatives, and concerned parties to request assistance and spread knowledge about abandoned crew members.

- Contractual Protections: Seafarers should have clear contracts outlining all of their rights, including compensation, return to their home country, and working conditions. Legal clauses in employment agreements may serve as a disincentive to abandonment.

- Crisis Management Plans: Plans for crisis management should be in place at shipping companies to handle monetary issues or emergencies that might result in abandonment. These plans may contain emergency cash, backup strategies, and specific guidelines for taking care of the crew's welfare in the event of abandonment.

- Awareness and Training: The rights that they have and how to report situations of abandonment should be made clear to seafarers. Training programmes can assist them in comprehending the rules and practises put in place to safeguard their interests.

- International Cooperation: To effectively combat abandonment, governments, business associations, and unions must collaborate. An integrated solution to this issue may be made possible by international cooperation.

- In order to effectively avoid and address the issue of abandonment of seafarers, governments, the maritime sector, and international organisations must work together. The marine sector may endeavour to solve this issue and safeguard the rights and welfare of seafarers by enacting preventive measures and guaranteeing compliance with current legislation.

6. Call of actions.

- If you think you are in danger of abandonment, DO NOT WAIT. If the ship owner dos not respond contact the insurance company.

- The insurance will cover you up four months outstanding wages and entitlements in line with your employment agreement, SO DON'T LEAVE IT TOO LATE.

- The insurance must also cover reasonable expenses such as food clothing with necessary, accommodation, drinking water and many more. It will apply from the moment of abandonment arrival back.

NOTE: You can always contact an ITF inspector or an ITF affiliated union using the ITF seafarer app or the look up section of the ITF seafarer website or by contacting the ITF Seafarer support team by email at seafsupport@itf.org.uk.

Relevant NGOs in consultative status with IMO include the following:

- International Transport Workers' Federation (ITF).
- International Chamber of Shipping (ICS).
- International Christian Maritime Association (ICMA).
- International Maritime Health Association (IMHA).
- International Association of Classification Societies (IACS).
- International Federation of Shipmaster's Associations (IFSMA).
- International Ship Suppliers & Services Association (ISSA).
- International Group of Protection and Indemnity Associations (P&I Clubs).
- International Harbour Masters' Association (IHMA).
- International Association of Ports and Harbors (IAPH).

Conclusions.

Abandonment can happen for a number of causes, such as the shipowner's financial issues, conflicts, bankruptcy, or other unforeseen events. It is a serious problem that poses serious threats to the welfare and safety of seafarers, regardless of the cause. Many international treaties and laws have been put in place to address the issue of abandonment, such as the Maritime Labour Convention (MLC), 2006, which outlines the rights and protections of seafarers and includes provisions for financial security to cover unpaid wages and repatriation costs. In order to recognise and address situations of abandonment, port state control, flag state control, and international reporting procedures all play a part. Stricter enforcement of these rules, increased awareness of the problem, better access to legal recourse for seafarers, and the promotion of ethical business practises within the marine sector are all actions taken to prevent abandonment. In order to identify solutions and punish individuals accountable for desertion, governments, industry players, and international organisations must collaborate. For the maritime sector to be safe and last, it is essential to protect the rights and welfare of seafarers.

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Analysis of the Effect of Head Truck Performance on the Cargodooring Process at the New Makassar Container Terminal 1

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ABSTRACT

Makassar Port is currently the choice of many people in using transportation services, because in addition to transporting in large quantities also travel long distances. Therefore it is necessary to have an analysis of the container loading and unloading service system at the Soekarno-Hatta Makassar Container Terminal, so that the port can optimize its operational management, especially in supporting facilities for loading and unloading activities such as Head Trucks. The purpose of this study was to determine the effect of the number of loading and unloading, container cranes, and RTG on the truck head and effective time and truck head modeling. In this study, a quantitative research method was used with a descriptive approach by collecting data and then analyzing and testing the established hypothesis with the results of the head truck performance analysis on loading and unloading equipment at the New Makassar Container Terminal (TPKNM) at Makassar ports. The direct effect of loading and unloading on the head truck and CC on the head truck has a positive effect but is not significant at AP value of 0.001, while the direct effect of RTG has a positive effect on the head truck but is significant at AP value of 0.637. The direct effect of loading and unloading has a positive effect on effective time but not significant at AP value of 0.001, while the direct effect of RTG on effective time has a positive and significant effect at AP value of 0.438. Likewise, CC positively and significantly affects effective time at AP value of 0.563.

1. Introduction.

Provide as the gateway to the Eastern Indonesia Region (KTI), the existence of the Soekarno-Hatta Makassar port, especially the container port, is very important for the growth and development of South Sulawesi. The Soekarno-Hatta Makassar container port has become a support for the growth of inter-island and even inter-country trade flows, which are growing day by day. This is due to the port's strategic position in the sea transportation network system both locally, regionally, and even internationally. Indonesia is an archipelagic country, so reliable transportation is needed to connect these islands. Access and distribution channels to regions in Indonesia are very important to support the development and progress of a region. Indonesia's vast territory makes regional development in parts of Indonesia less evenly distributed, especially in eastern Indonesia. As an entry point for trade and other industrial goods routes to an area, it is necessary to have an adequate port and container terminal that is useful to accommodate the distribution process. To realize this, Indonesia needs a good and efficiently managed port sector. The definition of a port is a ship mooring service consisting of port services such as ship services, goods services, container terminal services, and various business services. Effective and efficient service to port users (ships, goods, and passengers) is a major capital for the development of a port (Triatmodjo., 2010).

The New Makassar Container Terminal is one of the core business segments of PT Pelabuhan Indonesia IV (Persero). The services of the New Makassar Container Terminal are oriented towards several basic policies, namely: cost efficiency, time ef-

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fectiveness, and customer satisfaction. The development of the quality of container terminal services is also supported by the availability of modern facilities and equipment, as well as high-quality human resources capable of providing fast, precise, and safe services. The magnitude of the potential for transshipment of goods that occurs in the field requires an increase in the service side, both the operational side and the facilities side.

The port is a place where ships dock, it is hoped that it is a place that is protected from sea disturbances, so that loading and unloading can guarantee the safety of goods. Sometimes a coastal location can fulfill this condition and the water depth/size of the port pool meets the requirements for a certain ship size, so it only needs to build a mooring (wharf) to dock the ship so that loading and unloading can be carried out. Sea transportation aims to bridge the gap between regions and promote the distribution of development results. Sea transportation has an important role in the smooth running of a business because it has economic value, including large transport capacity and relatively low costs. Port transportation is made as a center for trade and traffic of goods cargo handling where ships can dock, dock or export, load and unload goods, and forward to other areas (Kramadibrata., 2002).

For port managers, ports are a business that can be used if managed properly to generate profits. Poor management can lead to financial losses. Within the national framework, the non-financial objectives of a port may have other interests such as from a strategic perspective. Despite the change from labor-intensive and technical industries, ports are becoming a source of direct and indirect employment for several companies associated with their activities. The port consists of several functions that can meet the needs of stakeholders in different ways (Ashury., 2022).

Containers can be interpreted according to the words crate and pack. A crate is a geometric-shaped box made of natural materials (wood, iron, steel, etc.). The pack is matters relating to packing or packaging. So a container is a large box in the shape of four rectangles, made of a mixture of steel and copper or other materials (aluminum, wood/fiberglass) that are weather resistant, used as a place to transport and store a number of goods that can protect and reduce the occurrence of loss and damage to goods and can be separated from the means of transportation easily without having to remove the contents (Amir., 2004)

2. Review of Related Literature.

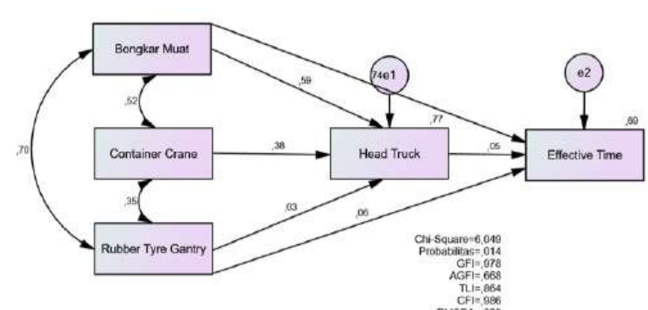
In Normayunengsi's (2019) research, the research results show the average time that a head truck can travel from the stacking yard to the pier. The most influential variables are head truck speed as the independent variable and head truck as the dependent variable. In this research, the research variables are the same, namely the number of loading and unloading, the number of containers, the number of head trucks, only in this study there is no number of head trucks as an independent variable and Budiansyah (2019) said that the waiting time for head trucks has a positive and significant effect on lost productivity. Furthermore, research by Deni Saputra (2018), in that study, all variables have a significant effect on loading and unloading speed and the most dominant container crane and Azza Aunillah (2016) the results of the equation show that if the productivity of container cranes and the frequency of ship calls are increased then the number of containers handled will also increase. V.F Andromeda (2021) idle time and container cranes have a significant effect on the cargodoring process where the loading and unloading process is the most time consuming, thus causing high logistics prices.

3. Methodology.

Data collection is the main thing in completing research. This is done as the main information and the first step in analyzing the operational performance of the loading and unloading equipment at the New Makassar Container Terminal, especially the head truck equipment. The descriptive method or data and information collection is carried out by directly observing the loading and unloading activities with the head truck and quoting from documents/archives from an agency, and individual dialogue related to the required data needs. he approach to assessing the measurement model is carried out to measure the variance extrad for each construct. Another measure of reliability is the variance extrad as a complement to the measure of construct reliability. The recommended figure for the variance extrad value is > 0,50. After testing the previous measurement model has passed the test, because it has passed the testing process, the process of testing the structural model comes from the measurement model, so making a structural model is only changing the 'arrangement' of the measurement model components. The structural model is the relationship between constructs that have a causal relationship (Ghozali., 2014)

The SEM model can be seen in figure Analysis of the structural model testing below.

Figure 1: SEM model.



Source: Authors.

Structural model testing will look for the Hypothesis value

H1: Loading and unloading against the Head Truck.

H2: RTG to Head Truck.

H3: Container Crane to Head Truck.

H4: Unloading against Effective Time.

H5: RTG to Effective Time.

H6: Container Crane to Effective Time.

4. Sources of Data.

Collecting data in the field for this study which was carried out at the New Makassar Container Terminal, for about 2 (two) months. This survey was carried out by examining using a head truck sample on each ship. There are 28 units of head trucks at the New Makassar Container Terminal with an average hauling capacity of 40 tons in good condition. The data needed for the analysis is the head truck data for each ship with a sample size of 105 ships.

5. Empirical Results.

The results of the measurement analysis produce measurements of the goodness-of-fit-model of the measurement model. It can be concluded that the model made can be identified, almost all of the data with variable indicators, both latent and manifest variables, are said to be appropriate. In the measurement model test, the chi-square result is 6.049, the probability is 0.014. Testing the model hypothesis shows that this model is in accordance with the data or fit to the data used in this study. The chi-square value is affected by the DF value, if the DF value is smaller, the chi-square value will decrease. Then the GFI result is 0.978 with conditions > 0.90, the AGFI value is 0.668 with conditions > 0.90, the TLI value is 0.864 with conditions > 0.9, the CFI value is 0.986 with conditions > 0.90, and an RMSEA value of 0.220 with conditions < 0. 8.

High GFI and CFI values indicate better fit and there is no standard for how much GFI and CFI values can be accepted as proper values, but many studies recommend values above 90% as a measure of goodness-of-fit (Ghozali., 2014).

Hypothesis calculations on the measurement model can be seen in table 1 below.

Table 1: Testing the CMIN Measurement Models.

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	14	6,049	1	0,014	6,049
Saturated model	15	0,000	0		
Independence model	5	381,124	10	0,000	38,112

Source: Authors.

The probability number p in the CMIN Default Measurement Model is the value of p (probability level) where the number is worth 0.014 because the number p0.014 <0.05 which should be P> 0.05 then (H0) is rejected, meaning that there is no significant effect between one independent variable to the dependent variable. The results of the DF calculation produce a value of 0 on the saturated model or identified model, then the model is included as just identified, which is a model that has been identified so that an estimation of the model assessment is not needed.

After the model is tested, it can be tested on the hypothesis. The basis for making a decision to test the hypothesis is done by looking at the p value with a significant level of. The results of the hypothesis can be seen in Table 2 Summary of the results of the analysis of the structural model hypothesis test below.

Table 2: The output results of the structural model hypothesis test.

Hypothesis	Jalur	Estimate
H1	BM→HT	0,592
H2	RTG→HT	0,031
H3	CC→HT	0,381
E4	BM→ET	0,740
E5	RTG→ET	0,060
E6	CC→ET	0,055

Source: Authors.

The output results show that there is a direct relationship between the number of loading and unloading trucks with the number of truck heads and an indirect relationship between the number of loading and unloading trucks and the number of truck heads, then to the effective time. The number of loading and unloading has a positive effect on the number of truck heads with a standardized coefficient of 0.592 and is significant at a p value of 0.001. RTG also has a positive effect on the number of truck heads with a standardized coefficient of 0.031 and a significant p value of 0.637. The number of CCs has a positive effect on the number of truck heads with a standardized coefficient of 0.381 and is significant at a p value of 0.001, likewise the number of loading and unloading has a positive effect on Effective Time with a standardized coefficient of 0.740 and is significant at a p value of 0.001. The number of RTGs also has a positive effect on Effective Time with a standardized coefficient of 0.060 and is significant at a p value of 0.438. CC has a positive effect on Effective Time with a standardized coefficient of 0.055 and a significant p value of 0.563.

Table 3: Table R Square.

	Estimate
HT	0,766
ET	0,685

Source: Authors.

The R-Square of the number of truck heads is 0.766 which means that the variability of the number of truck heads which can be explained by the variable variability of the number of loading and unloading, the number of CC and the number of RTG is 76.6%. While the R-Square Effective Time is 0.685, which means the Variability of Effective Time which can be explained by the variable number of loading and unloading, the number of CCs and the number of RTGs is 68.5%.

After carrying out the SEM test at AMOS, the next step is to carry out an Effective Time model analysis with the variables to be included in the number of loading and unloading (X1), the number of container cranes (X2), the number of RTG (X3), the number of head trucks (X4) as independent variables or independent variable, then effective time as the dependent variable or dependent variable. After testing the Multiple Linear Regression analysis on these variables, the following results were obtained:

1. The value of the constant a has a value of 270.722 indicating that the consistent value of the ET variable is 270.722.
2. The value of the coefficient X1 (total loading and unloading) is 1.62 indicating that for every 1% addition of loading and unloading, the ET value increases by 1.62. The regression coefficient is positive, so it can be said that the direction of the influence of variable X1 on Y is positive.
3. The value of the coefficient X2 (total CC) is -108.89 indicating that for every 1% addition of the number of CC, the ET value increases by -108.89. The regression coefficient is negative, so it can be said that the direction of the influence of variable X2 on Y is negative.
4. The value of the coefficient X3 (Total RTG) is 12.33 indicating that for every 1% addition to the number of RTGs, the ET value increases by 12.33. The regression coefficient is positive, so it can be said that the direction of the influence of variable X3 on Y is positive.
5. The coefficient value of X4 (Number of Head Trucks) is 9.1 indicating that for every 1% addition of the number of head trucks, the ET value increases by 9.1. The regression coefficient is positive, so it can be said that the direction of the influence of variable X4 on Y is positive.

Effective Time hypothesis testing test:

1. Hypothesis Testing 1: It is known that the sig value for the effect of the amount of loading and unloading on the effective time (ET) is t count 6.4 > 1.98. So it can be concluded that there is an influence of the variable number of loading and unloading on the effective time variable.
2. Hypothesis Testing 2: It is known that the sig value for the influence of the number of CC on the effective time (ET) is t count -2.34 <1.98. So, it can be concluded that there is no effect of the variable number of loading and unloading on the effective time variable.
3. Hypothesis Testing 3: It is known that the sig value for the influence of the number of RTGs on the effective time (ET) is t count 0.98 <1.98. So, it can be concluded that there is no effect of the variable number of loading and unloading on the effective time variable.
4. Hypothesis Testing 3: It is known that the sig value for the influence of the number of head trucks on the effective time (ET) is t count 1.01 <1.98. So, it can be concluded that there is no effect of the variable number of loading and unloading on the effective time variable.

F-test was carried out at the level of $\alpha = 5\%$. If F count > F table 5%, then the regression line equation model is accepted or variable X can predict Y together.

$$F \text{ table} = F\,(k;n\text{-}k)$$

$$F = (4;101)$$

$$F = 2.46$$

It is known that the calculated F value is 47.69 > F table 2.46. So, it can be concluded that there is a simultaneous influence of the independent variable (X) on the dependent variable (Y).

The results of the regression analysis as a whole show the value of R Square Effective time (0.65 indicating that the correlation value or the relationship between the number of loading and unloading variables, the number of CCs, the number of RTGs, and the number of head trucks has a strong relationship level of:

$$D = R \times 100\%$$

$$D = 65.6\ \%$$

Conclusions.

Based on the research that has been conducted at the New Makassar Container Terminal to obtain the results of the head truck performance model in the cargodoring process at the Makassar Container Terminal with a sample of 105 ships using the variable number of loading and unloading, number of container cranes, and number of RTG, the final results of this study, show that each hypothesis that has been tested is positive / negative and significant / insignificant so that it can be described as follows:

The direct effect of the number of loading and unloading on the number of head trucks and the number of CC on the number of head trucks has a positive and significant effect at a p value of 0.001, and also the direct effect of the number of RTGs has a positive effect on the number of head trucks but is significant at a p value of 0.637.

The direct effect of the number of loading and unloading has a positive effect on effective time and is significant at a p value of 0.001, and also the direct effect of the number of RTGs on effective time has a positive and significant effect at a p value of 0.438. Likewise, the number of CCs has a positive and significant effect on the p value of 0.563.

The indirect effect of the number of loading and unloading to the effective time mediated by the number of head trucks shows a value of 5.97 > 1.98 where the indirect effect of the number of loading and unloading to the effective time is significant and there is mediation of the number of head trucks. The relationship between the indirect effect of the number of RTGs on effective time and the mediation of the number of head trucks shows a value of 0.40 <1.98 where the indirect effect of the number of RTGs on effective time is not significant or there is no mediation. Likewise, the relationship between the number of CCs on effective time mediated by the number of head trucks shows a value of 0.57 <1.98 where the indirect effect of the number of CCs on effective time is not significant or there is no mediation.

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The Role of Ships Without Nationality in the Irregular Maritime Migration

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ABSTRACT

Stateless ships are means of transportation that are used in some types of the trade including certain illicit activities. Among these activities, one of the most prevalent is the irregular maritime migration in various parts of the world. These flows of migrants have resulted in the response on behalf of the maritime community. A whole series of national and international regulations focus on the particular terms that govern flagless vessels concerning the respective types of trade. Furthermore, the adoption of this maritime practice has created a set of issues ranging from the State's jurisdiction to inspect these unregistered vessels, especially in the High Seas, to the rights and obligations of vessels without nationality. Different policies regarding the extent of the State's jurisdiction are implemented by the interested parties, especially the inspecting States. The analysis of this issue will contribute to the resolution of certain issues and will raise scientific and practical questions in the academic community of shipping. This study is also expected to contribute to the scientific orientation.

1. Introduction.

The Nationality of vessels has been one of the main features that characterize ships ever since maritime activity has evolved as business activity. At the same time the question of the determination of the criteria that define a vessel's Nationality arose. In some cases, it is not possible to establish a link between the ships and a State's Nationality. In fact, the phenomenon of stateless or flagless ships is inherent in the maritime industry often by serving clandestine activities. The international community found her in front of the dilemma of the exact definition of the ships without Nationality. Different opinions are supported by different States and parts of the academic community.

Although flagless vessels are broadly associated with the illegal trafficking of drug substances, in recent years the illicit maritime migration has evolved in many areas of the world. Apart from the traditional areas of the Caribbean and the Mediterranean, new areas have emerged as crossroads of migratory flows. The response of the international community includes both initiatives at the transnational level and regulations established by the States. In many cases, the approaches of the stakeholders differ significantly.

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2. Definition of Flagless/Stateless Ships - Evolution.

Ships without a nationality are also called flagless, stateless, or unregistered and can be subdivided into two separate categories. Some ships can be genuinely regarded as ships without nationality and there are the ships that can be assimilated that they do not have nationality under specific provisions of the international legal system. An important feature is that the proof of a vessel's Nationality does not lay on the presence of documents and other signs such as the clothing of Flag. This is because documentation is indicative of a vessel's Nationality and should not be regarded as the source of its Nationality (Dubner & Arias, 2016-2017, p. p. 125). The determination of a vessel's Nationality should not depend entirely on documentation.

2.1. Ships without nationality or registry.

According to the United Nations Convention on the Law of the Sea of 1982 (Article 91) all ships that cannot claim nationality under the necessary provisions, imposed by the respective Flag, are deemed stateless (Guilfoyle, 2009, p. p. 16). Additionally, ships without nationality or registry are the ships that do not fly a nation's flag or do not possess the necessary documents that prove their nationality or the master or individual that is in charge of the ships does not make a verbal claim of nationality (U.S. Government Publishing Office (GPO), 2011).

Furthermore, if the master claims a registry but the Flag State whose registry is claimed rejects this claim, then the ship is not supposed to have a nationality or to be registered to a ship registry. Similarly, if the master of the ship or the person in charge refuses to claim a Nationality for the vessel or tries to obscure that the vessel is registered to a Ship Registry, then the vessel is deemed stateless (United States of America v. Matos-Luchi, 2010).

Relevant to this category of stateless vessels is the case of vessels that were initially registered in a Ship's Registry, but in the process of times, the Flag State has cancelled its authorization (Dubner & Arias, 2016-2017, p. p. 111). Wider approach of statelessness is adopted in the US Maritime Drug Law Enforcement Act (MDLEA) of 1986 according to which if the Flag State does not reply or does not affirmatively assert the nationality of the vessel, then the vessel is regarded as flagless (Kontorovich, 2009, p. p. 1228). Another case of flagless ships is when the Flag State is not recognized as an international person by the international community (Churchill & Lowe, 1999, pp. pp. 213-214) as is the case of the Ship Registry of the Republic of Somaliland.

Finally, there is the case of certain categories of vessels that are excluded from the obligation to register to a Ship Registry, as is the case of non-motor vessels with less than 16 feet in the State of Florida, USA (Johns & et al, 2014, p. 76). It should be kept in mind though that in the case of small vessels the United Nations Convention on the Law of the Sea of 1982 (Article 91) applies according to which, even if a vessel is not registered to a Ship Registry, it can be asserted that it maintains the nationality of the owner of the vessel (Guilfoyle, 2009, p. p. 16).

2.2. Ships assimilated to ships without nationality.

According to the Convention on the High Seas (Article 6, Paragraph 2) which is part of the United Nations Convention on the Law of the Sea (UNCLOS I) of 1958, if a ship flies more than one flags and uses them according to convenience then she cannot claim any nationality and may be assimilated to a ship without nationality (United Nations Office of Legal Affairs (OLA), 1958). Similarly, when a vessel flies one flag but at the same time claims the nationality of another State, then it is regarded as a stateless vessel (Brendel, 1983, p. p. 316).

Another case of vessels that are assimilated to flagless are the ships that have changed nationality during a voyage or a port of call as stated in the United Nations Convention on the Law of the Sea of 1982 (Article 92, Paragraph 1). It is not necessary to receive the verification or rejection of the claim of nationality by the Flag State in case of vessels that fly one Flag but at the same time claim nationality of another. The mere action of change of Nationality during a voyage renders the vessel stateless (United States of America v. Dominguez, 1979).

3. Trades with Flagless Ships ? Reasoning.

Flagless ships are active in the trade of Illegal, Unreported and Unregulated fishing (IUU fishing) causing the reaction of the Food and Agriculture Organization (FAO) (Shaver & Yozell, 2018, p. p. 6). The extensive activities of stateless vessels in various parts of the world along with the fact that their actions are not regulated and controlled by any Flag State have resulted in the response of the international community. In particular, all unregistered vessels that compete in the fishing industry are not allowed to land or tranship fish or products of fish as well as to reach any port facilities, except in case of emergency connected to the safety of the personnel or the vessel itself (Food and Agriculture Organization (FAO) - Indian Ocean Tuna Commission (IOTC), 2016). In other cases, such as the Mexican-Guatemalan Imbroglio of 1958, flagless ships involved in fishing activities have caused the escalation of regional conflicts among the riparian States, including the inspecting State and the State of the Nationality of the fishermen (Wolff, 1981, p. p. 235).

Another illicit conduct that is facilitated by the use of flagless vessels is terrorism and the transportation of weapons of mass destruction. As stated in the Drug Trafficking Vessels Interdiction Act of 2008, § 101, 18 U.S.C.A. § 2285, stateless submersible and semi-submersible vessels mostly used in drug trafficking can be used for the implementation of various illegal transnational actions including terrorism (U.S. Government Publishing Office (GPO), 2008).

In close connection with terrorism and the transportation of weapons of mass destruction is the use of unregistered vessels to serve the arms trade and more specifically the smuggling of weapons. A typical example is the application of vessels without nationality in the transportation of weapons of Iranian origin around the Arabian Peninsula onboard unregistered vessels, most probably heading to the Houthi fighters in Yemen (Williams & Shaikh, 2020, p. p. 38). These flagless vessels were intercepted by the naval forces of various Arabian States. In the wider geographic area of the Sea of Arabia, the use of unregistered vessels that smuggle weapons to the Horn of Africa is a common practice mainly due to the war of Yemen (Shaver & Yozell, 2018, p. p. 15).

One of the main illegal uses of flagless vessels is narcotics trafficking. Either by directly distributing drug substances to the mainland or by acting as mother ships for other smaller ships that will distribute the merchandise to the local markets, stateless vessels are broadly used in this type of trade (Brendel, 1983, p. p. 325). Consequently, many regulations and laws concerning vessels without Nationality are connected to the transportation of drug substances (Dubner & Arias, 2016-2017, p. p. 102). Contrary to a common belief, especially popular in the USA, drug trafficking is not regarded as a universal crime. For this reason, national sets of laws and regulations do not automatically apply to flagless vessels and their crew (Tousley, 1990, p. p. 384).

There is a close connection between the stateless vessels and the migratory flows. In many cases, networks that participate in the illicit movement of immigrants choose to use vessels that are not registered to a Flag State. In the modern era, this method of maritime migration has appeared in the flows of refugees from various European countries, with Jewish ancestry, heading to then Palestine, modern Israel (Moyn, 2015, p. p. 1).

4. Who Is Authorized To Inspect Flagless Ships.

The issue of the jurisdiction over stateless vessels is a matter of concern mainly on the high seas where the rights of the inspecting States faces significant limitations as opposed to the territorial sea, the contiguous zone, the Exclusive Economic Zone and the continental shelf (Guilfoyle, 2009, pp. pp. 10-16). Although the use of stateless vessels is not a universal crime, it should be kept in mind that this shipping practice is involved in various types of illicit activities by threatening the public order. (Bennett, 2012, p. p. 461) For this reason, it raises questions concerning statelessness's real impact on the States and the maritime sector as a whole.

4.1. Jurisdiction on the high seas.

The United Nations Convention on the Law of the Sea of 1982 (Article 92, Paragraph 1), which resulted from UNCLOS III, clearly defines that on the high seas, or else called international waters, only the Flag State can exercise jurisdiction on ships that fly its Flag, save in exceptional cases (United Nations Division for Ocean Affairs and the Law of the Sea, 1982). This is also known as the law-of-the-flag regime. In the case that that the ships are unregistered, the Article 110, Paragraphs 1 & 2, apply to allow warships to inspect all vessels that are suspected not to have a nationality, for the reason of verifying their nationality. This authorization is granted regardless of the conduct of possible illegal trading on behalf of the inspected vessel.

The interpretation of Article 110 has led to the split of the academic community regarding the scope and the extent of a State's jurisdiction towards flagless vessels on the high seas. Some States and part of the academia preserve that there are only allowed to inspect vessels to verify their nationality and check the necessary documents (Kontorovich, 2009, p. p. 1128) as is the case in Australia (Australian Government, 1991). The main argument supporting this opinion is that although according to UNCLOS Article 110 States are authorized to conduct surveys on stateless vessels, there are no equivalent treaty base analogous authorizing States to enforce full jurisdiction on the High Seas. For example, in the case of piracy, there is UNCLOS Article 110 that provides the States with the right to board a vessel and there is Article 105 that clearly defines the right of the States to exert enforcement jurisdiction, such as to seize this vessel (Papastavridis, 2009, p. p. 162).

On the other hand, other scholars move a step forward by supporting that States have the right to substitute the absent Flag State in its role of safeguarding vessels seaworthiness and application of the international regulations (Papastavridis, 2009, pp. pp. 160-161) or even seize the vessels as is the common procedure in the USA and some occasions in the UK (Guilfoyle, 2009, p. p. 17). It should be kept in mind that US Coast Guard vessels actually exercise their authority over stateless ships in various parts of the world in many cases distant from the USA territory (Dubner & Arias, 2016-2017, p. p. 112). If a vessel does not enjoy the protection of any State then it is subject to the jurisdiction of all States.

Another aspect, which is aspired by States like Norway, is that although stateless ships are not to be excluded from sailing, they should be governed by the national laws of the State that conducts the survey, for example, the Norwegian laws (Fife, 2007, p. p.301).

The question of jurisdiction over flagless vessels can be assessed by the point of view of the genuine link too. Members of the academic community argue that a State can exercise its authority over an unregistered vessel as long as it can establish a relationship with the respective vessel similar to the genuine link (Brendel, 1983, p. p. 333). This opinion is based on the Convention on the High Seas (Article 6) which is part of the United Nations Convention on the Law of the Sea (UNCLOS I) of 1958, requiring for a State to "effectively exercise its jurisdiction and control in administrative, technical and social matters over ships flying its flag". In this case, the State is obliged to discharge its duties concerning the other States.

Stateless ships are not under the regulatory control of any Flag State, thus having no restrictions concerning the seaworthiness, the protection of the environment and the application of both national and international laws. For this reason, it could be assumed that flagless ships are more prone to illegal actions such as involvement in piracy, drug trafficking, maritime migration (Moreno-Lax, 2017, p. p. 5), etc (Papastavridis, 2016, p. p. 468). If the international community wishes to address this issue, it is possible to achieve this goal by allowing all Flag States to inspect any unregistered vessels and to detain them until they register to a Ship Registry (Papastavridis, 2009, pp. 161-162).

The jurisdiction over unregistered vessels has been addressed on behalf of the international community on grounds concerning various illicit activities such the drug trafficking. The United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances of 1988, also known as the 1988 UN Narcotics Convention, Article 17, Paragraph 2, proclaims the right of all States to inspect flagless ships with the intention to suppress the illicit drug trafficking (United Nations Office on Drugs and Crime (ODC), 1988). Nevertheless, the right of the inspecting States to seize unregistered vessels remains ambiguous, under the provisions of this Convention and there is not a clear statement concerning the right of the inspecting States to seize flagless vessels.

According to the US Courts, any ship without nationality that sails on the high seas is expected to be inspected by national authorities under both customary and treaty international law. A typical example is the case of United States v Ibarguen-Mosquera where the Court ruled that any State can inspect flagless vessels as a consequence of their statelessness (Wilson, 2011, p. p. 27). It should be taken into consideration that a limited list of States actually performs inspections to unregistered vessels, namely the USA, UK, Norway and Italy (Bennett, 2012, p. p. 460).

However, although national authorities are allowed to inspect any ship without nationality on the high seas, this does not necessarily imply that the use of ships without nationality on the high seas is illegal and therefore it should not be treated as a universal crime. Some scholars even argue that a vessel's registration in a Ship's Registry is more of a necessity than a requirement, for the vessel to be active in the maritime sector (Dubner & Arias, 2016-2017, p. p. 109). It does not pose the same threat to both the national and international community as the other categories of crimes (Bennett, 2012, p. p. 435). Furthermore, in the case of flagless ships that are used in operations involving maritime migration, if the theory that the sailing of ships without nationality is illegal was adopted, then there would be serious consequences in terms of other areas of the international law, such as the refugee law.

It is important to bear in mind though, that a State's jurisdiction over stateless ships is not unlimited. In particular, when a State asserts jurisdiction over a flagless vessel, then a full range of domestic regulation applies to this vessel. Furthermore, since this State does not apply its Nationality over this vessel, then it is can be regarded stateless by the rest of the international community. Consequently, the domestic regulations of other States apply too. For this reason, no State can assume exclusive jurisdiction over stateless vessels in the High Seas (McDorman, 1994, p. p. 540). Instead, it can be argued that a State can only apply prescriptive jurisdiction on stateless vessels.

Another interesting aspect of the State's jurisdiction on unregistered vessels is the connection between the State which intends to perform an inspection of flagless vessels and the individuals on board these vessels. All States are authorized to perform inspections on stateless vessels with individuals onboard that share the same nationality with the inspecting State (Churchill & Lowe, 1999, p. p. 214).

In case that the individuals on board the unregistered vessel are not citizens of the State which inspects the vessel, then a series of international treaties (Treves, 2010, p. p. 6) apply especially concerning the refugee law. It remains broadly unclear whether the boarding State is entitled to exercise jurisdiction over citizens of other States that are onboard flagless vessels (United States of America v Cesar James-Robinson, et al., 1981). It appears that it has to rely on a positive basis to apply its regulations to these persons. This controversy reflects the split between the approach of the jurisdiction in rem, which focuses on the stateless vessel and the jurisdiction in personam, which focuses on the citizens (Papastavridis, 2009, p. p. 162).

4.2. Right and obligations of flagless ships.

Statelessness status implies certain rights and obligations for the involved vessels. One such differentiation of the flagless vessels, when compared to the rest of the vessels, is that the former does not have the right to enter territorial waters and ports (Brendel, 1983, p. p. 332). One important outcome of the status of statelessness is its impact on the level of protection that this vessel enjoys on behalf of a State. Normally, a vessel is under the diplomatic protection of the Flag State. Consequently, the lack of a Flag State deprives the stateless vessel of the protection, diplomatic or other, of a Flag State (Dubner & Arias, 2016-2017, p. p. 122).

5. Connection with Irregular Maritime Migration.

Irregular maritime migration generally uses flagless vessels as opposed to registered vessels in order to achieve the movement of migrants, refugees and asylum seekers from place to place (Council of Europe - Parliamentary Assembly, 2011). Illicit movement of people includes smuggling, trafficking and slavery (Guilfoyle, 2009, p. p. 180).

5.1. The evolution of irregular maritime migration and its connection with unregistered ships.

In the history of irregular maritime migration, there are cases where flagless ships were used to facilitate the illegal movement of people. One such case is the vessel Exodus 1947, initially flying the Honduran flag, which turned into a flagless vessel in 1947. This vessel contributed to the flow of immigrants, with Jewish ancestry, fleeing Europe heading to then Palestine, modern Israel, after the end of World War II (Thomas, 2010).

The Mediterranean Sea is one of the most widely used sea corridors for the movement of immigrants originating from Syria, Iraq, Iran, Afghanistan, Pakistan, Bangladesh as well as the sub-Saharan African States. Certain circumstances, such as the ongoing humanitarian crisis that resulted from the civil war in Syria since 2011, have led to significant flows of immigrants to neighboring countries (Heisbourg, 2015, p. p. 7). A large proportion of this population aimed to transit through the southern and northern banks of the Mediterranean Sea, in order to reach their final destination in European Union countries. Among the transit countries, the most prevalent is Turkey, which is also a destination country, Libya and Morocco (Mann, 2018, p. 355). It is important to keep in mind that in the case of the flows from the Turkish and North African coasts there are organized smuggler networks (Pastore, et al., 2006, p. p. 10) that assist the immigrants in their efforts (United Nations Office on Drugs and Crime (ODC), 2010, p. p. 14).

A similar migratory flow takes place between transit places on the coast of West Africa, usually Moroccan ports, and the Spanish Canary Islands in the Atlantic Ocean (United Nations Office on Drugs and Crime (ODC), 2010, p. p. 13). The originating places in most cases are the sub-Saharan States of West Africa, as well as the North African States, such as Algeria and Morocco.

Another interesting factor is the interaction among the alternative transit routes. While immigrants originating from Africa would normally follow the migratory flow that leads to Europe via Spain or Italy, potential tightening of measures in these areas could lead to a shift of the flow to the route that leads to

Europe via Greece (United Nations Office on Drugs and Crime (ODC), 2010, p. p. 23).

The other region with major flows of irregular maritime migration is the Caribbean Sea. The physical proximity of the destination, which is the USA, with one of the originating States such as Mexico is a major factor in the movement of the immigrants (McAuliffe & Mence, 2017, p. p. 29). In this case, the land borders' crossing stands out as an attractive alternative. Other countries of origin include Haiti, Cuba, Ecuador and other Latin American countries. Apart from the common USA-Mexican border there also the maritime routes with the initial stream of irregular immigrants which started in the 1960s from Haiti (Klein, 2014, p. p. 429). About the same period Dominican Republic emerged as a country of origin for immigrants heading to the USA (Graziano, 2006, p. p. 2).

The use of vessels is the main method that is used by irregular migrants to enter the Australian territory, due to the relatively remote character of this island continent (McAuliffe & Mence, 2017, p. p. 26). In this case, Indonesia, which also shares limited land borders with its neighboring States, is the traditional main transit point for immigrants originating from South Asia, South-East Asia and the Far East. Only in the case of Sri Lanka the majority of immigrants sail directly from their country of origin to the final destination which is Australia (Hugo, et al., 2017, p. p. 171). Political turbulence and state repression have fueled the flow of immigrants from the Rohingya ethnic minority of Myanmar to the neighboring States and particularly to Australia since 2015 (Hugo, et al., 2017, p. p. 28). Similarly, there have been waves of maritime migration after 1975 involving the Vietnamese "boat people" following the fall of Saigon (McKay, et al., 2011, p. p. 608). Since the 1990s the bulk of irregular immigrants heading for Australia originates from Iran, Iraq, Afghanistan, Pakistan, China and Sri Lanka (McKay, et al., 2011, p. p. 609).

The Horn of Africa has evolved into an area where immigrants originating mainly from Ethiopia and Somalia transit either through the Red Sea or the Gulf of Aden, in order to reach their final destination (McAuliffe & Mence, 2017, p. p. 27) quite often the Gulf Countries (United Nations Office on Drugs and Crime (ODC), 2010, p. p. 9). Usually, they intend to arrive in Yemen and the Arabian Peninsula as a whole, though in recent years this geographic area has experienced the opposite migratory flow of Yemenis fleeing their country, to escape the civil war (Mohamud, 2016, p. p. 55).

5.2. Legal framework affecting the irregular maritime migration by unregistered ships.

The legal framework concerning the movement of migrants by flagless vessels constitutes of both domestic and international regulations.

5.2.1. Domestic regulations ? Bilateral agreements.

In the domestic legal systems, some countries have chosen to treat the unregistered vessels in the high seas as if they were registered in their own national Ship Registry. A typical example is the Italian Navigation Code as amended in 2002, Article 4, according to which all flagless vessels in the high seas can be inspected as if they were Italian territory (Hessbruegge, 2012, p. p. 429). In addition to domestic regulations there can be bilateral agreements between countries, usually having common maritime boundaries, such as the one signed by Italy and Libya in 2007, which was renewed in 2009 concerning the clandestine maritime migration between North African and the Southern European States. Another such bilateral agreement was signed in 1997 between Italy and Albania regarding the irregular maritime migration from the latter to the former (Gallacher & David, 2014, p. p. 103).

Since irregular maritime migration is closely associated with the statelessness of vessels, it is easily understood that any regulations targeting irregular maritime migration have an impact on the flagless vessels too, even though they do not necessarily target this category of ships. In this context, one of the most influential domestic initiatives in USA are the Victims of Trafficking and Violence Protection Act of 2000, known as Trafficking Victims Protection Act (TVPA) and the Trafficking Victims Protection Reauthorization Act of 2003. Both Acts focus namely on the prevention, protection and persecution of actions related to trafficking and their validity extends beyond the US borders (Bryant & Landman, 2020, p. p. 123).

5.2.2. International treaties.

On the other side, there are international treaties that have a global effect and are concerned with the status of flagless vessels that interfere in the irregular maritime migration. The United Nations Convention on the Law of the Sea of 1982 (Article 92, Paragraph 1) defines that in the high seas any State maintains the right to exercise its jurisdiction towards unregistered vessels under certain circumstances (United Nations Division for Ocean Affairs and the Law of the Sea, 1982).

However, in the case that stateless vessel is employed in the slave trade, which is a form of maritime migration, then any State can extend jurisdiction. The exercise of State's jurisdiction is justified by the characterization of the slave trade as a universal crime. There is a universal concern for this form of maritime migration and consequently, the universality principle applies to citizens that are held in custody for committing this crime onboard flagless vessels (Tousley, 1990, p. p. 383).

The 1951 Geneva Convention relating to the Status of Refugees, Article 33, Paragraph 1, is concerned with the rule of nonrefoulement, according to which rescued people are forwarded to the country where their journey has started. This International convention prohibits the refoulement under any circumstances thus including the case of vessels without nationality that are active in the irregular maritime migration (Fitzpatrick, 1996, p. p.235).

In the international legal framework there are treaties that although they do not necessarily interfere with stateless vessels, it should be noted that they provide the framework for the handling of maritime migration. One such convention is the International Convention on Maritime Search and Rescue of 1979 (SAR Convention 1979) (International Maritime Organization, 1979).

Another international initiative affecting maritime migration is the UN Protocol to Prevent, Suppress, and Punish Trafficking in Persons, Especially Women and Children of 2000, known as the Palermo Protocol. In this Protocol, there has been a clear distinction in maritime migration between trafficking and smuggling. The main differences have to do with the existence or absence of the migrant's consent, border crossing and exploitation (Gozdziak & Vogel, 2020, p. p. 110). In particular, in the case of trafficking, there is no migrant's consent and border crossing is not necessary. Furthermore, there is ongoing exploitation of the migrant even after the arrival at the desired destination. In comparison, in smuggling there is always the migrant's consent, it is transnational and it terminates upon arrival of the migrant to the planned destination.

In the European area of concern, there is the 1995 Council of Europe Agreement according to which it is required by all participating countries to fight against illicit activities in the sea by eliminating the use of flagless vessels in such activities. In particular, in Article 3 (**??**) the involved parties are to take necessary steps to establish their jurisdiction over stateless vessels too (Guilmore, 1996, p. p. 5).

In relation, to the same subject areas in the Caribbean, the Agreement Concerning Co-operation in Suppressing Illicit Maritime and Air Trafficking in Narcotic Drugs and Psychotropic Substances was signed in 2003, known as the 2003 Caribbean Agreement. This regional agreement has emerged from the previous bilateral arrangements between the States of the Caribbean. Its main innovation is that Article 27 provides for the obligatory application of State's jurisdiction over unregistered vessels (Papastavridis, 2016, p. p. 477).

Conclusions.

The case of vessels without Nationality has preoccupied both the international community and national authorities. As an outcome, although there is a generally accepted terminology of the stateless vessels incorporated in international Treaties, there are national interpretations too. Next to the genuine definition of stateless vessels, there are vessels that can be assimilated to be stateless too. In some States, such as the USA, there is a broader definition as to which vessel can be treated as flagless thus affecting the extent of State's jurisdiction. On the other hand, in other areas of the world State's intervention in issues involving stateless vessels is much more limited. The question of the limits of State's authority over stateless vessels in the High Seas can be answered in different ways.

Certainly, flagless vessels are prone to illegal activities, although statelessness itself is not an illegal activity. Apart from the widespread use of stateless vessels for drug trafficking and other activities, there is growing use of this category of vessels in the illicit transportation of migrants. Next to the well-established migratory flows heading towards the USA and Europe, new trends have evolved reflecting challenges in the field of inequality in economic development or geopolitics such as war and civil unrest. Although generally there is an abundance of data concerning migratory flows, there are areas of the world that illicit maritime migration takes place and it remains mostly obscure, due to lack of documentation and monitoring mechanisms. State's response to the illicit maritime migration with the use of stateless vessels either lays on the implementation of the international Treaties or the signing of bilateral agreements. Additionally, in some cases, unilateral initiatives on behalf of the States are implemented.

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Future Opportunities for Port City Development: A Reciprocal Evaluation for Competitive Advantage for Malaysian Seaports

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ABSTRACT

The seaport is a crucial feature of economic progress since it facilitates commerce, provides additional benefits to a port and city and enables domestic and international companies to expand their openings in the market. One of Malaysia?s least urbanised areas is the East Coast Region (ECR) of the Peninsular, which is also experiencing several development challenges. For instance, many inhabitants are poor or unemployed, while many households suffer from a low income. The region also is underdeveloped in logistical and transportation terms, as well as in its infrastructure and related facilities. This study presents an analysis of how the ?port city? has been defined, the ways that ports and cities exist symbiotically, and the principal influences over the way port cities develop. This study employed semi-structured interviews with 14 respondents, the majority of whom possessed considerable knowledge and experience in the related field. The result shows that eight factors influence port city development, such as facilities and infrastructure; relationships; port city planning; port performance and competition; green environment and quality of life; population growth; port city attractions and benchmarking. In addition, the port-city reciprocation needs to be strengthened to boost economic growth in the ECR of Peninsular Malaysia.

1. Introduction.

A port can be a key driver of the economy of a city or region, with its influence extending far past its frequently isolated and secure location. Ports exert considerable impacts on terrestrial and marine environments, while they affect both urban and rural residents, especially when the city hosts the headquarters of shipping and maritime operations. The growth of a port needs to acquire various forms of knowledge from an extensive array of players in the public and private domains. These parties should hold a stake in the port's economic well-being, the logistical and transportation requirements, as well as the effects it has on the environment of the surrounding city and marine locations (Hein, 2016). Furthermore, several players with a public role in port cities worldwide have voluntarily organised networking initiatives, aiming to gather delegates who belong to the maritime cluster of industries. These include groups of shipping and import-export organisations, handlers of cargo, maritime agencies and union workers. Also involved are representatives of a port's own groups, such as its chamber of commerce, its municipality, as well as the port authorities and those of the region (Merk, 2013).

From the ancient world until today, the development of ports has been associated with the growth of a town or city next to or near the port (Hoyle, 1989). Table 1 illustrates this, despite initially including just Stages I to V. Nevertheless, it is clear that

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inside many towns and cities that contained ports, these first port facilities, harbours and natural estuaries underwent development to become industrial ports. A further phase saw industrial activities shift away from the water's edge to the interior and perhaps subsequently to a purpose-built location outside the boundaries of the city. Finally, many waterfronts experienced redevelopment (Monios et al., 2018). The addition of Stage VI reflects a subsequent version of the transition, in which the city-port links underwent renewal and extra elements came into consideration, for example, globalisation and transport chain intermodalism. Stage VII is newly recovered whereby the dry ports have been applied as an interface between seaports and city to ensure the continues growth of regional development as well as the concept of geologistics can be applied effectively throughout the region (Jeevan et al., 2015; Zain et al., 2022).

Table 1: Different stages of a typical port city's physical development.

Period	Stage and characteristics
Ancient/medieval to 19th century	I Primitive port city: Close spatial and functional association.
19th to early 20th century	II Expansion of the port city: Commercialism and industry grow rapidly, forcing the development of the port past the city limits. Linear quay facilities and general cargo operations.
Mid 20th century	III Modernised and industry-focused port city: Separation and larger area required due to expansion of industry, particularly featuring oil refineries, containers and roll-on-roll-off.
1960s - 1980s	IV Retreating from the water's edge: Increasingly separated areas of maritime industrial development arising from seafaring technological developments.
1970s - 1990s	V Waterfronts redeveloped: Considerably large terrestrial and marine spaces consumed by sizeable modern ports; original cores undergo urban renewal.
1990s - 2000+	VI Connections between port and city rediscovered: Role of the port transformed by globalising and intermodal factors; concept of integrated port and city enhanced by urban redevelopment.
2001-2022+	VII- Reintegration of port city concept via dry ports: This new dimension will be a substantial source to stimulate regional development and geologistics application in particular region.

Source: Hoyle (1989); Jeevan et al., (2015); Zain et al., (2022).

It is possible to measure the direct economic effects of ports on their city by assessing various factors. These include the volume of cargo, the gross value and the number of jobs directly linked to the port area activities. The services associated with the area of the port also have connections to the backward and forward linkages, as well as the jobs indirectly created by such activities. None of these would occur in cities if they did not have ports (Bazan-Lopes, 2002). Zhang and Lam (2013) and Xiao and Lam (2017) supported this concept, stating that local employment, taxation and economic functions were principally generated when a port city first developed due to the handling of cargoes that took place. According to Chan and Yip (2010), ports in different regions developed further improvements to their ports to compete with others and meet the demands of sea transport organisations. Some ports aim to have the leading global container port throughput. The ports of Hong Kong and Singapore have competed with each other for decades.

According to Shan et al. (2014), port cities operate both as ports and cities, with both features being interdependent. The authors noted that developing seaports might assist the host cities to gain an economic boost due to the flows of cargo, passengers and finance, as well as various value-added functions. Additionally, seaports might be able to stimulate infrastructural expansion that features, for instance, links to roads and railways, which would be economically advantageous for the city. Various internal and external elements have influenced the relationships between ports and cities since the 1960s. In particular, global systems of transportation have changed, there has been a maritime industry revolution and port infrastructures have taken on new designs (Bazan-Lopes, 2002). The majority of the world's large cities have supporting seaports, and a city's growth rate can also be attributed to seaport merchandise. Ports are fed by the hinterland and port cities are served by ports (Radhakrishnan, 2017). Historically, nearly all cities on the coast have contained a port, with all of these sustaining an urban development. Therefore, the port has been regarded as the engine of nearby urban and regional economic growth (Xiao and Lam, 2017). Marketers of cities might also use ports as key promotional elements. For instance, the port of Rotterdam is identified as a major factor in the city's economic development and one of its primary attributes, while the label 'world port city' is key to the city's marketing.

The future role of the city will be crucial as the world continues to change rapidly. Cities are focal points of the activities related to the economy and knowledge, and the majority of the world's population are city dwellers (Rechnitzer and Filep, 2009). Moreover, the city has historically driven greater levels of production and expansion, and cities are predicted to be vital to national and regional development and competitiveness (Zain et al., 2022). Given this background, the interactions between the principal operations of oceanic maritime trading, the port's economic functions and the facilities inland are crucial to any port. These interfaces represent the structures and links of the intermodalism between the land near the sea and that of the interior (Notteboom and Rodrigue, 2005; Rodrigue et al., 2014). Therefore, the port city is a timely and critical topic to be explored especially from the Malaysian perspective. Owing to the significant of this paper, several aims have been designed including exploring the characterisation of port city from the local point of view, discovering the mutual roles of ports and city in economic development as well as investigating the enablers that influencing the port city growth.

1.1. The growth of seaports in the East Coast region of Peninsular Malaysia.

Malaysia can be defined as an oceanic country strategically bounded by the South China Sea and the Straits of Malacca. The South China Sea separates the two large land masses that comprise the main parts of the country, namely East Malaysia and West Malaysia (the latter is referred to as Peninsular Malaysia) (Soon and Lam, 2013). The State or Federal governments, being higher authorities, control the establishment of ports in Malaysia. At present, there are seven (7) main federal ports in Malaysia: Port Klang, Penang Port, Kemaman Port, Kuantan Port, the Port of Tanjung Pelepas (PTP), Johor Port and Bintulu

Port. The State Governments of Sabah and Sarawak are the controlling authorities of all the ports in Sabah and Sarawak, respectively, except Labuan Port and Bintulu Port (MOT, 2020). In addition, the benefits from mining, as well as the oil and gas industries, are realised by various private port facilities and jetties, including Port Dickson and Lumut (Heide, 2020). As Chen et al. (2016) noted, Penang Port, Port Klang, PTP, Johor Port, Bintulu Port and Kuantan Port are the main seaports in Malaysia.

Kelantan, Terengganu and Pahang are the three states that constitute the eastern region of Peninsular Malaysia (or the ECR of Peninsular Malaysia). Compared to other regions in Peninsular Malaysia, this region remains the least built-up. It faces various development issues, including high levels of poverty and unemployment, low household incomes, poor logistics and transport, a low rate of urbanisation and inadequate infrastructural facilities. These problems hamper the economic development of this region (Bhuyan and Siwar, 2011). Compared to states in the southern (Johor Bharu) and central regions (such as Kuala Lumpur, Selangor, Negeri Sembilan and Melaka), the economic output of areas such as Kelantan, Pahang and Terengganu has not been good (Hassan et al., 2011).

As outlined in the ECER Master Plan (2019), high out-migration and low household incomes are two features of the eastern region of Peninsular Malaysia, where socioeconomic growth is lagging. Limited jobs were created for the locals as a result of low levels of private investment. To pursue higher income and better employment opportunities, many of the local population have moved to the more developed urban areas, mainly in the southern and central regions. Thus, the poor situation in ECR Malaysia proves that the economic imbalance occurs in the East Coast and West Coast of Peninsular Malaysia. On the West Coast such as the Port of Klang, the economy is growing rapidly due to the strong interaction between the city/industry and the Port, so it is far different from the economic performance in the East Coast, except Kuantan Port which is directed towards the port city. Therefore, this needs to be focused again in the east coast area, especially in Ports and cities in the Kelantan and Terengganu areas.

According to Jeevan et al. (2021), employability, quality infrastructures, quality of life and job growth are not such significant elements of regional development, especially in the ECR of Peninsular Malaysia. Clearly, there must be equilibrium in economic development. This would ensure this region develops in the right direction towards economic equality.

In the ECR of Peninsular Malaysia, the main port is Kuantan Port, which faces the South China Sea. A major deep-sea port in the north-east, it mainly handles conventional cargo, iron, bauxite and chemicals (refer to Figure 1). Southern Thailand is bounded by Kelantan's location, and it has become the ideal and preferred site of the Logistics Centre for the north-east of Peninsular Malaysia, as well as a Cross-Border Gateway, owing to its closeness to Indochina. The expansion of Tok Bali Port (also known as Tok Bali Supply Base) is a key government development (Kelantan State Sustainable Development Master Plan, 2019). Located on the east coast of the Peninsular in Terengganu State, the port of Kemaman is a deep seawater port, which has the capacity to handle shipping of over 150,000 DWT, while it also manages cargoes of goods that are dry bulk and liquid bulk, as well as general (Rauzilan and Suhrab, 2021).

Figure 1: The spatial organisation of port city in Malaysia.

Source: Authors.

In general, the impact of international trade has a significant impact on Malaysia's seaport industry. In 2020, Malaysia's container port traffic was recorded at 26.6 million TEUs, a reduction from the prior year's figure of 26.8 million (CEIC, 2021). Table 2 shows the number of TEUs processed by West Coast (Port Klang, PTP, Penang Port, Johor Port) and East Coast (Kuantan Port) Malaysia's seaports from 2011 to 2020.

Table 2: Container Throughput (TEUs) in West Coast and East Coast Malaysia's seaports.

Year	West Coast	East Coast
2011	18,938,906	132,796
2012	19,462,092	136,101
2013	19,761,663	126,548
2014	21,235,769	131,244
2015	22,803,308	140,959
2016	23,502,803	128,897
2017	22,524,029	147,041
2018	23,728,833	149,912
2019	25,192,701	154,150
2020	25,483,640	149,882
Total	**222,633,744**	**1,397,530**

Source: Malaysia Transportation Statistics (2020).

In comparison to Kuantan Port (ECR of Peninsular Malaysia), the data in Table 2 reveals that seaport capacity expansion has focused more on West Coast Malaysia's seaports. Furthermore, the data in Table 3 shows that the overall freight traffic in Port Klang, PTP, Penang Port and Johor Port has been greater than that of Kuantan Port and Kemaman Port. As a result, in the central and northern areas, there is an urgent need for port city growth that would lead to local growth. In comparison to other places, the level of seaport operations on the east coast is not as strong. As a result, it is critical to build good bonds between seaports and urban centres to improve the output of both aspects.

Table 3: Total Cargo Throughput by Ports, Malaysia, 2011-2020 ('000 Freight Weight Tonnes).

Year	Port Klang	PTP	Penang Port	Johor Port	Kuantan Port	Kemaman Port
2011	194,168	115,459	29,390	32,674	15,207	3,998
2012	197,907	118,991	29,328	25,909	16,064	6,681
2013	200,278	122,667	30,081	26,979	19,332	4,359
2014	217,289	134,040	30,047	27,303	21,367	4,864
2015	219,786	138,466	30,314	28,652	40,030	6,480
2016	245,457	129,342	30,978	28,122	16,341	5,824
2017	212,308	130,522	32,773	28,376	17,462	5,516
2018	220,700	139,807	34,409	31,012	17,998	5,111
2019	243,108	137,203	33,128	31,144	26,099	8,119
2020	221,421	144,625	30,035	30,036	27,266	6,956

Source: Malaysia Transportation Statistics (2020).

In 1989, Hoyle elaborated on the variables and complexities related to port city development across the globe. These elements and procedures have environmental, political, legislative, economic and technological dimensions, among others. Nevertheless, there is very limited published research on this topic. Studies have explored themes such as port city planning (Van den Berghe and Daamen, 2020; Hein, 2021), port spatial development (Chan and Yip, 2010; Ouariti and Jebrane, 2020), port city competitiveness (Douglass, 2004; Zhao et al., 2017); port city policies (Merk, 2013; Lacalle et al., 2020); port city relationships (Ducruet, 2007; Chen, 2017; D'agostini and Jo, 2019) and port city sustainability (Wagner, 2019; Zheng et al., 2020). The paradigm of the port city concept in Malaysia has received minimal consideration in the research undertaken so far. Most studies related to the port city concept in Malaysia are less or not conducted in the ECR of Peninsular Malaysia. While, at the global level, lack of studies focused on port city development factors/concepts, and not presented, specifically in this context. Studies in Malaysia especially on the West Coast area, for example, a study by Abdullah et al. (2012) focused on port city development and quality of life in Pasir Gudang Port, Johor, Malaysia, and a study by Shah et al. (2010) focused on the physical development of port city in the Port of Klang. Shah et al. (2010) study did not empirically discuss the concept of port city development and emphasized on the change in land use form within the urban area, distribution of physical activities and the direction of land use expansion of the port city area. This current study is the first phase for ECR of Peninsular Malaysia, and in the future will be discussed empirically based on quantitative data (survey) to confirm the factors obtained to further strengthen the results.

Overall, the literature is necessary to prove that with the existence of the relationship between the city and the port according to certain phases, however, this development phase does not mention in more detail the tangible and intangible factors for the development of the port city. For this reason, the interview method helps the researcher to identify wider factors in supporting the concept of port city development in the ECR of Peninsular Malaysia, and the findings of this study, hopefully, can be referred to by other stakeholders of other ports. Therefore, the research objective was to investigate the concept of port cities and their development, focusing on the east coast of Peninsular Malaysia. This research analysed the definition of a port city, the reciprocal roles of the port and the city, as well as the potential factors that influence the development of port cities.

2. Methodology.

As Noble and Smith (2014) stated, the generic name 'qualitative research' means a set of techniques and approaches for gathering interpretative or explanatory data focusing on meanings and subjecting that data to analysis. Fulfilling the objectives of the current study required a qualitative approach because the topic has to be comprehended and only minimal studies had been conducted on this subject. According to Creswell (2014), exploration is a key element of qualitative research so it can be an advantage if a researcher has no knowledge of which variables are the most important and thus need to be examined.

Three forms of interviews were outlined by Stuckey (2013), Jamshed (2014) and Merriam (2009): highly structured or uniform, semi-structured and unstructured or informal. This study featured fourteen (14) respondents, each of whom experienced an in-person semi-structured interview. They were from various organisations, including port authorities, the ministry of transport, port operators, logistics operators, the regional planning division and state authorities, and were included to obtain insider perspectives or views on port city development (see Table 4). The main purpose of an interview is to obtain a special kind of information. Face-to-face interviews allow researchers to explain questions that are difficult for respondents to understand in order to obtain clear and accurate answers (Oltmann, 2016). The researcher wants to discover what is in and on someone else's mind or to determine the other person's perspective (Patton, 2002). In addition, the semi-structured interview is more powerful than other types of interviews for qualitative research because it allows researchers to acquire in-depth information and evidence from interviewees while considering the focus of the study. Moreover, it allows flexibility and adaptability for researchers to hold their track as compared to an unstructured interview, where its direction is not fully considered. It is anticipated that an expert who has more work experience will be able to offer more exact details compared to someone without such experience, which ensures the outcomes have greater validity.

All the interviewees were well-experienced members of staff with a wide knowledge of the maritime industry and town planning, especially in the ECR of Peninsular Malaysia. The interview sessions were conducted from December 2021 until February 2022, and the information was constantly updated to include any changes over time. Prior to the interview sessions, the questions were designed to ensure the sessions would be guided and remain within the context under discussion. The questions were designed in two sections; Section A focused on the demographic profile such as type of organisation, position in the organisation and years of experience, while section B emphasizes the research questions, which are the definition

Table 4: The experts who participated in the interviews.

ID	Type of organisation	Position in the organisation	Years of experience
P1	Seaport Authority	Senior Manager	18
P2	Ministry of Transport	Senior Manager	24
P3	Ministry of Transport	Executive	7
P4	Seaport operator	Senior Manager	19
P5	Ministry of Transport	Senior Manager	11
P6	Seaport operator	Operation Manager	8
P7	Seaport operator	Senior Manager	20
P8	State authority	Senior officer	22
P9	Regional planning division	Senior Manager	18
P10	Seaport operator	General Manager	24
P11	Regional planning division	Senior Executive	13
P12	Seaport authority	Senior Manager	30
P13	Logistics operator	Senior Manager	21
P14	Regional planning division	Chief Operating Officer	25

Source: Authors.

of a port city from a local perspective (B1), the reciprocal role played by port and city (B2), as well as the factors that influence the development of a port city (B3).

The average duration of the interview session with each respondent was one to two hours. Purposeful sampling was the technique used to obtain the samples, so this was classified as a process of non-probability sampling. Qualitative researchers make extensive use of purposeful sampling to identify and select cases that are rich in information connected to whichever topic is the focus of the study (Palinkas et al., 2015). Purposeful sampling means a selection is made of specific respondents and for specific events to obtain relevant data that cannot be obtained from other respondents (Maxwell, 1996; Tongco, 2009). Purposeful sampling was more likely to be used in this study because the main respondents consisted of players with expertise in land and port development. Qualitative researchers generally estimate sample sizes by employing the concept of data saturation (Guest et al., 2020; Ishak and Bakar, 2014; Lebar, 2017; Creswell, 2013). As supported by Charmaz (2006), the data collection process stops when the category or theme has reached a saturation point, a step that was applied in this study. Failure to reach data saturation compromises the validity of one's research (Fusch and Ness, 2015).

The research question or questions are answered through the data analysis process. The responses can be referred to as categories, themes or findings (Merriam, 2009). Audio recordings were collected when gathering data from the interviews in the current study. Each recording was transcribed, after which codes and themes were identified by analysing the data. Themes were obtained through thematic analysis, and these provided an elaboration of the port city concept in Peninsular Malaysia's east coast region, with a particular focus on the Ports of Kuantan and Kemaman, as well as the Tok Bali Supply Base. Atlas.ti software and conventional manual methods were used to perform inductive thematic data analysis. Following the thematic analysis technique, an analysis of the qualitative data was performed and then a search through the dataset was conducted to locate, analyse and present patterns that repeated (Braun and Clarke, 2006). Thus, the aim of thematic analysis is to use interview data to locate patterns in their themes. As shown in Table 5, the process contains six steps, as recommended by Braun and Clarke (2006).

Table 5: The step-by-step thematic analysis procedure.

Steps	Description of the process
1. Familiarisation with the data	Data transcribed; data can then be read and re-read, with initial thoughts noted down.
2. Generating preliminary codes	Data's notable features are coded; data connected to the codes are collated.
3. Searching for patterns or themes	Potential themes may provide codes, which are collected and checked to determine whether the themes would effectively relate to the coded extracts and generate a thematic analysis map.
4. Reviewing themes	Themes are checked; a thematic map is generated.
5. Defining and naming themes	Each theme's specifics and the overarching study message are refined through continuous analysis; basic meanings and names for all themes are established.
6. Producing the reports/manuscript	Last analysis; an academic report produced.

Source: Braun and Clarke (2006).

3. Results and Discussion.

According to Creswell (2007), to obtain reliable information and meet the criteria, diversity among the selected respondents needs to be considered Therefore, the respondents had to have experience related to ports and the land/region around ports (see Table 4).

3.1. Descriptive Analysis of Demographic Information.

Based on Table 6, the respondents held various positions, including Executive, Senior Manager or Officer, General Manager and Chief Operating Officer. Most of the respondents involved in this study consisted of senior managers (78.58 per cent). Generally, senior managers were actively involved in this study because these middle-level managers are generally responsible for implementing the goals set by the top management. Al-Khalifa and Aspinwall (2000) concluded that middle-level managers are good sources of information because they execute the decisions made by the top management. In fact, their role is to interact with both the top management and daily operations employees, as well as be able to understand company performance. Since most top managers are not actively involved in day-to-day operations, the role of the middle manager is also important to communicate the company's mission, goals and priorities to its employees, as well as offer suggestions and feedback to the top management (Hirte, 2018). Thus, it is undeniable that these middle managers could understand the highly important and closely interrelated features of the development of ports and cities, as well as provide accurate input when answering the interview questions.

In addition, the top management (general managers and chief operating officers) played an important role as respondents because they were involved in the formation of plans to carry out objectives and policies, and they also delegated the tasks of running an entire business. 'Chief executive' is the title generally used to refer to company's officer with accountability for the organisation's overall actions and outcomes (Steiner, 1969). Given these attributes, most of the selected stakeholders were able to contribute comprehensive information to this study. Information was generally obtained from respondents who had extensive experience concerning the issues studied. This is evident in the fact that 50 per cent of the total respondents had work experience of more than 20 years, while 35.7 per cent of the respondents involved had work experience of between 11 and 20 years. Finally, 14.3 per cent of the respondents had less than 10 years of work experience. Thus, this specific group provided answers that had significant implications for the current study. In terms of the participants' experience, nearly nine in ten had been involved for over 10 years. Therefore, their information was valuable and the validity of this section's data was further justified.

Table 6: General background of respondents.

	Percentage (%)
1. Position in the organisation	
Chief Operating Officer	7.14
General Manager	7.14
Senior Manager / Officer	78.58
Executive	7.14
2.Years of experience	
<10 years	14.3
11-20 years	35.7
>21 years	50
3.Type of organisation	
Port Authority	14.3
Port operator	28.6
Ministry of Transport	21.4
State authority	7.14
Regional planning division	21.4
Logistics operator	7.14

Source: Authors.

Table 6 also shows the employment fields of the respondents who were knowledgeable about port city development. A total of 28.6 per cent of the respondents were port operators. A total of 21.4 per cent consisted of respondents from the Ministry of Transport and regional planning division. Meanwhile, port authority respondents made up 14.3 per cent; finally, the smallest group of respondents were logistics operators and those from the state authority, comprising about 7.14 per cent. In general, the majority of the respondents involved in this study were senior managers with extensive experience, views and knowledge of the maritime industry and urban planning. As the main study focused on the factors influencing the development of ports and cities, the main party that needed to be considered was the port operators (from Kuantan Port, Kemaman Port and Tok Bali Supply Base, all of which are located in the ECR of Peninsular Malaysia). Similarly, the regional planning division, port authority, and state authority were very useful in providing input on how the strong relationship between the port and the land is firmly established. In conclusion, all the stakeholders cooperated directly in providing information on the port city development concept.

In this study, themes or categories were generated based on the concept of port cities in the ECR of Peninsular Malaysia. The data collected from the results of the interviews were analysed with Atlas.ti software. This software is used specifically to process and analyse qualitative data (as are NVivo software, CAQDAS and NUD.IST). The research questions were used to inform the coding procedure. At this point, the category development was assessed to ensure they would be able to give descriptions of the port city concept from a Malaysian outlook. The next section discusses the answers to the research questions. All the interview data were anonymised to protect the confidentiality and anonymity of the participants, who are referred to as respondents *P1* to *P14*.

3.2. Definition of A Port City from Local Perspective.

All fourteen (14) experts who participated in this study agreed that ports and cities are 'interdependency' or supportive of each other. Based on the view of expert *P1*, "*ports cannot grow without the support of the community or city itself. The industrial sector and urban communities need port services to obtain raw materials or sell goods abroad*." Respondent *P4* claimed that *"the city integrates with the port, thus [the] city [is] developed due to [the] port activities, while the port is developed to support the community as well as [the] economic activities related to the port itself."* The interdependence between port and city was also mentioned by respondent *P14*, who said that a city is built around a port, whereby the port and maritime industries have a strong influence on the local economy and the city assists in supporting the development of the port. This interdependence, also known as the interconnection or interrelationship between the port and the city, has been realised by many scholars, such as Veenboer (2014), Ducruet (2006), Hall and Jacobs (2012) and Zhao et al. (2017).

Moreover, respondents *P5, P6* and *P13* claimed that the definition of a port city can be related to 'transport connectivity'. According to respondent *P5, "in Malaysia, we are not yet a port city, but we are heading towards a port city, because a port city is complete with resources or facilities - such as transportation* *including [via] sea, land and air - that are in one place.*" Meanwhile, *P6* stated that *"a port city has a link with three modes of transportation: road, water and air. The presence of these three components is considered as fulfilling [the criteria of] a port city."* Finally, *P13* defined a "*port city as the area that is equipped with transport links. If there is integration between these modes of transportation between seaport and land, it will make it easier for stakeholders to enhance the local economy*."

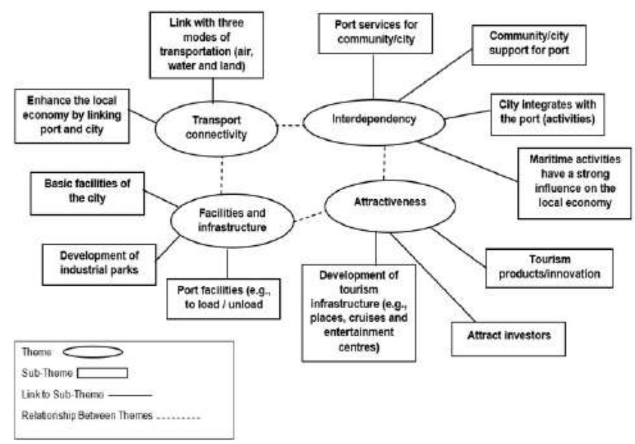
Respondents *P7, P12* and *P13* emphasised that the definition of a port city can be viewed in the context of 'facilities and infrastructure'. Respondent *P7* pointed out that *"most ports, such as Shanghai and Rotterdam, are built close to the city. In terms of development, the city builds based on the surrounding facilities. Therefore, a port city needs facilities to support the port. For example, in Pahang, there is an industrial park that supports Kuantan port."* Meanwhile, *P12* defined a port city as *"a port that has facilities for the purpose of ships loading or unloading goods as well as having connectivity between port and city."* Finally, *P13* defined a port city *as follows: "there are basic facilities in the city. ... Johor Port has a strategic place; for example, the ... factories and shipping lines are located close to each other."*

According to Benckendorff (2014), 'attractiveness' is a core component of tourism. An attraction can be a place, person, event or thing that is the focus of the tourist's attention, and the reason why the tourist has been attracted to a destination. The historical development of the concept of the attraction has an inextricable link to the expansion of tourism. In other words, there are ports (beside ships and their operators) that create the material and organisational conditions for the development of maritime tourist voyages (Miotke-Dzikegiel, 2007). When arriving at the Port Klang, Penang Port, Port of Tanjung Pelepas, Kuantan Port or Bintulu Port seaports in particular, tourists, ships' passengers and crew members have the chance to roam around to discover the unfamiliar cultures of these new regions (Jeevan et al., 2019). Activities in specialised seaports that are focused on tourism are known as seaport tourism (Jugovic, 2006). Respondent *P10*'s view was that "*when the port combines with the city, ... there are many attractions [and] places for visiting. Some tourists use cruise ships with elegant services to travel or holiday at specific destinations.*"

A principal element of economic development in the long term is investment. Any region with sufficient infrastructures might be investment targets, while the inhabitants will be able to easily and conveniently perform their daily activities, enabling increased productivity (Windhyastiti et al., 2019). If the government develops the infrastructure connected to tourism, it indicates their intention to draw investments into specific areas. The outcome is an expansion in the tourism sector and greater welfare for the surrounding inhabitants. Penang, Port Klang, Kota Kinabalu, Langkawi, Melaka and Kuching are the six such areas in Malaysia. Each port has infrastructure focused on cruises and scheduled arrivals of these cruises, while immediate tourist-centred products can often be readily accessed.

Langkawi, Penang, Port Klang and Melaka are examples of cruise terminals in Malaysia whose locations are near to various immediate attractions. As a result, passengers from the cruises have the chance to easily access the atmosphere of a major city and other ecotourism facilities, beach areas, traditional cultural activities and unfamiliar foods. Port in Malaysia are also well-equipped with wide-ranging and up-to-date features, while they offer suitable berths for international cruise ships (Tourism Malaysia, 2017). In conclusion, port cities can be defined as cities with ports that feature the components of water-based and land-based transport hubs. Moreover, ports are advantages in the ways they contribute to port cities' growth (Cong et al., 2020). The themes that define port cities, as derived from local perspectives, are summarised in Figure 2.

Figure 2: Summary of themes of definition of a port city, as generated from a local perspective.



Source: Authors.

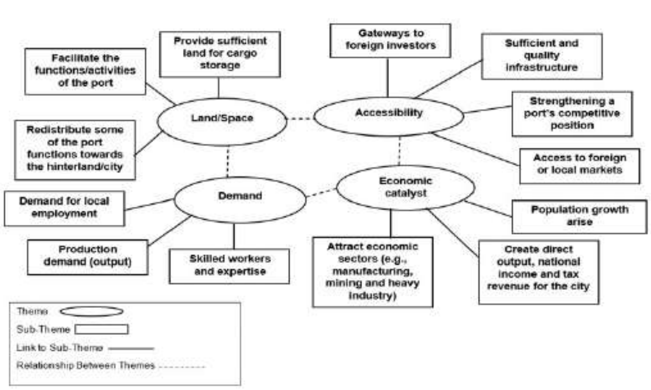
3.3. The Reciprocal Roles of The Port and The City in Economic Development.

A port is a transport hub, with a location next to the sea and near to river systems, that offers water-based intermodalism facilities that allow ships to enter and exit safely. A port acts as a centre from which to distribute the trading system's industrial and agricultural produce because it is an assembly point as well as a water- and land-based transport hub (Cong et al., 2020). Port development also requires support services based in the city itself. Respondents *P1* and *P8* believed that, *"ports need to meet the services needs of the community. For example, in the context of Kuantan Port, the target is to serve not only the Pahang region but also the entire ECR of Peninsular Malaysia."* According to *P8*, *"the main role of [the] city is to provide sufficient land for cargo storage or to facilitate the functions/activities of the port."* Respondent *P14* also highlighted that "*the city will provide [a] supply of goods or commodities, [the] workforce and [a high-]quality living environment. [The] city also plays a role in addressing challenges faced by [the] port, such as [the] scarcity of land, by redistributing some of the port function towards [the] hinterland, i.e., to freight redistribution centres/inland ports."* Jeevan's (2017) view was that a dry port could develop as an extended seaport, as a regional intermodal node and as an interface terminal inland.

Excellent accessibility is of vital importance to all port cities and hinterlands. Respondent *P7* pointed out that *"airports and* *seaports are important as gateways to foreign investors and global supply chains."* According to Munim and Schramm (2018), if ports have high-quality infrastructures and logistics, the country itself benefits by being more locally and globally accessible, while it also has the chance to branch out into global markets. As Notteboom et al. (1997) claimed, the competitiveness of a port can be strengthened considerably by combining infrastructural quality, access to the hinterland and levels of production. Notteboom et al. (2022) also noted that the port has become a gateway to networks inland, which are frequently substantial. This type of gateway is a nodal point from which flows of intercontinentally transported goods are transshipped on to areas of the continent, while the reverse is also the case.

Port cities can develop more extensively if they have a port. Ports produce goods, operate and develop in ways that expand direct output, jobs and the city's tax returns, as well as the country's revenues. Long-standing port cities have become more prosperous and new port cities (for instance, Singapore, Shenzhen, Hong Kong and Dubai) have grown due to the development of modern industrial systems and transport. According to respondent *P14*, *"ports provide important economic opportunities, which [include] access to global supply chains."* Port play a major role in accelerating industrial development and driving Gross Domestic Product (GDP) growth. Port activities create demand for local employment, provide fiscal revenue, attract various economic sectors and enable better access to foreign or local markets.Respondent *P12* agreed that "a *port city provides socio-economic benefits to the urban population. Thus, population growth arises from economic growth."* Meanwhile, respondent *P14* said that "*the role of a port city [is to be] an economic catalyst for the region. It opens up other economic sectors, including manufacturing, mining, heavy industry, finance, services, etc."* The themes involved in the ports' and cities' reciprocal roles, as derived from a local outlook, are summarised in Figure 3.

Figure 3: The themes involved in the port's and city's reciprocal roles, as derived from a local outlook.



Source: Authors.

The reciprocal integration between seaports and city are crucial because there are many disadvantages that gained by city form seaports and vice versa. For example, the city will be affected by less healthy lifestyle of residents due to industrial pollutions. More specifically, land reclamation, air, water, noise and odor pollution are among the major environmental impacts stemming from port development (Zain et al. 2022). In that case, the adaptation of 4^{th} industrial revolution in seaport sector may prevents these issues to enlarge dramatically. On the other hand, competition between public and freight transportation, optimum usage of limited infrastructure in the city, high cost of living, limited option for human resource are some of disadvantages provided by city to seaports (Zain et al. 2022). Owing to issues due to the seaport and city integrations, several strategies can be proposed such as developing the master plan for post city ecosystem development, integration the port city with the advancement of IR 4.0, introducing the usage of inland terminal as a medium to connect seaport and cities and integration port development planning with environment impact assessment for a sustainable environment. In addition to that, the fundamental question needs to be answered especially on the key factors that influencing the port and city development. This section is crucial for ensuring seaport and city to sustain after the integration has been done.

3.4. The Factors Influencing Port City Development.

This section discusses the factors that influence port city development from a local perspective. Figure 4 shows the cluster (theme) and sub-themes connected to influences on port city development in the ECR of Peninsular Malaysia, based on the interviews conducted with fourteen (14) respondents or experts. As stated by Creswell (2009), themes (also known as factors, categories or nodes) are outcomes obtained based on research questions. For each theme, all the text excerpts were removed from the transcript and classified into subcategories using Atlas.ti. The development of this theme provided a basic analysis of the respondents' views on port city development. The results revealed that eight (8) themes were found in this study; these are described in the following section.

3.4.1. Facilities and infrastructure.

Most respondents emphasised that port facilities and infrastructure (e.g., warehouses, cranes, berths, telecommunications, technology, breakwaters and good water quality) are very important in developing a port city. In addition, adequate infrastructure is also needed around the land close to the port (e.g., roads, railways, bridges, telecommunications, buildings, space, houses, as well as special routes or roads for heavy vehicles) to support the port activities (*P3, P4, P5, P6, P7, P10* and *P12*). Respondent *P3*, from the Ministry of Transport, noted that *"the port needs to provide more warehouses before moving towards the port city. Thus, warehouse development requires large-scale road infrastructure for heavy vehicle routes, as well as to overcome heavy vehicle routes in residential areas. Therefore, the parties involved must look at the factors involved as a whole."* Respondent *P5* stated that *"the type of road [i.e., the material used] to the port is different, [and it should be suited] more to heavy-duty vehicles."* In addition, respondent *P10* suggested that *"specific roads or highways need to be built for trucks or heavy vehicles."* Thus, public vehicles have to use different roads or routes to avoid traffic congestion, while road damage and safety aspects need to consider the public. In addition, the movement of heavy vehicles to and from the port can be accelerated without interruption from public vehicles (*R5* and *R10*). Other than roads and warehouses, ports need sufficient facilities and infrastructures to support industry or customers *(P4, P5, P6, P7* and *P10)*. These include breakwater, dredging and quay or berth constructions (*P4* and *P10*); cranes; ship anchorage areas; terminal yard and vessel traffic services; the equipment used for marine oil spills (*P5*); marine radar and logistics hubs (*P6*); and wharves to handle large ships (*P7* and *P10*).

Additionally, access to transport has a crucial part to play in forming a city's spatial setup, from which its economic and social possibilities are also created and shaped (Sun et al., 2016). Respondents *P4, P7* and *P11* believed that *"transport connectivity [railways and roads] is necessary in Malaysia to facilitate economic activity, to handle cargo between ports and industries and to speed up connectivity between ports and customers or [the] land."* Respondent *P3* mentioned that *"in terms of connectivity to [the] land, the majority of commodities/goods are delivered by truck [road] from the port." P14* also noted the need for *"good infrastructure, high accessibility and connectivity, including multimodal or intermodal transport."* Therefore, transport connectivity is a result of close collaboration between ports and the surrounding cities. Thus, a complete range of facilities and interconnections between port and land are necessary (*P1, P2, P8, P9, P11* and *P13*). Respondent *P1* pointed out that *"if the land is not developed, the port function cannot be utilised to the maximum extent. Therefore, industry, rail, road networks and all [other] facilities must be developed."* Meanwhile, respondent *P2* mentioned the internet connection problems around the port and on land: *"thus, the port side needs to get faster internet access and, at the same time, the community can also enjoy the use of the internet."* These statements indicate that the development of a port must align with the development in the area around the port or on land.

Respondent *P8*, from the state authority, argued that *"the land area of the ECR of Peninsular Malaysian needs to improve or upgrade some infrastructures - such as [the] roads, bridges, traffic, communication [and] public transport in order to facilitate [the] port and community."* Respondent *P8* further explained that "*the bridge needs to be improved as there is not enough height for ... passing ships. Moreover, maintenance work at the shipyard cannot be carried out as [ships] cannot enter through the low-altitude bridge."* Respondent *P9*, from the regional planning division, said that "*the development of tourism platforms and free industrial zones are needed to support [the] port activity and move towards the port city.*" She also added that port city development requires basic facilities and adequate infrastructures, such as a water supply, electricity, telecommunications and space for commercial activities. In addition, housing development is important to support population growth. The views of respondents *P11* and *P13* were that *"physical factors for port city development [were needed,] such as roads and highways, industrial parks and business premises."*

The main limitation on ship handling is the depth of the port's water area. Ship movements in such areas are connected with problems like shallow water, which can have an impact on the sea bed. Such events can result in ship hulls being damaged (Galor, 2007). As stated by respondents *P2, P4 and P7, "the main limitation on ship handling is the depth of [the port's] water. An adequate water depth is necessary to accommodate larger ships. Accordingly, large ships involve cheaper costs for traders."* Respondent *P6* claimed that *"water depth is the most important factor to ensure that the port is built in the long run. If the incoming ship has a depth problem, [this] has a very big impact, i.e., the ship will move to another port."* According to respondents *P5* and *P10, "the water depth in the port must be adequate, particularly for large ships. There is a port on the ECR of Peninsular Malaysia that has a deep-sea [section] but the area is still small to accommodate large ships; thus, the next plan is to extend the wharf. To develop or extend a new wharf, it is necessary to [build a] breakwater so that the ship is not exposed to risk."* Respondent *P3* stated that, *"ports with naturally deep water do not need to spend substantial amounts on ensuring an adequate water depth."* Meanwhile, respondent *P11* stated that the *"geographical location and water depth are the physical characteristics of port city development."* Mei-e and Baoguo (1998) claimed that the development of a port is influenced by several key elements: the depth of the water, the condition of the waves and the land area next to the port.

This study also found that technology is an important factor in the development of a port city (*P1, P4, P5, P9* and *P12*). Respondents *P1, P5* and *P9* pointed out that *"through information technology, many work processes can be shortened or accelerated to reduce waiting times, for example, developing systems for free zones, ... cargo handling and the online documentation process for imports and exports.*" Therefore, ports must switch from the traditional methods and develop a more fully automated system (*P4*), while they also need high-tech cranes that make container handling more productive, efficient and reliable (*P12*). Since the volume of traffic is expanding, modern ports need to guarantee that the way they handle cargoes is well-performed, reliable and efficient. This reduces the period of time that a ship needs to berth in the port and enables operations to avoid interruption. Logistical organisational changes and the usage of new digitalised technology are required to achieve this (Ilin et al., 2019). Ports are part of a complex urban setting as they provide important economic opportunities, such as access to global supply chains, while cities are the centres of knowledge, innovation and the specialisation of production and services (Notteboom et al., 2022). Recently, ports' operating environments have altered substantially. While technology has developed rapidly, the size of vessels is constantly increasing, as is the proportion of cargo containers. Cargoes can be handed far more quickly due to automated cargo-handling (Hinkka et al., 2016).

Based on the findings, training centres also influence the development of port cities. According to respondent *P7, "in parallel with the development of a port city, stakeholders need to develop training centres to support the marine environment."* Meanwhile, respondent *P8* noted that *"ports and governments* *need to develop training centres for residents to gain skills and provide employment opportunities for them."* The Malaysia Shipping Master Plan 2017-2022 outlined the government's emphasis on developing the Maritime Education and Training Blueprint. This was due to the need to enhance the industry's development since greater skills and expertise were required in this sector (Boonadir et al., 2020). Therefore, there is a need for manpower with high levels of skills and expertise (who may be derived from the city/residents) to contribute to the development of the port city. According to respondent *P9*, *"communities or residents, especially young people, must be prepared with [the] skills and expertise that contribute to the port and the economy."* Moreover, respondent *P3*'s view was that *"infrastructure and skilled manpower must be sufficient to develop the port city.*

3.4.2. Relationships.

The relationships between collaborators, investors, the government, agencies, the community and politics have become important factors in the development of port cities. Respondents *P1* and *P5* recommended that *"the port needs to link with all parties, such as the government, agencies and the community, in the development of the port city."* Therefore, the port and the city cannot grow or develop on their own. In addition, respondent *P13* stated that, *"there is the need to connect with the community through surveys and take the public's views on port city development."* The port and the government should provide an initial explanation to the residents in the surrounding areas about the development of the port city; for example, the advantage of a port city is that it can provide employment opportunities and offer training schemes to residents (*P2* and *P8*).

Respondent *P4* said that *"the government must participate in developing facilities at the port [e.g., breakwater and dredging constructions] in terms of cost or major investment."* Meanwhile, respondent *P6* agreed that, *"cooperation with the government was needed to overcome the problem of sedimentation in rivers or seas, which requires a considerable budget."* Finally, respondent *P14* believed that *"[the] relationship among the stakeholders may create a sense of ownership and responsibility to work towards a common vision."*

Respondents *P1, P4, P11* and *P12* stated that *"developing a port city must have full collaboration [between] the Federal and State governments [i.e., the local authority], industry, [the] port, the Economic Planning Unit, [the] Ministry of Transport, [the] Town and Planning Unit, [the] East Coast Economic Region Development Council [and] other parties related to the development of the areas."* A port is a supply-driven industry (providing services and facilities) (*P4*). While respondent *P7* and *P13* believed that *"through collaboration, stakeholders can exchange ideas and encourage investment. For example, ports [could] make agreements with shipping lines and introduce the services offered to attract customers."*

In the context of investment, the government and other stakeholders need to find investors to build industries, so investment from the land [in industry] is important to develop [the] port (*P12*). If there is no development on land, there is no reason to invest and to develop the port (*P1* and *P4*). The government and the stakeholders need to play a role in port and land development as this involves major investment or a large budget. Meanwhile, *P7* and *P9* pointed out that, *"building a strong relationship with the government is very important to attract large investors. Therefore, the government, with the support of other agencies and [the] private sector, needs to implement strategies to attract foreign investors."* Additionally, communities can only participate by being entrepreneurs and supporting the activities of the port if government incentives (finance) can be provided. Port cities can only develop if their budgets are augmented through government assistance (*P4, P5* and *P7*).

As Acar (2019) claimed, a stable political environment can facilitate the expansion of the economy. A country will tend to be adversely affected without both a stable political environment and the development of its economy. Having achieved political stability, a country might be able to develop more quickly in economic terms. Therefore, port city development must be in line with stable politics (*P12*). Thus, political stability is very important for port city development since politics is a driver of the development of an area (*P1*, *P5* and *P7*). Respondent *P13* concluded that *"Malaysia needs stable politics to develop the port city."* Thus, the effects of political instability can slow the port city development process.

3.4.3. Port city planning.

The management of a port generally includes various forms of planning, which take the servicing of users' needs as the driver of the utilisation of resources. The results of the current research indicate that some of those responding expressed the view that the development of a port city required both port and city planning. Notteboom et al. (2022) classified forms of planning into short- (one to three years), medium- (three to five years) and long-term (10-30 years). Respondent *P1* stated that *"a port city needs a development plan by developing industries around the port, whereby it must be supported from the government side."* Urban planning relates to attempts to ensure that land use is ordered and regulated in efficient and ethical ways, which prevents disputes over land use. Land development within the jurisdiction of a government can be managed through land use planning. The ability to achieve this enables government bodies to plan for the community's needs and safeguard environmental resources. The activities related to society, culture and the economy that occur at different places but form a system of activities characterise the 'urban area' (Rodrigue, 2020). According to respondent *P13, "[the] development of a port city needs some arrangement of the facility in or around the port [e.g., clinics, markets, police stations] and the parties or companies closest to the port are shipping liners, forwarding [companies] and factories so that movement of cargo is faster. Residential areas need to be situated far away from the seaport."* Respondents *P2, P3* and *P5* recommended that *"arrangement[s for] land use such as residential areas [and] infrastructure must be done comprehensively, not only focusing on seaport development, and the location of the port needs to be away from residential areas or populated areas must be [some] distance from the port."* The view of respondent *P13* was that *"port development areas must not interfere with residential areas."* Meanwhile, respondent *P14* pointed out that "*port and city planning must be integrated and synchronised."*

Seaport cities are artefacts of seaports and their growth depends on seaports (Radhakrishnan, 2017), so the port and the city must work together to promote local economic growth (*P1, P4, P6, P8, P9, P10 and P13).* Based on the view of respondent *P1*, "*to create a city around the port, the government needs to develop the surrounding areas such as [with] roads, business premises, housing and other land development."* It can be concluded that [the] development phase not only focuses on the port but the surroundings are also involved. Meanwhile, *P10* and *P13* emphasised that, *"the land is important and it is a major factor in the development of a port city."* Therefore, *P4, P6, P8* and *P9* proposed additional land or space be allocated for industrial development and administrative areas around the port, as well as to facilitate the general welfare of the residents. Meanwhile, respondent *P9* emphasised the zoning of areas for mixed development. This means that there should be sections for industries and commercial areas close to the port, and the commercial areas must be centralised together with the public facilities. Thus, the development of land requires spatial relationships between the port or its economic areas and the city. In historical terms, cities have often been sited due to the formation of a port, which would enable trading between countries, attract investment and facilitate the process of urbanisation (Zhao et al., 2017). According to Sun et al. (2016), access to transport, policies connected to space and interactions between neighbourhoods combined to expand the use of land for industry or commerce.

3.4.4. Port performance and competition.

A port provides various services for ships, cargoes and transportation to the hinterland. Ports have been required to provide services more rapidly since shipping lines have been in increasing demand. As a result, numerous ports worldwide have developed and modernised so they can improve their performance (Dayananda and Dwarakish, 2020). In a summary by Park et al. (2014), productivity in terms of operations, assets (equipment) and finance are the three main indicators of port performance. This study found that the port performance indicators include capacity, efficiency and effectiveness.

The role played by ports in modern supply chains is continually expanding. The capacity of a port and its terminals is measured by the highest tonnage of throughput it can handle, TEU, while this can also be assessed by its handling capacity over a set time period (Lagoudis and Rice, 2012). Respondent *P1* reported that *"there are several ports on the ECR of Peninsular Malaysia experiencing under-capacity [i.e., too little space]. For example, a port should be able to handle 10 ships/vessels a day. But [the number of] ships entering the port [may] reach 15 ships a day, so those five ships need to wait."* Meanwhile, respondents *P3, P4* and *P12* noted that *"in order to develop a port city, the capacity of the port can be increased to the optimum level [e.g., port services, facilities, infrastructures, number of ships, container and cargo]."* In contrast, a city may be hampered in its development next to a port by various limitations and poor-quality logistics (Zhao et al., 2017).

Port efficiency and effectiveness are the components of port performance. Generally, the term efficiency means how a port performs operationally, how it can maximise its output using the resources it possesses or its capacity to produce a set output with a specific amount of resources (Notteboom et al., 2022). Meanwhile, effectiveness illustrates the success with which resources are used to achieve the objectives pursued (Mihaiu et al., 2010). According to respondents *P1* and *P13*, *"the faster the port can handle cargo, the more ships will come."* Thus, a port needs to ensure efficient cargo handling so that the ship arrives and departs on time (*P10*). In addition, respondent *P6* noted that *"the effectiveness of port city development is how many job opportunities [are created for] the locals."*

The definition of port competition is competing for trading activities. The terminal forms the unit of competition, while the respective trades' chain managers are the logistical, transportation and industrial organisations. The broad definition of the port complex is co-developed by the authorities and policy makers of the port (Notteboom et al., 2022). Even within a particular region, the operators of ports and container terminals may be competing vigorously due to the modern dynamic business context (Kaselimi et al., 2011; Liu et al., 2020). The services and efficiency of a port operator can only be improved if they recognise and reassess the competitive elements involved (that is, their services' capacity, efficiency and costs) (*P1*). According to Liu et al. (2020), answers to these forms of competition are strenuously reviewed and evaluated by the operators of ports and container terminals. For example, the Port of Hong Kong is facing major competition from the Port of Shenzhen as the latter's costs are lower and its efficiency is rising. According to respondent *P5, "the growth of a port depends on the goods or commodities handled. It is also a competitive factor among other ports."* Respondent *P12*'s view was that *"to build a larger port, there must be many factories to support [the] activities of the port, and the most important thing is the goods to be marketed."* Innovative ways of producing goods have profoundly impacted ports since more volumes must be moved. The expansion in overall worldwide trade has been matched by the growth in maritime demand. A rise in trade boosts maritime demand, while the reverse is also the case. The growth in global production and maritime demand are clearly correlated (Chai, 2005).

3.4.5. Green environment and quality of life.

Going green is a trend of seaports all over the world and environmental management has become a critical aspect of a port's operation. Managing the environment has various benefits, offering consumer satisfaction, improved corporate reputation, savings on costs and protection for the environment (Teerawattana and Yang, 2019). The economy of a maritime city is vitally affected by shipping (UNCTAD, 2017), atmospheric pollution might be generated and, in residential areas on the coast, human health and the sea itself might be adversely affected (Gonzalez et al., 2018). Since many port cities suffer through the diversion elsewhere of the potential financial gains, they frequently become negatively impacted by pollution of the local environment, as well as higher levels of traffic congestion and crime. These factors reduce the urban competitiveness of port cities, thus impairing their capability to attract investors (Merk, 2013; Merk and Hesse, 2012; Zhao et al., 2017). According to respondent *P5, "the development of a port city should [bring] a [better] quality of life [to] the port and land/residents' areas."* Therefore, the port and land area must be clean, so the port, industry and community must comply with green practices (*P2*). Respondent *P12* supported this, saying *"[the] development of a port city needs to consider green elements or environmental factors.* It can be concluded that the pollution at a port and around the industrial area must be kept under control.

In general, green application has been detected as an influencing factor for port city development. This application is significant due to many issues has been raised in seaport which has been a main contributor for pollution and climate issues which affects the progress of sustainable development of the nation. The combination of seaport and city boosting the interrelationship of intermodal transportation, effectiveness in last mile connectivity and efficient interconnectivity with various mode of transportation which eventually lead to minimum congestion and cleaner environment especially through the application of modal shift in intermodal system. Reduction in empty vehicle movement, the implementation of co-modality as well as utilising inland terminals eventually prevents the issue of decarbonization. This healthy cooperation between seaport and city extend the sustainable growth in city as well in seaports especially by enhancing job opportunities, investment opportunities, infrastructure growth and additional business development.

The application of lean, agile, resilience and green (LARG) is an additional advantage for seaport for being sustainable in the maritime trade with the support of the resources from adjacent cities (Salleh et al. 2020) Owing to these benefits, the symbiosis collaboration between seaports and city may produce a sustainable environment for business and human factor growth. The application of concept from 4^{th} industrial revolution may assist seaports to be more sustainable because these nodes have employed substantial planning for waste management services, alternative energy services, and waste reception facilities, as well as proposing the usage of affordable and clean energy (Salleh et al. 2021 & Jeevan et al. 2022). These procedures protect the environment in the cities and improving the competitiveness of the seaport from the trade perspective.

According to Abdullah et al. (2012), a review of various countries' development models for port cities indicated the crucial requirement to integrate the land use planning of both ports and their urbanised areas. However, matters of logistics and transport efficiency appear to be the priorities when port areas improve their infrastructures, while the comfort and quality of life of the inhabitants tend to be disregarded. Many residential districts close to ports suffer from ongoing dependence on heavy goods vehicles, which leads to more highways, congestion and road accidents. Thus, the port city areas' inhabitants and employees might experience a reduced quality of life. Nevertheless, the port and the city often remain in close proximity, and the expansion of many ports' activities tends to mean that more products must be transported through urban areas. This adversely affects the flow of traffic and life in the city, while it also creates a more noticeable discrepancy between the principles of developing urban areas and those linked to developing ports (Zanne et al., 2021). While the port may be a valuable hub and impact its associated regions positively, there remains the need to address various challenges.

Respondent *P2*'s view was that *"the port location needs to be away from residential areas for the safety and comfort of [the] residents."* Moreover, ports need to identify the types of commodities handled on their premises (e.g., flammable items or chemicals), which could pose a danger to the surrounding population (*P4*). Generally, many consider the area immediately around a port to be bleak, unsafe, unclean and unappealing, while such districts typically contain aesthetically poor buildings and enormous, noisy and polluting equipment. Many locals may experience a sense of disconnection from the port, especially when the latter has shifted from the city (Notteboom et al., 2022). Respondent *P11* supported this, saying *"ports must look at the overall safety aspects of the population [congestion, accidents and criminal]."* In addition, respondent *P8* pointed out that *"to develop a port city, not only [must] factories ... be developed around the port, but [also,] from the security aspect, it is necessary to provide fire and rescue departments, police, customs departments and other security intelligence departments to increase the safety of residents."*

3.4.6. Population growth.

A growth in population entails numerous effects, including the national population's age structure, migration to other countries, wealth gaps and the scale of the nation's working population. The overall growth of the economy is affected by and affects these factors. Gross Domestic Product (GDP) changes are used to measure national economic growth. The use of the formula 'population multiplied by per capita GDP' allows GDP to be broken down into its constituent parts: population and economic features. The expansion of the economy equates to the growth in both population and per capita GDP, which is normally given in changes by percent (Peterson, 2017). In line with respondent *P4*, *"population growth and increased economic activity have led to urban growth."* As Chen et al. (2018) stated, the population bases of port cities are connected to the throughput of the ports, with the port scaled reflected through this indicator. The throughput of a port is influenced by several complicated and mutually influential factors. These include the structure of a region's industry, the growth of the urban population, as well as international economics and trade. Meanwhile, respondent *P5* noted that *"population growth affects port development."* However, respondent *P9* emphasised that *"the population must reach a sufficient level to develop the port city."*

3.4.7. Port city attractions.

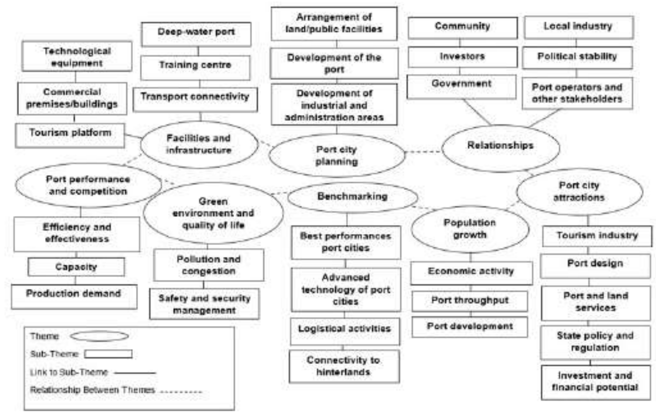
As argued by Palyvoda et al. (2020), a seaport's attraction to investors in influenced by external and internal elements. The former include the extent to which the state regulates activities, how the region's maritime economy and complexity have developed, the port's appeal in material and technical terms, as well as its appeal to investors. The latter include the port's potential productivity, its finances, its managers, its investment schemes and the extent to which development has featured innovation. According to respondent *P5*, *"[the] development of a port city needs to create a future plan to attract many investors to cover operating costs [e.g., dredging or maintenance]."* Respondent *P8* said that *"[the] development of a port city requires [the attraction of] investors to the hospitality industry and not just [to] develop production plants."* Respondent *P10* noted that *"the city must have interesting places for tourists to visit. The city grows with visitor support, if there is an attraction near the city."* Finally, a beautiful port design can be an attraction for the visitor (*P13*).

3.4.8. Benchmarking.

The management tool of benchmarking has its philosophical basis in continuous improvements and changes. Benchmarking is an attribute of the approach known as total quality management (Carpinetti and De Melo, 2002). Increased production levels and improved business performance are its main objectives. Since the port is a tertiary sector organisation, it is a suitable environment in which benchmarking can be applied. This approach can address the complicated context of the port (Cuadrado et al., 2004). As respondent *P13* stated, *"in order to develop the port city in the ECR of Peninsular Malaysia [Kelantan, Terengganu and Pahang], the stakeholder must refer to the best places of port cities in the world, such as Qingdao, Vancouver, Istanbul, Shanghai, Busan, Le Havre [and] Rotterdam."* The Malaysian ports of Klang and Tanjung Pelepas (PTP) have been rated as belonging to the leading 20 ports worldwide. In 2021, each reached performance milestones, with the former processing a container volume of 13.64 million twenty-foot equivalent units (TEUs) and the latter processing a volume of 11.2 million TEUs (The Edge Market, 2022). This set of criteria indicate that Port Klang is a potentially international-class future port city, an evaluation determined through its activities related to logistics, throughput and infrastructure (Anor et al., 2012).

On the other hand, the most prominent port in Malaysia is the Port of Tanjung Pelepas (PTP), whose container terminal features advanced technology. Additionally, the inland area near the PTP has good connections to the port. It is convenient to move cargoes from the large industrial estates because the road system connects the port to highways between Malaysia and Singapore and between the north and south of Malaysia. Thus, the port has good connections to northern Peninsular Malaysia and the border with Thailand. In conclusion, to make the ECR of Peninsular Malaysia a port city, the authorities need to refer to the various ports that have moved towards being port cities in both the local and global contexts. Figure 4 summarises the themes of influences on port city development, as generated from a local perspective.

Figure 4: Summary of themes of influencees on port city development.



Source: Authors.

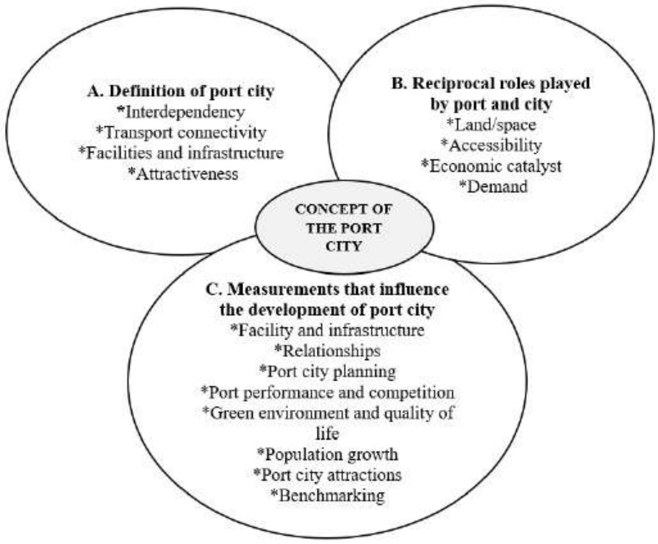
Implication and Conclusion.

The findings of the current study reveal Malaysian perspectives on the port city concept. Fourteen (14) respondents were interviewed to ascertain their views on the definition of a port city, the role of the seaport and the city, as well as the factors that influence the development of a port city (see Figure 5). Hein (2016), concluded that information or knowledge is needed from stakeholders for the economic growth of ports and cities. Parallel to this study, the respondents are made up of stakeholders such as seaport operators, seaport authority and regional planning. Hoyle (1989) summarizes the phase of port city development that has been going through since the late 19th century. The fact is, at that time, port development was necessarily linked to the growth of a city, so these two elements were interdependent on each other. In line with the findings of this study, it is believed that the definition of a port city can be viewed in the context of interdependency, transport connectivity, facilities and infrastructure and attractiveness (Figure 2); these features that must link the port and the land/city.

The idea or concept of defining the port city may guide the development of port city planning/policies for this country, particularly in the ECR of Peninsular Malaysia. When the port is developed, the surrounding cities also develop. It seems that both elements serve a wide variety of functions, and the resulting situation encourages port city interactions. Furthermore, the final phase (VII) of port city development (see Table 1) involves the integration of seaport and dry port operations, which connects the port function with the land/city (Jeevan et al., 2015). This finding is evidenced by the definition of the port city in the context of transport connectivity, facilities and infrastructure, where the dry port has been used as an interface between the port and the city to ensure the continuous development growth of the region.

These results also demonstrate that port cities play vital roles in enhancing regional development. The port also plays a considerable part in the culture, society and economy of its host city, while ports' connections to the wider world are also

Figure 5: Concept of port city development in East Coast region of Peninsular Malaysia.



Source: Authors.

important (Nicolini and Pinto, 2013). Simultaneously, each city has tended to grow into an influential place in which to conduct business. Cities can experience more dynamic economic expansion if businesses choose locations inside or near the city. The inhabitants can find appealing workplaces, shopping facilities, institutions of culture and education, new accommodation projects; in short, there is a complete infrastructure of society and technology (Witkowski and Kiba-Janiak, 2014). Therefore, the direct impact of ports on cities has been supported by Bazan-Lopes (2002). He concluded that various factors of the port positively affect the development of the city, for example, job opportunities for the local community can be offered through the activities of a port. Indirectly, the increase in cargo/goods can boost port activities, as well as contribute to the development of surrounding cities.

This study found that the reciprocal roles of the port and city can be viewed through the nodes of *land/space, accessibility, economic catalyst and demand* (Figure 3). Stakeholders such as the government or state authorities, port authorities, members of the community and port operators may optimise their role in port city development through collaborative or cooperative approaches to ensure that each party is not acting in isolation and that no one is left out of the port city development process. In addition, addressing these roles (as stated by the interviewed respondents) will enable ports and cities/land to more actively support the demand of both ports and cities, as well as overcome the challenges that hinder the development of port cities. Radhakrishnan (2017) supports that most large cities with good growth rates have developed port functions. As supported by Xiao and Lam (2017), the port has been considered as an engine of urban and regional economic growth.

Ports generally develop in different stages. According to Bird (1963), port evolution has three phases, from its primary establishment to its subsequent extension, which involves transferring from simple terminal facilities (wholesale and warehouse) to more advanced facilities. Transportation systems, as well as social, regional and economic activities, take place in port cities (Hoyle, 1997-1998). The current study found that eight (8) clusters/factors influence the development of a port city: *facilities and infrastructure; relationships; port city planning; port performance and competition; green environment and quality of life; population growth; port city attractions and benchmarking* (Figure 3). The typical seaport has experienced considerable alterations. Compared to their status as basic transition points between sea transportation and inland water systems, as well as importing and exporting goods to assist the surrounding industries, the port is now empowered, having become a business ecosystem and allowed numerous parties to conduct various operations (UNCTAD, 2021). According to the local perspectives, a state needs an industrial area to be able to grow in parallel with the port. For example, the Malaysia-China Kuantan Industrial Park (MCKIP) was developed together with the expansion of Kuantan Port. Contributions from industry are very important to the development of the port, so the port must provide extensive facilities to industries or customers. In line with Chen et al. (2016), the development of the port in the ECR of peninsular Malaysia needs to have a balance to overcome socio-economic problems compared to the main ports in Malaysia, which are more developed and geared towards port cities.

The development of port cities is dependent, to some extent, on governments, states, as well as other agencies and stakeholders. The seaport has been referred to as a catalyst for regional socioeconomic and spatial progress. Ports exhibit a range of functions, including transportation, industry, commerce, logistics and distribution, in addition to features connected to spatial development (Bochenski et al., 2021). Thus, the economy of a port might be significantly impacted if the stakeholders (including national and regional governmental institutions) can cooperate harmoniously. In short, it is hoped that the exploration of the port city concept will allow it to be translated into planning decisions, which can also deal with the entire port city conglomerate. In future studies, these factors can be explored on a larger scale to serve as guidelines for port cities in other areas.

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Redundant constraints in diesel engines' mechanisms: a case study

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ABSTRACT

IMO Model Courses 7.04 and 7.02 for marine engineers' knowledge requires students to acquire competencies that relate to basic construction and operation principles of marine diesel parts, wear detection, maintenance, and repair. But achievement by students of special skills and competencies is usually clouded by misunderstanding relations between marine diesel parts construction, features of their assembling, operation, and maintenance conditions with their wear and failures. Among other issues these is the result of practical cases lack in general engineering disciplines content. The aim of article was to illuminate used in Kherson State Maritime Academy (KSMA), case-study and authors practical experience based approach of general and specific knowledge mutual integration in studying «Machines and Mechanisms Theory», «Applied Mechanics», «Marine internal combustion engines» and «Marine Machinery Maintenance and Repair» academic disciplines. Presented in article results made it possible to enhance the achievement of special skills and competencies by future marine engineers.

1. Introduction.

The use of real world examples is widespread in mathematics education, physics, chemistry, electric engineering and marine energetics education, with the objective of increasing students' interest and promoting effective learning [3], [5], [7], [8] («When studying the science, the examples are more useful than the rules» - Isaac Newton).

Case-study approach makes possible for students and recent graduates to achieve new understandings from bringing them real-life experiences in civil, thermal, electric and mechanical engineering [2], because it provides a glimpse of how real-world engineering differs from traditional textbook problems and how engineering can impact on corporate bottom line. In basic engineering courses, studied in undergraduate the teaching process is important as studies objects will be used as a carrier to pull teaching along [14].

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2. Literature review and problem statement.

Students' interest in learning and future practicing in specific field by increasing gradually and systematically their engineering practice ability usually reach exactly in basic engineering education. Marine engineers tutoring, judging by the authors practice in KSMA, have a few specific options. From the one hand the lack of students' interest in some complicated chapters of «Applied Mechanics» academic discipline, for example topic «Redundant constraints in mechanisms», have a reason in absence in common handbooks [1], [4], [13] detailed practical cases related to marine machinery structure and operation, to illustrate the impact of redundant constraints on the life cycle of marine machinery. Therefore it is common for educators to use well-studied examples for railway transport, metallurgical and other non-marine machinery that additionally decreases students' interest. From the other hand, IMO Model Courses 7.04 and 7.02 for marine engineers learning require students to acquire competencies that relate to basic construction and operation principles of marine diesel parts, wear detection, maintenance, and repair. Some of those are shown in table 1. Shown there content of the IMO Model Courses does not regulate understanding by students relations between marine diesel parts construction, features of their assembling operation, and maintenance conditions with their wear and failures, but this understanding is the way to enhance the achievement of special skills and competencies. Authors convinced that providing during studying general and specific knowledge mutual integration and intersubject interrelations could make a synergetic effect and deepen understanding by students both of general and specific knowledge, namely load transfer and failure emergence processes which take place in marine machinery elements while assembling and operating.

Table 1: IMO Model Courses 7.04 and 7.02 content (excerpt).

IMO model course	7.04 OFFICER IN CHARGE OF AN ENGINEERING WATCH	
Function	1. Marine Engineering at the Operational Level.	3. Maintenance and Repair at the Operational Level.
Competence	1.4 Operate main and auxiliary machinery and associated control systems.	3.2 Maintenance and repair of shipboard machinery and equipment.
Knowledge, understanding and proficiency	1.4.1 Basic construction and operation principles of machinery systems / 1.4.1.1 Diesel engine.	3.2.3 Maintenance and repair such as dismantling, adjustment and reassembling of machinery and equipment / 3.2.3.8 Diesel engine.
Competence demonstration methods	- Name the materials used in the manufacture of the listed items, then describe, with the aid of sketches, the assembled construction of these items: - *a cylinder liner; - a piston; - a connecting rod; - a piston pin; - the crankshaft.* - Uses engine builders' manuals to obtain working clearances specified by the instructor.	- Dismantles and inspects all parts for wear and deterioration, including: – *pistons;* – *liners;* – *bearings.*
IMO model course	7.02 CHIEF ENGINEER OFFICER AND SECOND ENGINEER OFFICER	
Function	1. Marine Engineering at the Management Level.	
Competence	1.1 Manage the operation of propulsion plant machinery.	
Knowledge, understanding and proficiency	1.1.1 Design features, and operative mechanism of marine diesel engine and associated auxiliaries.	
Competence demonstration methods	Describes with the aid of sketches/computer aided drawing, material selection, and design features of the combustion chamber components of diesel engine: *- piston assembly.*	

Source: Authors.

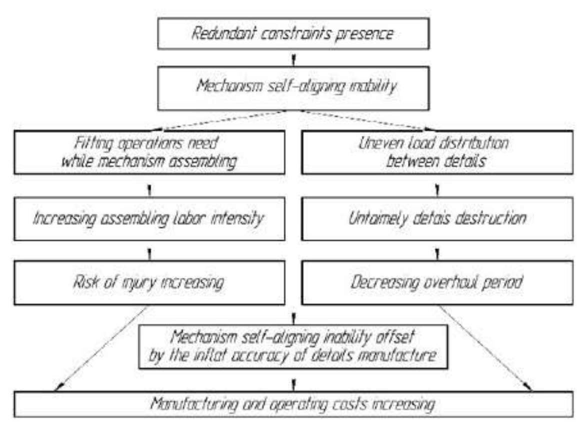
The main hypothesis of this work is that «Applied Mechanics» discipline «Redundant constraints in mechanisms» topic content extending by considering practice features of marine equipment (namely marine diesel engines) design, failures and assembling features is the way of future marine engineers specific professional skills and competencies achievement intensifying. The main aims of the work are:

- to analyze the common failure of marine trunk-type diesel rod bearings failures;
- to show redundant constraints impact on it, and elimination measures through diesel parts modifying that took place in practice;
- to show that extending "Applied Mechanics" content by including mentioned examples could intensify achievement of specific professional skills and competencies by students of marine engineering specialties.

3. Materials and methods.

Described circumstances encouraged authors to use of the case-study method because it allows combining theory and complex reality in the classroom. The use of the case-study method allows students to apply the acquired knowledge to solve specific practical problems and develops the ability to acquire competence [8], [14]. To provide this method in practice it was necessary to consider and analyze specific cases of diesel elements failures that have occurred in practice and analyze it, using specific machine and mechanism theory tools, to provide than an understanding of the impact of the presence of the redundant constraint in the mechanisms on the life cycle of the machine (fig. 1), and arouse students' interest in the professional specific disciplines study in senior courses. Moreover, detection and elimination of redundant constraints for the marine diesels' mechanisms is interesting because it is most common marine engines and especially acute because they contain multi-supported shafts, links which are intake in several kinematic pairs.

Figure 1: Redundant constraints influence on machine life cycle scheme.



Source: Authors.

4. Development.

4.1. Parts failures.

Main part of marine trunk-type diesels details (crankshafts, pistons, bearings) failures has their reason presence of misalignment while operation. In diesels, where piston connected with rod by cylindrical joint, most common of connection rod bearings failures (fig. 4) are: metal to metal contact (fig. 4, a); fatigue of outer-surface lining (fig. 4, b). Reducing the probability of the described failures is provide on practice maintenance by performing fitting operations while assembling, namely clearances $g_1...g_4$ measuring and additional tooling of connection rod bearings. The need to perform fitting operations is due to the mechanism links self-aligning inability because of redundant constraints presence.

4.2. Causes of failure.

Trunk-type diesel slider-crank mechanism contains three (n = 3) movable links - crankshaft 1, connection rod 2 and piston 3. Number of 5-class kinematic pairs here is $P_5 = 2$ (O_5, B_5), number of 4-class kinematic pairs is $P_4 = 2$ (A_4, C_4), pairs of third, second and first class are absent ($P_3 = P_2 = P_1 = 0$).

Total kinematic pairs number is:

$$P = P_5 + P_4 + P_3 + P_2 + P_1 = 2 + 2 + 0 + 0 + 0 = 4 \quad (1)$$

The sum of kinematic pairs movabilities:

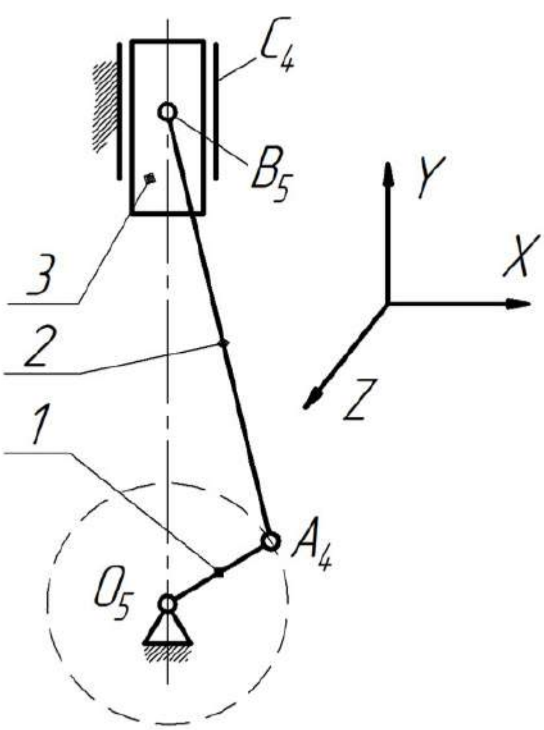
$$f = 1P_5 + 2P_4 + 3P_3 + 4P_2 + 5P_1 = \\ 1 \times 2 + 2 \times 2 + 3 \times 0 + 4 \times 0 + 5 \times 0 = 6. \quad (2)$$

Number of independent locked circuits by Gohman formula [13] is:

$$k = P - n = 4 - 3 = 1 \quad (3)$$

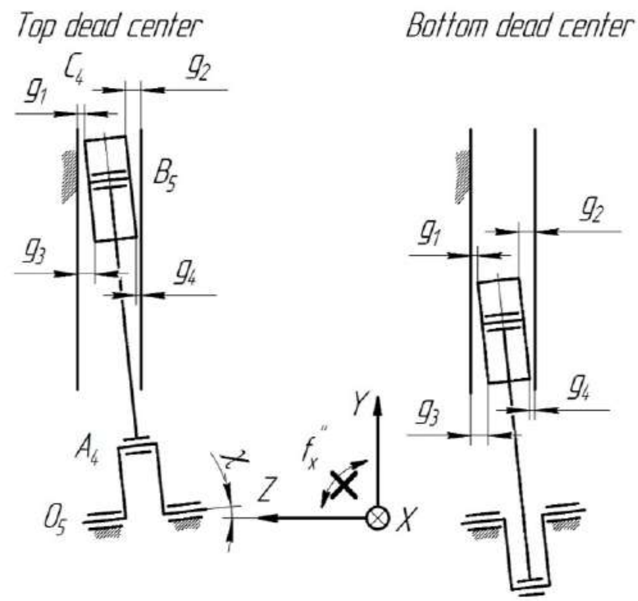
Single independent locked circuit in mechanism - $O_5A_4B_5C_4O_5$.

Figure 2: Structural diagram of slider-crank mechanism with piston and rod cylindrical connection.



Source: Authors.

Figure 3: Piston-cylinder liner clearances distribution diagram in slider-crank mechanism with piston and rod cylindrical connection in angular misalignment χ condition.



Source: Authors.

Total mechanism mobility by Voinea and Atanasiu [17] is:

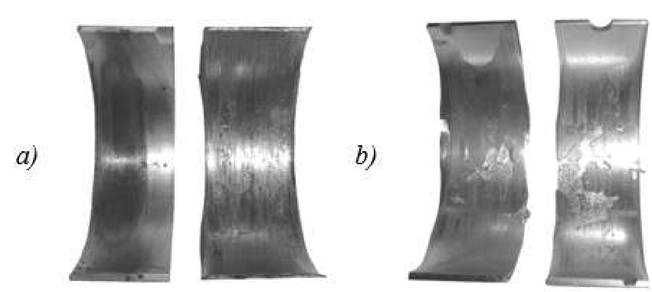
$$W = f - \sum r_i = 6 - 5 = 1 \quad (4)$$

where $r_1 = 5$ – independent locked circuit $O_5A_4B_5C_4O_5$ kinematic pairs axes rank.

Single mechanism mobility is its basic mobility $W = W_b$.

$$f = 1P_5 + 2P_4 + 3P_3 + 4P_2 + 5P_1 = \\ 1 \times 1 + 2 \times 2 + 3 \times 1 + 4 \times 0 + 5 \times 0 = 8. \quad (5)$$

Figure 4: Photographs of marine diesel engine misalignment-reasoned connecting rod bearings failures: metal to metal contact (a); fatigue of outer-surface lining (b).



Source: substech.com.

Redundant constraints number by Somov and Malyshev formula [13]:

$$q_{SM} = W + 5P_5 + 4P_4 + 3P_3 + 2P_2 + P_1 - 6n = \\ 1 + 5 \times 2 + 4 \times 2 + 3 \times 0 + 2 \times 0 + 0 - 6 \times 3 = 1. \quad (6)$$

Circuit Reshetov's method [13] confirms given results and allows to specify redundant constraints type and location (table 2). Single angular redundant constraint q_1 in mechanism made impossible mechanism self-alignment due to movability around X-axe ($f_x^{''} = 0$) inability and causes uneven gaps $g_1 ... g_4$ (fig. 3) distribution which in practice compensating through additional tooling of connection rod bearings.

4.3. Failure elimination measures.

Liquidation of existing redundant constraint is possible by addition in circuit mobility around X-axe due to kinematic pairs class change. The easiest way to do it is connecting piston and rod by spherical joint. In this case class of B kinematic pair became third from fifth (fig. 5). Therefore, number of 5-class kinematic pairs became $P_5 = 1$ (O_5), number of 4-class kinematic pairs - $P_4 = 2$ (A_4, C_4), 3-class $P_3 = 1$ (B_3), second and first class $P_2 = P_1 = 0$.

The sum of kinematic pairs movabilities:

Total mechanism mobility:

$$W = f - \sum r_i = 8 - 6 = 2 \tag{7}$$

where $r_1 = 6$ – independent locked circuit $O_5A_4B_3C_4O_5$ kinematic pairs axes rank.

Total mechanism mobility including basic mobility $W_b = 1$ and piston 3 local mobility $W_l = 1$ (rotation around Y-axe) - $W = W_b + W_l = 2$.

Table 2: Circuit method application to slider-crank mechanism with cylindrical piston and rod connection.

Circuit	Planar movabilities f_n	Non-planar movabilities $f_н$
$O_5A_4B_5C_4O_5$	$f_x^{'}$ $f_y^{'}$ $f_z^{''}$ Ø C B W_b OA	$f_x^{''}$ $f_y^{''}$ $f_z^{'}$ Ø C A q_1
$W = 1$, $q = 1$		

Source: Authors.

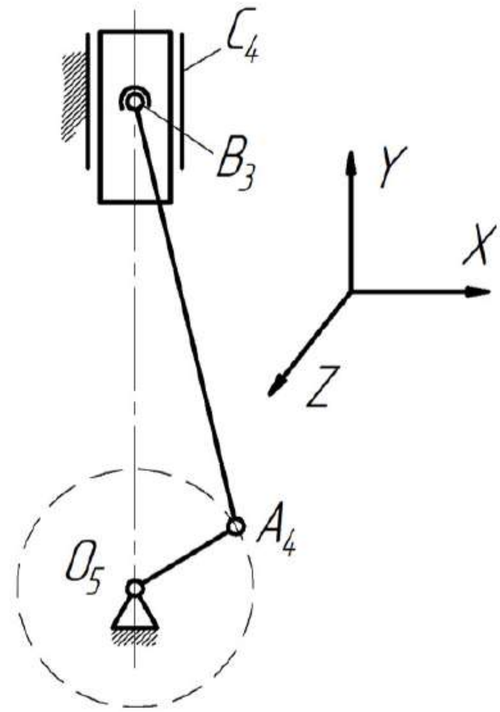
Redundant constraints number is:

$$q_{SM} = W + 5P_5 + 4P_4 + 3P_3 + 2P_2 + P_1 - 6n = 2 + 5 \times 1 + 4 \times 2 + 3 \times 1 + 2 \times 0 + 0 - 6 \times 3 = 0. \tag{8}$$

$$q_{OZ} = W + 6k - f = 2 + 6 \times 1 - 8 = 0. \tag{9}$$

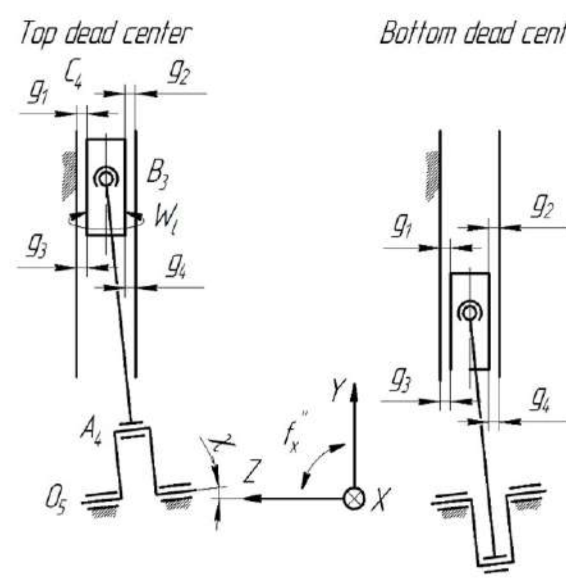
Circuit method confirms given results (table 3).

Figure 5: Structural diagram of slider-crank mechanism with piston and rod spherical connection.



Source: Authors.

Figure 6: Piston-cylinder liner clearances distribution diagram in slider-crank mechanism with piston and rod spherical connection in angular misalignment χ condition.



Source: Authors.

Making kinematic pair B spherical through adding $f_x^{''}$ movability, provides piston self-aligning on cylinder liner in angular misalignment χ condition. This became the reason of gaps $g_1 ... g_4$ alignment (fig. 6) while diesel assembling and operation and ensure even load distribution on connection rod bearing A

(fig. 7, b) compared with basic cylindrical joint (fig. 7, a). Piston and rod spherical connection realized in Sulzer ZA40-type (fig. 8) marine diesels. Existence in its mechanisms piston local movability W_l around own axe makes possible, due to ratchet mechanism, to provide piston rotation during engine operation [15], [18].

Table 3: Circuit method application to slider-crank mechanism with spherical piston and rod connection.

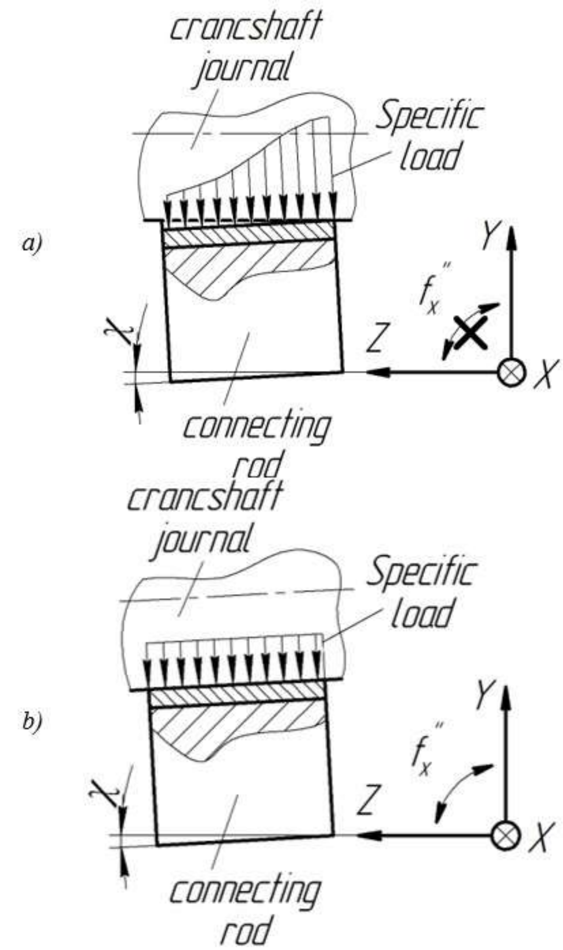
Circuit	Planar movabilities f_n	Non-planar movabilities $f_н$
	f_x' f_y' f_z''	f_x'' f_y'' f_z'
$O_5A_4B_3C_4O_5$	Ø C B OA W_b	B BC W_l A
$W = 2,\ q = 0$		

Source: Authors.

Providing links self-aligning possibility and piston local movability in Sulzer ZA40-type diesel slider-crank mechanism in operation gave following merits:

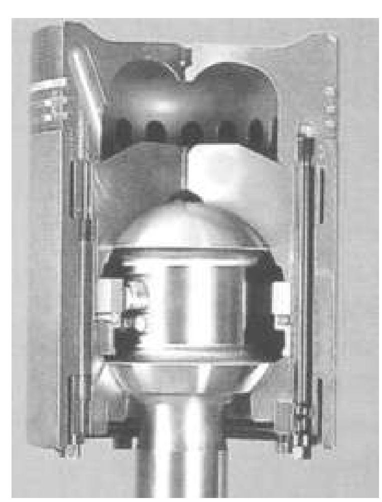
- eliminate the need for fitting operations work while diesel assembling and reduce the time for its maintenance and repair;
- even temperature distribution around the piston crown as there are no particular inlet and outlet zones;
- optimum sealing and working conditions for the piston rings because the small, symmetrical deformations of the piston allow the use of the smallest running gap between piston and cylinder liner;
- low and stable lubrication oil consumption because the small piston running gaps minimize piston slap and obviate the need for the traditional oil cushion, thereby allowing the oil scraper ring to be located at the lower end of the piston skirt;
- good margin for unfavorable running conditions with the smallest risk of seizure because the grey-iron piston skirt is always turning to a fresh part of the cylinder liner surface.

Figure 7: Connecting rod bearing load distribution diagram in the cylindrical (?) and spherical (b) piston and rod in angular misalignment χ condition.



Source: Authors.

Figure 8: Photograph Sulzer ZA40 engine's piston and rod spherical connection in section.

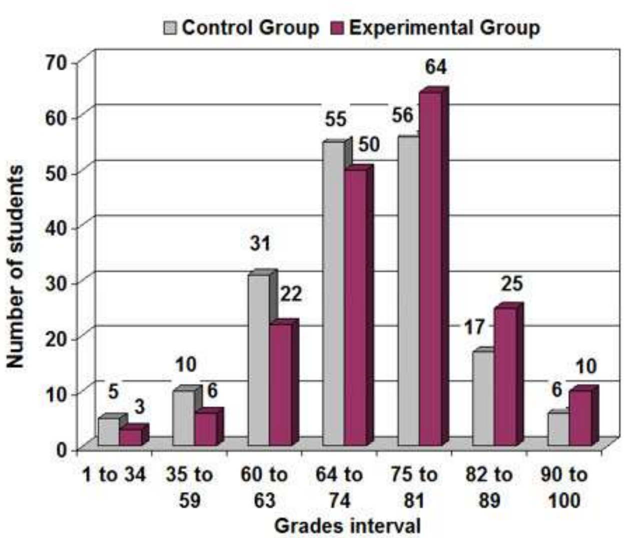


Source: Sulzer Brothers limited.

5. Results.

Using developed by the authors and presented in this paper issues in teaching the ”Applied Mechanics” and «Machines and Mechanisms Theory» disciplines for students majoring in ”Ship power plants operation” in KSMA continued in 2016-2020. Experimental evaluation of academic progress was done for 12 academic groups of students (total 360 persons) which were divided into two experimental groups - control and experimental. In the control group ”Redundant constraints in mechanisms” section of ”Applied Mechanics” discipline (4-th semester) was studied in a regular way using typical ”non-marine” examples from widespread textbooks. In the experimental group, we used presented in this paper (and also in [11] and [12]) examples from our engineering practice. Studying theme ”Redundant constraints in mechanisms” began there from trunk-type diesel elements failure analysis. After that we used to ask the audience a few questions - why is this happening? How to prevent this? What constructive decisions had to be made to avoid those failures? How do redundant constraints influence marine diesel slider-crank mechanism maintenance features? How do diesel elements construction effect on load distribution between them and their failures? These questions were answered during the classwork, performing a structural analysis of the mechanisms, finding the number and location of redundant constraints, and suggesting options for their elimination. Then, a comparative analysis of students' learning of topics ”Diesels movement parts design” and ”Diesels movement parts maintenance and repair” of disciplines, respectively ”Marine internal combustion engines” (5-th semester) and ”Marine Machinery Maintenance and Repair” (6-th semester) was performed. Assessment of knowledge was performed in the test form.

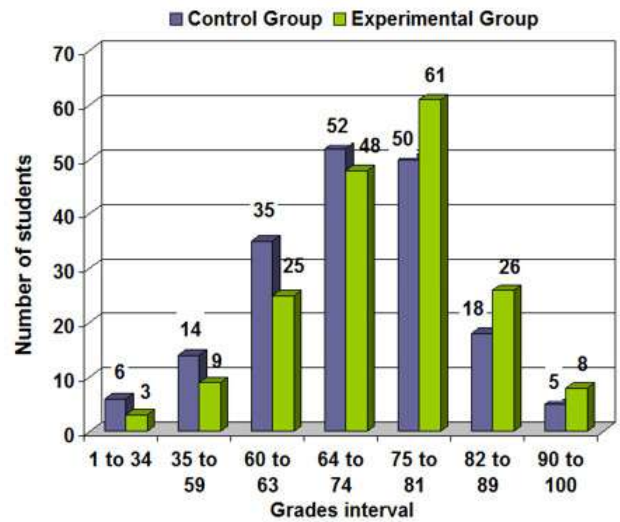
Figure 9: Students rating result (discipline ”Marine Internal Combustion Engines”, topic ”Diesels movement parts design”).



Source: Authors.

The results of knowledge assessment for the control and experimental groups are presented in the fig. 9 and fig.10. The results of the experiment made it possible to show that the applying of the proposed methodology and content of teaching the section ”Redundant constraints in mechanisms” of the ”Applied Mechanics” discipline allowed to intensify learning process of mentioned special disciplines and to enhance the achievement of special skills and competencies by future marine engineers.

Figure 10: Students rating result (discipline ”Marine Machinery Maintenance and Repair”, topic ”Diesels movement parts maintenance and repair”).



Source: Authors.

Conclusions.

Apparently, the main aspects that encourage students to study engineering are mainly motivational, as well as creating something new, or solving some complex operational problems. General engineering education is an important phase to show to the aspiring students that their main motives, being able to do and solve and to be technically challenged, are satisfied. At the same time, the learning of future marine engineers may be very specific, tied to the characteristics of the operational possession and specific powers to the first service, regulated by the IMO Model Courses. In this case, general engineering education sideways of specific skills achievement is not allowed to reach the maximum possible progress in the future specialty. In this article, an example of general and specific, required by courses 7.04 and 7.02, knowledge mutual integration in ”Applied Mechanics” and specific academic disciplines, studying KSMA, is given.

Presented in this work case-study approach of ”Redundant constraints in mechanisms” section learning tested over a number of years and gave the positive results. The following are specific conclusions that can be drawn from the observations made in the current work:

- case, extending ”Applied Mechanics” academic discipline content for marine engineers, allowing to show the effect of redundant constraints on the design and common failures of marine diesel parts, which is often encountered in practice and understandable to students is developed;

- the developed case allows filling the vacuum existing in the special literature on "Applied Mechanics" for marine engineers. This makes it possible to facilitate the work of educators and students in the preparation and study of general engineering and specific disciplines;
- an experiment conducted over a number of years made it possible to establish that the application of the proposed approach to the study of the section "Redundant constraints in mechanisms" makes it possible to intensify the achievement of special skills and competencies of marine engineering specialties students. Particularly after the study of the topics "Diesels movement parts design" and "Diesels movement parts maintenance and repair" of, respectively, "Marine Internal Combustion Engines" and "Marine Machinery Maintenance and Repair" academic disciplines, the number of failed students decreased by 60%, learning quality increased by 25...30 % (the number of C, B, and A-graded students), the number of excellent students increased by 60...67%. This study further emphasizes the necessity to deepen teaching the "Applied Mechanics" course for future marine engineers, because its role is unmistakable in keeping up the specific education standards at a high level.

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Predicting Preliminary Structural Strength Requirements of Cargo Vessels using Artificial Neural Network

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ABSTRACT

In the preliminary stage of a ship design, different classification societies rules are usually followed for predicting the structural strength after finalizing the principal particulars of the ship. Most of the formula for evaluating the requirements of structural strength of a ship using classification societies rules are empirical and the time required is very significant. In present study, an artificial neural network (ANN)-based method is proposed to predict the structural strength requirements for cargo vessels. Keel Plate Weight (KPW), Bottom Plate Weight (BPW), Inner Bottom Plate Weight (IBPW), Side Shell Plate Weight (SSPW), Bulkhead Weight (BW) and Main Deck Weight (MDW) is predicted as a function of ships' rule length (L), breadth (B) and draft (T). An ANN model was trained to achieve a root mean square error (RMSE) of less than 0.13. The R^2 of the trained model used to evaluate the new data is 0.998, which indicates that the various requirements of weights calculated by ANN model is in good agreement with the classification societies results.

1. Introduction.

Determining structural strength requirements has a significant impact on the preliminary ship design process because it effects the overall construction costs of the ship. Now-a-days structural strength requirements of a ship are calculated using the Finite Element Method (FEM) and Classification Societies rules. Classification societies rules are based on empirical formulas. However, there are several drawbacks in using FEM for preliminary structural strength analysis. For example, the accuracy of FEM solution highly depends on the initial boundary conditions. Furthermore, the high cost of FEM analysis, which is primarily due to the high computational power and the time required to generate many accurate structural strength analysis databases. Using classification societies empirical formula is time consuming and much effort is also required. Another drawback of using those formulas is that different classification societies have different rules [Kabir et.al. 2022]. Recently trained Artificial Neural Network (ANN) models have gained attention for learning the responses of large, complex, and nonlinear systems [Liu et.al. 2016]. Using ANN can significantly reduce the time requirements for determining the structural strength requirements.

Kabir et.al. 2022 calculated the variations of the structural strength requirements among classification societies such as RINA, BV, IRS and DoS for a coastal cargo vessel. In present study, required data set for ANN models is generated using the results of Kabir et.al. 2022.

2. Principal Particulars.

The General Arrangement (GA) plan and the principal particulars of the coastal cargo vessel used by Kabir et.al.[1] is mentioned in Fig.1. and Table 1 respectively.

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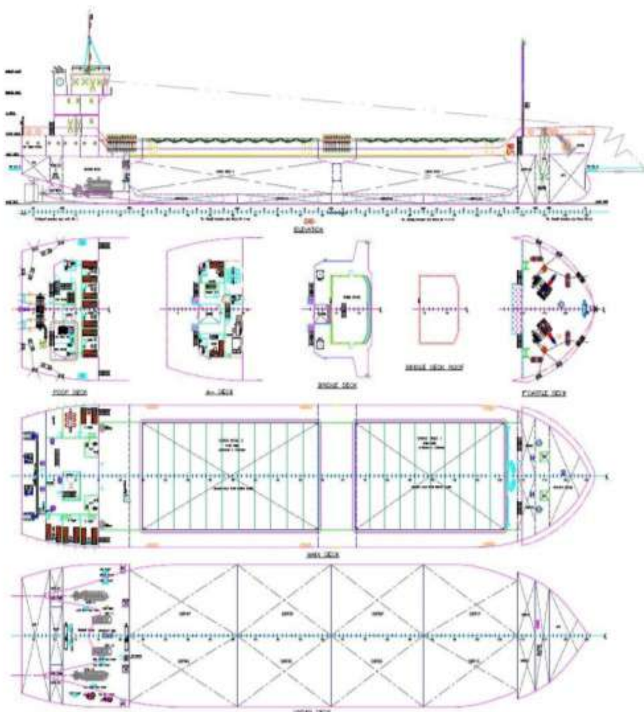
Table 1: Principal particulars of the coastal cargo vessel [Kabir et.al. 2022].

Particulars	Data	Unit
Length Overall	83.00	[meter]
Length LWL@ Scantling Draft	81.52	[meter]
Length BP@ Scantling Draft	79.90	[meter]
LWL extreme at scantling draft	81.52	[meter]
97% of above	79.075	[meter]
Rule length	79.075	[meter]
Breadth of the ship	18.000	[meter]
Depth, D	6.00	[meter]
Design Draft,	4.50	[meter]
Scantling Draft,	4.50	[meter]
Block co-efficient, C_b	0.84	[meter]
Service Speed,	10	[Kn]
Deadweight	4000	[Ton]

Source: Authors.

Figure 1: General Arrangement plan of a coastal cargo [Kabir et.al. 2022].



Source: Authors.

3. Formula for Structural Strength Requirements.

Various formula of classification societies for determining the structural strength requirements of a cargo vessels length ranging from 65.00 meter to 89.00 meter is presented in Table 2.

Table 2: Formula for the minimum net thickness of plating.

Location	Area	RINA	BV	IRS
Keel	-	$5.1+0.026LK^{1/2}+4.5s$	$3.8+0.040LK^{1/2}+4.5s$	$t=(t_o+0.03L)\sqrt{k}+2$
Bottom	Longitudinal framing Transverse framing	$3.2+0.018LK^{1/2}+4.5s$ $4.1+0.018LK^{1/2}+4.5s$	$1.9+0.032LK^{1/2}+4.5s$ $2.8+0.032LK^{1/2}+4.5s$	$t=(t_o+0.04L)\sqrt{k}$
Inner Bottom	Outside the engine room Engine room	$1.9+0.024LK^{1/2}+4.5s$ $3.0+0.024LK^{1/2}+4.5s$	$1.9+0.024LK^{1/2}+4.5s$ $3.0+0.024LK^{1/2}+4.5s$	$t=(t_o+0.03L)\sqrt{k}$
Side	Below freeboard deck Between freeboard deck and strength deck	$3.1+0.017LK^{1/2}+4.5s$ $3.0+0.004LK^{1/2}+4.5s$	$2.1+0.031LK^{1/2}+4.5s$ $2.1+0.013LK^{1/2}+4.5s$	$t_t=(5.0+c.L)\sqrt{k}$
Bulkhead	Transverse watertight Longitudinal watertight Tank and Wash	$1.3+0.004LK^{1/2}+4.5s$ $1.7+0.013LK^{1/2}+4.5s$ $1.7+0.013LK^{1/2}+4.5s$	$1.3+0.004LK^{1/2}+4.5s$ $1.7+0.013LK^{1/2}+4.5s$ $1.7+0.013LK^{1/2}+4.5s$	$t=(5.0+c.L)\sqrt{k}$
Main Deck	Area within 0.4 amidships: Longitudinal framing Transverse framing	$2.1+0.032LK^{1/2}+4.5s$ $2.1+0.032LK^{1/2}+4.5s$	$1.6+0.032LK^{1/2}+4.5s$ $1.6+0.032LK^{1/2}+4.5s$	$t=(6+0.02L)\sqrt{k}$

Source: Authors.

Where, L = Rule length, K = Material factor, s = Spacing of short side of the plate panel, c = Co efficient, t_0 = Constant.

Minimum thickness of various structural members without and with corrosion addition of the coastal cargo vessel for different classification societies calculated by Kabir et.al. 2022 is shown in Table 3 and Table 4 respectively. Table 5 represents the weight of various structural members of the coastal cargo vessel for different classification societies calculated by Kabir et.al. 2022.

Table 3: Minimum net thickness of plating without corrosion addition.

Location	Area	RINA (mm)	BV (mm)	IRS (mm)
Keel	-	9.766	9.573	10.163
Bottom	Longitudinal framing	7.391	7.198	8.163
	Transverse framing	8.448	8.225	
Inner Bottom	Outside the engine room	6.565	6.565	8.372
	Engine room	7.665	7.665	
Side	Below freeboard deck Between freeboard deck and strength deck	7.369 6.016	7.476 5.828	8.163
Bulkhead	Transverse watertight Longitudinal watertight Tank and Wash	4.384 5.653 5.653	4.384 5.653 5.653	5.791
	Area within 0.4 amidships:			
Main Deck	Longitudinal framing Transverse framing	7.398 8.188	6.898 7.055	7.582

Source: Authors.

Table 4: Minimum net thickness of plating with corrosion addition.

Location	Area	RINA Theoretical	Rounding	BV Theoretical	Rounding	IRS Theoretical	Rounding
Keel	-	10.766	11	10.573	11	12.163	12
Bottom	Longitudinal framing	8.391	8	8.198	8	10.163	10
	Transverse framing	9.448	9	9.225	9		
Inner Bottom	Outside the engine room	8.315	8	8.315	8	10.372	10
	Engine room	9.415	9	9.415	9		
Side	Below freeboard deck	9.119	9	9.226	9	10.633	11
	Between freeboard deck and strength deck	7.766	8	7.578	8		
Bulkhead	Transverse watertight Longitudinal watertight Tank and Wash	6.134 6.653 6.653	6 7 7	6.134 6.653 6.653	6 7 7	7.791	8
	Area within 0.4 amidships:						
Main Deck	Longitudinal framing Transverse framing	7.898 8.688	8 9	7.398 7.555	7 8	9.082	9

Source: Authors.

Table 5: Weight of plates in cargo hold area as per classification societies.

Location	RINA	BV	IRS
Keel	5.82 Tons	5.82 Tons	6.35 Tons
Bottom	64.91 Tons	64.91 Tons	81.14 Tons
Inner bottom	51.93 Tons	51.93 Tons	64.91 Tons
Side	37.58 Tons	37.58 Tons	45.94 Tons
bulkhead	10.51 Tons	10.51 Tons	14.02 Tons
Main Deck	23.73 Tons	20.76 Tons	26.69 Tons
Total	~195 Tons	~192 Tons	~239 Tons

Source: Authors.

4. Prediction using Neural Network.

Artificial neural networks (ANNs) are inspired by human brains. It can be created in a computer by mimicking the process of real neurons [Krogh, A. 2008]. Many types of problems can be learned to solve by ANNs [Basheer, 2000 and Abiodun et.al. 2019]. The main objective of designing an ANN model is that the model should make good predictions for new data or, in other words, the model should exhibit good generalization. The first step of designing such a network is creating a dataset.

4.1. Dataset preparation.

Ship rule length (L), Breadth (B), Draft (T), KPW, BPW, $IBPW$, $SSPW$, BW and MDW of different classification societies are the features of the dataset. RINA, BV, IRS and DOS is used to generate the total 5000 datapoints. 10% of the dataset is used as a test data and the remaining observations, 90% are used for training. 10% data are used to validate the model's accuracy after each epoch. A summary of the data breakdown is shown in Table 6.

Table 6: Partition of the dataset.

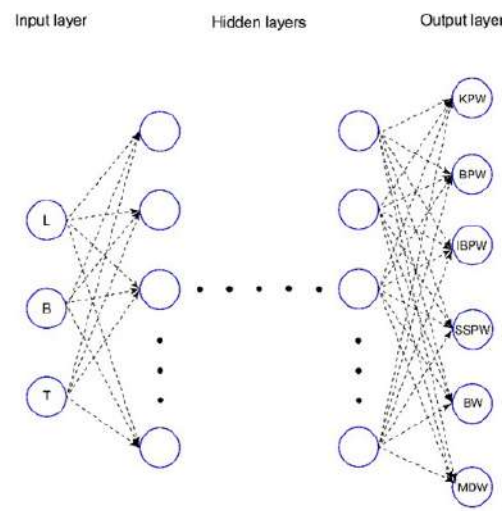
Dataset	Observations
Training data	4050
Validation data	450
Testing data	500

Source: Authors.

4.2. Network architecture.

The used ANN architecture is shown in Fig.2, consisting of an input layer, hidden layers, and an output layer with neurons in each layer. The input layer takes all the input features namely Ship rule length (L), Breadth (B), Draft (T) and then calculates the weighted sum of the inputs, and then the bias term is added. This linear combination goes through a non-linear activation function to output transformed features. The output of the input layer then goes to the next layer, and this process continues layer by layer until the last layer, which predicts the output features namely KPW, BPW, $IBPW$, $SSPW$, BW and MDW for RINA, BV, IRS, and DOS. Thus, the input features are mapped to the output features through a series of mappings.

Figure 2: ANN architecture used in the scantling requirements prediction network.

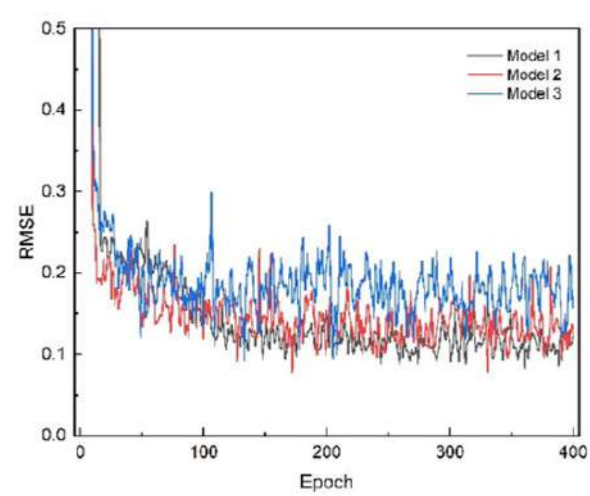


Source: Authors.

5. Results and Discussion.

In present study, three different ANN models are used for training. The models are trained for 400 epochs in which all the training data is fed to the network in batches of 32 observations before the weights are allowed to update using the root mean squared error (loss) of the batch. The model's training loss is shown in Fig. 3. RMSE of models along with network architectures is shown in Table 7. From Table 7 it is evident that model 1 with two hidden layers and eight nodes predicts better.

Figure 3: Training losses of ANNs after 400 epochs.



Source: Authors.

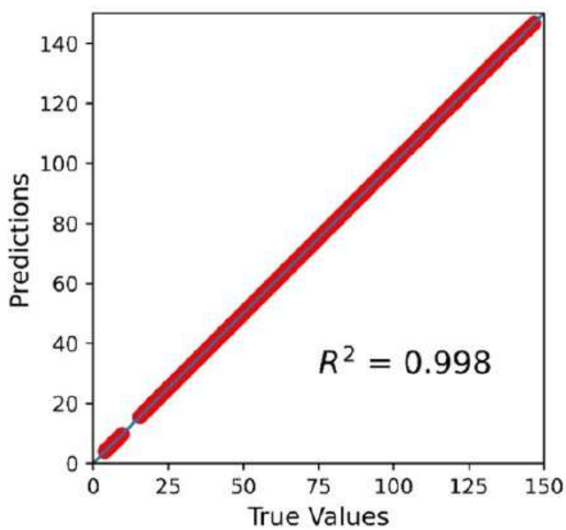
Table 7: ANN performance for 3 different models.

ANN model	No of hidden layers	No of nodes	RMSE
Model 1	2	8	0.126520
Model 2	2	16	0.128367
Model 3	3	8	0.170921

Source: Authors.

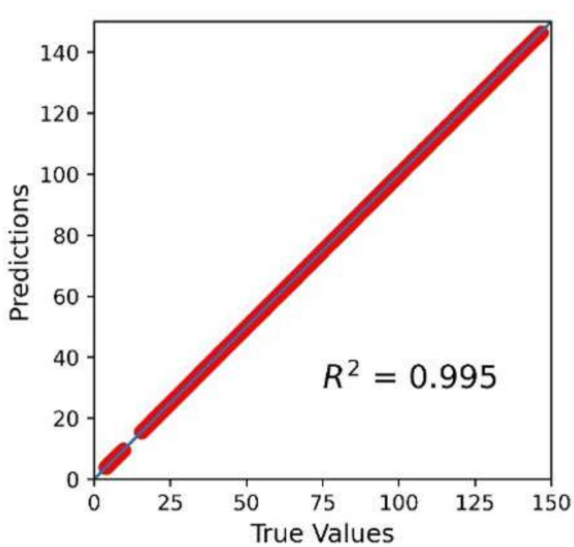
The R^2 values of the models were shown in Figs. 4~6. From Figs. 4~6, it is noticed that Model 1 has the highest R^2 value of 0.998 which is close to the maximum value of 1.0.

Figure 4: R^2 value of Model 1.



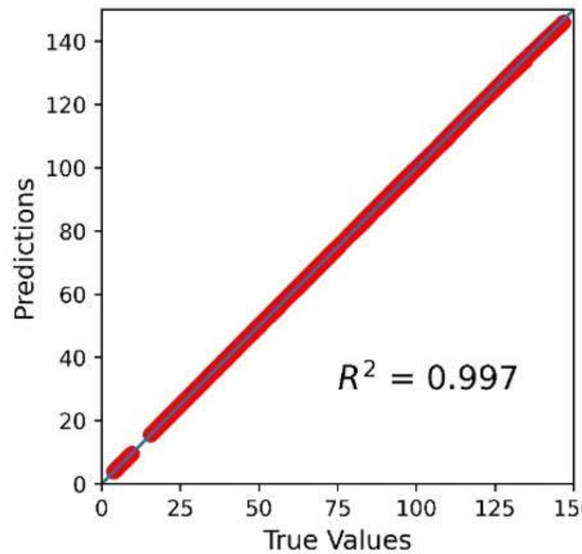
Source: Authors.

Figure 5: R^2 value of Model 2.



Source: Authors.

Figure 6: R^2 value of Model 3.



Source: Authors.

Conclusions.

The purpose of this study is to develop an ANN model to calculate the structural strength requirements of cargo vessels. Three different classification societies and DoS formula is used to generate the dataset for ANN. ANN models are trained and the results are found to be in good agreement with the classification societies results. Therefore, ANN can be used as an alternative to classification societies formula for predicting the structural strength of the cargo vessels in the preliminary design stage.

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Ship Simulation Study to Determine the Safety of Navigation Channel at Terengganu River, Malaysia

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ABSTRACT

Major development such as construction of Malaysia iconic draw bridge at Terengganu River shown the reduction of width for the navigation channel surely will affect the safety of the river user. This study aims to simulate the ship navigation process along the river channel to assess the safety of the channel. using the full mission ship simulator with real-time simulation approach and based model of the navigational channel and with worst weather environment. The results show the ship simulations track of the ship navigate through the navigation channel is safe, although encountered a few obstructions along the navigating process. This paper will provide proof that the navigation channel is safe for its user and few obstructions are highlighted.

1. Introduction.

Safety of navigation channels is the main motivation of this article. To determine the safety of navigation channels, several studies need to be done to address the safety manouverbility along the navigation channel. One of the related studies is the simulation test which can be one of the factors in ensuring the safety of the navigation channel.

According to Bhaskaran (2008), a simulator can assist in many things such as training, case study and also validation of safety assessment based on scenarios. This shows simulator study results can lead to determine the safety of navigation channel.

In order to gain a batter results, a real-time simulation test is used in this study. According to Belanger (2010), real-time simulation is the best method in validation process. A real-time simulation will have a high accuracy value since it recreates almost the same surrounding factors.

A navigation channel is the channel created for the marine user to navigate safely along a waterway from one point to another. Terengganu river has their own navigation channel that located along the Duyong Island up to its river mouth which passes through Malaysia iconic Drawbridge.

According to Wahaba (2019), Terengganu river had been very important to the locals since lots of maritime activities had actively been conducted, for instance fishing activities, offshore activities, shipyard services and recreational activities. This river flows through the state capital of Terengganu, Kuala Terengganu and flows into the South China Sea.

Kori (2022) stated, Terengganu is constantly developed from year to year, with great economic growth. For the maritime sector Kuala Terengganu has a popular inland waterway near Duyong Island. This river lane is known as the place for boat builder and nowadays has been a busy navigation waterway since many activities are using the area including the ship building and repair operations, offshore crew transport operations, monsoon yacht races, fishing vessels activity and enforcement agencies' activity.

The rapid development such as the building of drawbridge has given an impact to the safety of navigation since the marine traffic flow will be impeded. According to Madehow (2018), a

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draw bridge is a movable bridge that can be lowered or raised accordingly. Usually, a drawn bridge been built over a navigational waterway. This kind of bridge is to allow boats and ships to cross its path. Most of the bridges are more expensive to operate and maintain than stationary bridges. They also can impede traffic on water when they are lowered and on roadway or rail line when they are raised.

For this specific article, Section 2 is devoted to literature review on certain aspects related to study, Section 3 states the methodology used for this study. Section 4 explains the results from the simulation study and finally, the conclusions are presented.

2. Literature.

Terengganu Draw Bridge is the iconic bridge that link Kuala Terengganu city center to Kuala Nerus via Seberang Takir crossing Terengganu River. The overall length of the bridge is 632m, with a width of 23m (Zelan,2018).

According to Hashim (2017), the exiting navigational channel after dredging work in 2006 has the width of 100m and draught of 7m. but when the draw bridge been built, the channel width reduces to 25m because of the bridge pillar. The draught also decreases due to sand traps underneath the bridge. Vessels will be constrained by another factor that is limited air draft which is only limited to 10m height. The draw bridge existence will not only increase the density of marine traffic, but it also increases the surrounding hazard that eventually create a high-risk condition.

According to Salman (2013), a simulator is a device, designed to satisfy objective which mimics part of real situation in order to allow an operator to practice or demonstrate competence in an operation for controlled environment. When this simulator device been introduced to the maritime world, the device had been upgraded for bridge simulator and engine room simulator. This simulator is used for simulation technology for maritime training and nautical studies. The real ideas of simulator are to conduct and simulate a scenario for gaining the probability outcomes. Some of the seafarer state that a simulator is design for making mistake so that many things can be learn after and lots of things could be improve.

A bridge ship handling simulator is a replication of a ship bridge including all relevant instruments such as the radar system or the electronic chart display and information system (ECDIS). The bridge view is generated using several projectors or screens. The simulation process itself is described by a system model which represents a simplified version of the vessel and environmental dynamics (Philipp, 2017).

Now a day many industries consider the use of simulator techniques as a major contributing factor to the fundamental increase of the competency. The aviation industry is one remarkable example that motivated the first attempts to manufacture ship bridge simulator (Salman, 2013).

According to Ambroziak (2022), weather condition is a very crucial part in navigating a vessel. When it comes to risk, weather conditions play a vital role in order to provide safety passage for the marine users.

The elements that need to be taken care of are the wind, current, and waves. These three things are important when navigating a vessel. Since weather conditions are very crucial to mariners, as per said strong winds and their constant companions, rough seas probably present the most serious hazard faced by yachtsmen (Sanderson, 1994).

According to Malaysia Meteorology Department (2019), the wind speed at Duyong Island, Kuala Terengganu is 5knots up to 20knots. The maximum bad weather could reach up to 30knots. The direction of the wind is from Southeast and South. The normal wave height at Duyong Island ranged from 0.5m up to 1.5m. The worst case would be 2.0m height, that is when the monsoon hits around July up to December.

3. Methodology.

This study is focusing on the vessel navigation at the study area within the navigation channel. Six runs that include the existing environment condition and vessel will be tested. This run will be performed under the worst-case scenario since it will conclude that if the vessel is managed to passes through the worst so on the normal condition it will consider as safe. The vessel characteristic will be taken from the simulation library which refers to the nearest with existing vessel.

The manoeuvring simulation studies is carried out by using a ship-handling simulator, the simulator system must allow real- and fast-time simulations to be conducted using either 'hands-on' control (real-time conning) and automated control using an auto-pilot function and provides mathematical modelling of ships and other floating craft in 6 degrees of Freedom, namely surge, sway, yaw, roll, heave and pitch.

The ship-handling simulator system uses the industry standard S-57 electronic charts that provide the interactive backdrop to the simulations. To produce a more accurate set of simulations based on the proposed operations including in-bound and out-bound navigation, the studies need to incorporate the hydrodynamic current information.

A real-time simulation exercise is performed where a human pilot will operate the ship and support tugs, to a specified port or location within the study area. This process requires the geographic database and bathymetric values to be modelled within the simulator to the exact study area specification. The use of real time simulation ensures that technical ship handling and human factors with reference to response times and communication are effectively incorporated.

Table I shows the vessel model used for all the simulation runs. This vessel model is chosen based on the characteristic of commonly vessel navigate through the navigation channel. This vessel model consists of 54.5 meters in length overall, 10.8 meter of breadth and 3.0 meter draught. This model is also equipped with twin propeller and can reach a top speed of 30 knots.

4. Results.

A total of 6 simulation runs which consist of 3 runs inbound and 3 runs outbound of the navigation channel. All simulation

Table 1: Vessel simulation model.

Vessel model	Characteristic
	LOA: 54.5m BREADTH: 10.8m DRAUGHT: 3.0m

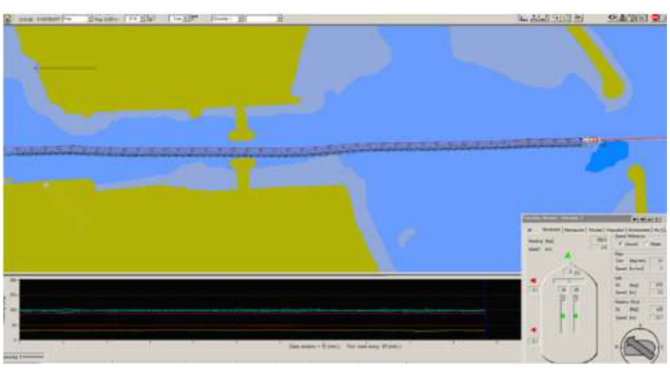
Source: Authors.

runs are the passed runs, with 2 near miss situation encounters.

4.1. Run 1 Outbound.

Based on this simulation model, the vessel manoeuvrability was hard since the weather is at worst condition. Even though the simulation is pass, but navigator should be very careful during navigating their vessel around this area. With a very limited width channel especially under the draw bridge, this is the hardest part for the vessel to pass through.

Figure 1: Run 1 Outbound .



Source: Authors.

4.2. Run 2 Outbound.

Figure 2 shows second simulation runs which encounter few obstacles and result of near miss situations to come in contact with draw bridge pillar. In this simulation, the speed of the vessel is increased to 7 knots and when the vessel enters the area under the draw bridge, the vessel experiences a bank effect situation which pull the vessel near to the bridge pillar.

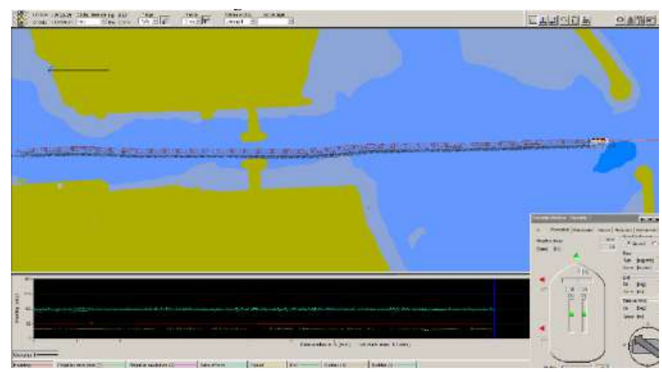
4.3. Run 3 Outbound.

Figure 3 shows the outbound simulation run. In this run, the manoeuvrability of the vessel is more stable since the vessel only navigated with 5 knots speed. Even though the environmental condition is set to the worst-case scenario, the simulation still pass with minimum obstruction.

Figure 2: Run 2 Outbound.

Source: Authors.

Figure 3: Run 3 Outbound.

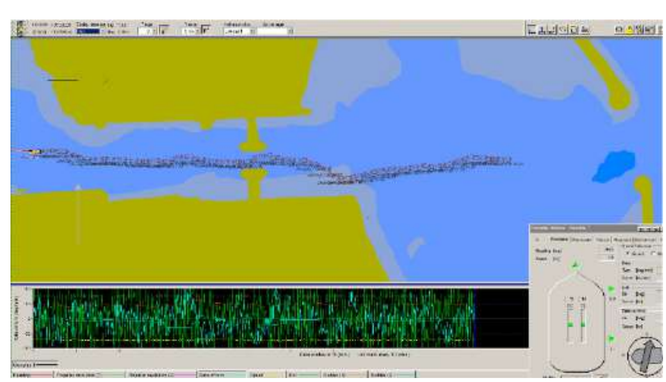


Source: Authors.

4.4. Run 4 Inbound.

Figure 4 shows the inbound simulation run of the model vessel. This simulation involves worst-case scenario weather. During the simulation the vessel experiences some obstruction and almost loss its manoeuvrability and results in near miss situation. The vessel almost come in contact with the right pillar. The vessel navigates at a speed of 7 knots.

Figure 4: Run 4 Inbound.

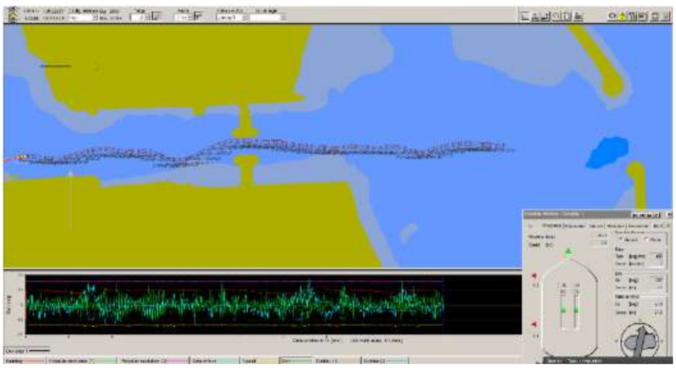


Source: Authors.

4.5. Run 5 Inbound.

Figure 5 shown the inbound simulation runs with a worst-case weather. During the simulation the vessel navigate with speed of 6 knots and experience a bank effect situation. Near the bridge pillar the vessel almost loss its control and result a after effect unstable manoeuvrability.

Figure 5: Run 5 Inbound.

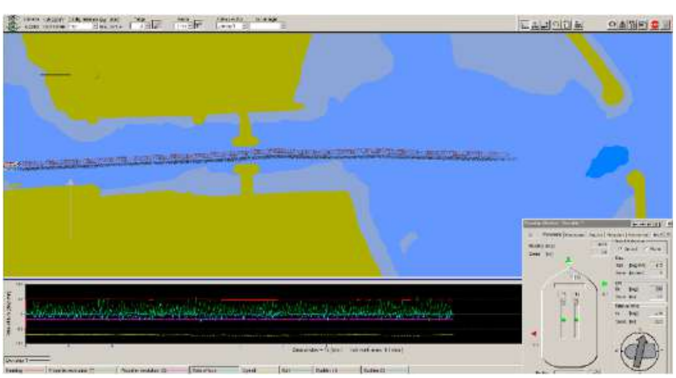


Source: Authors.

4.6. Run 6 Inbound.

Figure 6 is the most stable manoeuvrability since the vessel track shown smooth vessel simulation runs. In this inbound run, the vessel is test with a worst-case weather scenario and navigate with speed of 5 knots. This speed seems to be an ideal speed for navigate in this navigational channel since the vessel only experience minimum obstruction during the runs.

Figure 6: Run 6 Inbound.



Source: Authors.

4.7. Simulation Results Summary.

Table 2: Summary of simulation runs .

RUNS	SCENARIO	RESULT
1	OUTBOUND	PASS
2	OUTBOUND	PASS (NEAR MISS)
3	OUTBOUND	PASS
4	INBOUND	PASS (NEAR MISS)
5	INBOUND	PASS
6	INBOUND	PASS

Source: Authors.

Conclusions.

This simulation study has shown that the vessel navigates safely with a few obstructions. An ideal and suitable vessel speed can lead to a smooth navigation process along the navigation channel. Since all the simulation runs are pass with a worst-case weather scenario, this study can conclude that the navigation channel at Terengganu River focusing under the Malaysia Iconic draw bridge is safe for its user. Even though this is proof by simulation study, but all of the river users are being advise to navigate with caution and always alert with the surrounding situation.

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Seafarers as First Responders: An Ethnographic Study of Safety and Survival Training

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ABSTRACT

Seafarers are "on their own" at sea, isolated from medical care and unable to call 911 when requiring an emergency response. Critical, of course, is that organizations train seafarers in health and medical care at sea, as well as survival and safety – the latter being the focus of the current paper. Here, I strive to unpack what basic safety and survival training (STCW-95) means for future or current seafarers. Recognizing the role of the self in survival, I present a reflective, experiential, and analytic autoethnographic study of safety and survival training that brought to light and then reinforced the need to recognize seafarers as first responders. I unpack training as a participant in Basic Safety, a course necessary for a Transport Canada certification that is required to be part of crew at sea, to evidence the first responder roles of seafarers and to recognize the responsibility for survival of self, crew, and civilians that a seafarer bears. I then unravel the training experience, including experiences of fighting fires, search and rescue, and cold-water immersion, reflecting on implications for policy and practice, as well as to inform societal perceptions of seafarers.

1. Introduction.

In government and among certain social spaces, coastguard and search and rescue personnel are recognized public safety personnel (PSP); however, the label of first responder tends to be more readily attributed to police, firefighters, and paramedics (CIPSRT, 2022). Unrecognized in all contexts are Seafarers, who are the first responders in any disaster that occurs on ship—where fatal accidents and injuries happen on water across industries worldwide (Roberts, Nielsen, Kotłowski, & Jaremin, 2014). Seafarers are "on their own" at sea, isolated from medical care (Lefkowitz, Slade, & Redlich, 2018). For example, head injuries are common on ship and can be serious or life threatening; simply said, members of the crew must respond to these injuries (and all others). Their varying first-responder duties are also above and beyond the other tasks assigned to them on ship—i.e., their job (e.g., fishing, cooking, engineering) –for their other positions, as typically each crew member is delegated a set of emergency duties on a muster list to enact when an incident arises ((Hristova, 2019).

In the current autoethnographic study, I unpack experientially and analytically the experience of becoming certified to go to sea as a member of a crew. Experientially, I reflect on how course material and applications reveal the first responder role of any seafarer and my own experience completing the Basic Safety training course (STCW-95), which beyond practical components, cumulates into a written examination required for certification. Analytically, I interrogate the role of a seafarer in the preservation of life and reflect on implications for practice and society.

2. Background.

Dating back to 1990, evidencing the historical recognition of injuries at sea, Barss and Hall (1990) documented the medical needs responded to by crewmembers in the University-National Oceanographic Laboratory Systems. They described

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the 122 cases among regular and scientific crew (from 1985 to1987) requiring tele-medical communication for care. Cases included injuries (31%) and infected (34%) and non-infected (23%) medical cases (Barss & Hall, 1990). At sea, the crew (and passengers) are unable to call 911 for immediate assistance when requiring an emergency response. The first responder roles of Seafarers include that of a paramedic (i.e., require first aid training), firefighter (i.e., responsible for putting out fires on ship), and emergency responder (i.e., rescue) – among others. Each member of the crew is responsible for their survival, including in cases of ship abandonment. Yet, when considering and preserving the safety of civilian passengers, the crew is also responsible for their security and rescue.

Thus, without any doubt, Seafarers, beyond those employed in coastguard and search and rescue, are first responders and PSP—responsible for their health and survival, that of the crew, and that of civilians. Boats are loaded with personal and operational protective equipment, including lifesaving appliances, firefighting gear, medical equipment, and equipment in case of an oil spill. The crew are expected to be the first responder to any of these challenges as each may arise. The objective is to keep the "accident" from becoming a "disaster"—natural, personal, or professional. The crew are trained for emergency response for humans and the environment – ships require a pollution plan muster list as well as a disaster muster list.

2.1. Training.

Much of the research in the area of survival training occurs among public safety and armed forces populations (Øvergård, Bjørkli, Røed, & Hoff, 2010; Saus, Johnsen, Eid, & Thayer, 2012; Wahl, 2020) and involves simulators (Renganayagalu, Mallam, Nazir, Ernstsen, & Haavardtun, 2019; Sanfilippo, 2017; Saus, Johnsen, Saus, & Eid, 2010; Veitch, Billard, & Patterson, 2009). Some research is from the perspective of the instructor teaching with simulators (Sellberg, 2018; Sellberg & Lundin, 2017), while other research reflects on the structure of interactions during simulations (Hontvedt & Arnseth, 2013), simulation fidelity (Hontvedt & Øvergård, 2020), and the frequency of retraining (Bottenheft, Oprins, Houben, Meeuwsen, & Valk, 2019). Researchers have studied on-board training for maritime vessels, including a focus on familiarization of ship, which is key to reducing maritime incidents (Tvedt, Oltedal, Batalden, & Oliveira, 2018). Others have looked at safety equipment among fisherman, like Piniella (2007), who found that using safety equipment improperly compromises the health and safety culture on ship.

Norafneeza, Anwar, and Arryanie (2019) studied human factor "issues" in basic offshore training for platforms in tropical water. They found that not all alarms and public announcements are heard, and definitely not clearly, in cabins and noisy areas—which can delay responses in the event of an emergency. Thus, affecting survival is communication, essential to survival, but easily compromised by noise and less reliable when not manually activated (in comparison to automatic alarm activation). Others, like Barić, Čulin, and Bielić (2018), have focused on human factors such as how poor organization, cultural differences, and attitudes and improper behaviours can lead to accidents. Barić et al. (2018) propose leaders who make "good decisions" (p. 710), have good relationships across the group, and reduce any antagonism between persons of different specialization (e.g., Master, Chief Engineer) are key to reducing accidents (see Griffioen, van der Drift, & van den Broek, 2021 for a presentation of new models for supporting attitudes and behaviours that promote safety).

Researchers, including Jamil and Bhuiyan (2021), have studied learner experiences in maritime simulation programs. Jamil and Bhuiyan (2021) found that when training in simulation programs, necessary are clear definitions of "learning outcomes", improvement in learning context that support "exploration and second-chance learning", reducing gaps in theory versus practice by "ensuring skills-knowledge balance and in-depth scholarship building", the facilitation of tasks "for learning preparation and learning extension, and the repositioning of "simulation components and their assessment schemes across the academic programme" (p. 18). Learners' experiences, although the studies are few, are necessary given the movement to increase academic as well as vocational training for those going to sea. Internationally, though arguably a false dichotomy (Cowling, 1998), there appears to be a trend towards university-style education (e.g., critical thinking, theory, inquiry) that complements vocational training (e.g., acquisition of practical skills, structured thinking) in the practical certification of competency related qualifications for going to sea (M. Manuel & Nakazawa, 2008). Included here is the movement of degree acquisition for seafarers (M. E. Manuel, 2017).

2.2. Auotethnography and Current Study.

In an ethnographic study, an author of Jensen, Solberg, and Gudmestad (2019) participated in a scenario – a mass evacuation from a stranded cruise ship in Artic waters – that included survival in cold waters. In his experience, his primary lesson learned is that survival "is dependent on active participation from the survivors" (np.). Recognizing the role of the self in survival, what is missing in all reviewed literature and scholarship is a reflective, analytical autoethnographic study of safety and survival training that reinforces the recognition of seafarers as first responders. Moreover, missing is the examination of training to evidence the first responder roles of seafarers and recognize the responsibility for survival of self, crew, and civilians that a seafarer bears. Although simulators are key to training, research is necessary that goes beyond PSP and armed forces personnel, as well as the efficiency of simulation, to examine the training experiences of seafarers who undergo offshore safety and survival training that includes reflection on how one learns the first responder role.

2.3. Context: The Offshore Safety and Survival Centre and STCW-95.

In the Canadian province of Newfoundland and Labrador, instructors at the Offshore Safety and Survival Centre (OSSC) train individuals in emergency response to go to sea. Part of the Fisheries and Marine Institute of Memorial University of Newfoundland, the OSSC opened in the early 1980s, and offers a "comprehensive range of safety and emergency response training courses to the offshore petroleum, marine transportation, fishing and land based industries" (https://www.mi.mun.ca/departments/offshoresafetyandsurvivalcentreossc/, O4/22/2022, -np). The facilities are vast, including a survival tank (with a helicopter underwater escape trainer (HUET), fire fields (including propane), lifeboats, fast rescue craft launching devices, seagoing marine training vessel, and, among other tools and equipment, a virtual marine S92 VR helicopter cabin simulator. Although many courses are offered at the OSSC, the course I was undertaking is Standards of Training, Certification and Watchkeeping for Seafarers (STCW-95), which results in a certificate, and refers to the 1995 amendments to the international convent on STCW, 1978. The 1995 amendments, which completely revised the STCW, went into effect January 1, 2012 and were fully phased in by January 1, 2017. The course is designed to meet the International Maritime Organization (IMO) requirement – the IMO is an organization within the United Nations, and mandates training to go to sea. The course also meets the Canadian regulations – the Transport Canada regulations, which include the domestic vessels safety course (different then the IMO). Other offered courses include that providing Proficiency in Survival Craft (including rescue boats other than fast rescue boats; PSC), and Advanced Fire Fighting (AFF, which is actually advanced shipboard firefighting).

3. Methods.

In research and writing, experiences of an event, process, or undertaking can be a key source of information and opportunities for inquiry, particularly when engaged in rigorous analyses of the self against broader cultural experiences (Ellis, Adams, & Bochner, 2011). Autoethnography, an outcome of the postmodern confidence crisis in social science research where scholars strived to understand the truth and empirical nuances underpinning grand and master narratives (Lyotard, 1984), is a means to reflect and analyze personal lived experiences. Some autoethnographers focus on incidents of life changing proportions (Zaner, 2004), or "times of existential crises that forced a person to attend to and analyze lived experience" (Ellis et al., 2011 p. 275). Johnston (2020, p. 138) writes that "By accommodating and recognizing the impact that degrees of subjectivity, emotionality, and evocative personal experiences have on the research process (Harding, 2004), autoethnography can deepen our concerns for social justice and empathies for marginalized populations (Ellis & Bochner, 2000)". Although I am not suggesting that seafarers are a marginalized population, there is social justice needs that underpins the realities of sea life—there is a need for ensuring the safety, security, and survival of seafarers (and passengers)—and to recognize seafarers for their role as rescuers and survivors.

Nevertheless, sharing and reflecting on experiences can serve to create connection between individuals with similar experiences but can, also, unpack the link between cause and manifest as well as latent consequences. Where my reflectively rests, in the current study, is in my exploration of the processes involved for going to sea and what such processes suggest should inform policy and future directions of study. What quickly became clear is that every seafarer is a first responder in the context of any emergency on ship. On board, each person has a marked role if a disaster is to occur—all are responsible for the provision of safety and lead their own personal survival. Thus, in the current study, I reflect on what it means to be trained to be the first responder that is a seafarer preparing (or recertifying) to go to sea. I speak to the course material, the immersion in cold water, the learning of safety and survival, and the experience of putting out fires—all required by Transport Canada to be employed in any occupation of a seafarer.

I employ a phenomenological lens centred on my lived experiences in completing the course, before heading to sea, as I strove to create a new way of knowing and a new appreciation for the seafarer professions (Rennels & Purnell, 2017). The 'phenomenon' in question is the six-day course, where I sought to capture the structure, essences, messaging, cultural scripts, shifts in cultural understanding, lived experiences, and nuances around safety and survival at sea, as well as my location and positionality in relation to this social context (Pitard, 2019). In this—arguably realist—space, I learned to "question taken-for-granted ideas, assumptions, and presuppositions veiling a phenomenon" (Allen-Collinson, Vaittinen, Jennings, & Owton, 2018) and instead sought out the truths about training and the insight such training provided about life at sea.

Recognizing that my experience is still laden in my personal interpretations, I approached the autoethnography analytically – although I maintained evocative insights, largely as I reflect on my array of emotions I combatted, such as anxieties, fear, and elements. Though I hope to build a deeper understanding of the seafarer positioning in relation to the scholarly literature on this topic, rather than, as per evocative autoethnography (Ellis & Bochner, 2000), a focus on striving to pull readers into my own cathartic, lived experience, I use a process most commonly associated with features of analytical autoethnography. Specifically, I question societal powers and how they may create the lack of common understanding around the seafarer role, the impact of relationships, or even truths on interpretations of their relationships (Anderson, 2006), while also aiming to create a new interpretation that recognizes the realms of risk inherent to work at sea.

My data sources for the ethnography are rooted in field and class notes, collected over the period leading up to, during, and after the six work-day course, which started on an early Thursday morning and ending the following Thursday in the late afternoon. I took notes, prior, during, and after each experience, reviewing and looking for emergent themes across the notes—focusing on what was most pronounced and constant in the messaging received during training. I often had the advantage of writing in 'real-time' at least when in the classroom, which ensured I could note details of the moment rather than rely on retroactive memory. My primary data source remained my jottings that recorded my changing interpretations as I completed the training and learned about seafarers' roles when employed at sea in any capacity. Perhaps naively, I did not expect that all must serve in first responder capacities when I started the course, I had no idea that there is a need for faith in your crew for survival as well as faith in your own abilities.

My process was not solely autoethnographic, as I took the course with a group, and it was within this group that the ethnographic elements of participant observation also came to fruition. More specifically, I immersed myself completely in the training field, participating, experiencing, and observing phenomena to obtain an insider's perspective and thus interpretations rooted in an insider perspective (Davies & Francis, 2018). I caveat, however, that event after training I did and do not feel like an insider—my positionality feels more of that of a researcher. Different than my experiences in correctional officer training (author cite), I required this certification to complete my research objective – to go to sea. Thus, there was a new anxiety, one I never before experienced in research, the need to acquire the certification rather than just participate and observe. Thus, I was not a *trusted* outsider, I was no different than any of my classmates, I was observing and entering the social world of those I was also studying, in their setting and in their space – I was living my research experience.

In my case, participant observation represented a new starting point for research in the field of mariners (J. Douglas, 1976; J. D. Douglas, 1972). I believe that by participating in the field I would learn the questions to ask and where more research on seafaring may be welcome Although Davies and Francis (2018, p. 351) argue "true participation is fraught with epistemological and methodological challenges and is consequently quite rare", I had the opportunity and privilege of full participation. I had a role in the social group – I was part of the social group – and others interpreted my actions while I interpreted theirs – we were all immersed in the field that we collectively constituted. I did not worry about going "native" and becoming overly engrossed in the training course, as I too had to pass the written and practical exams. I was in essence the "complete participant", rather than a "participant as observer", "observer as participant" or engaged in "complete observation" (Gold, 1958).

Unlike traditional ethnographies, the ethical issues tied to my immersion in the field were not tied to the disclosure of my identity (other researchers were in the course), rapport building, earing respect, or establishing trust as I was not dependent on being accepted to understand the material or have the experience. I did experience role conflict – where I had to balance my researcher and participant role – to take no/tes but still learn all material and had to be respective of the privacy of other participants who did not elect to be part of my ethnography and thus be part of my research experience (see author cite). I took care to preserve anonymity in writing up my analysis, never identifying any instructor or participant. I consulted with a colleague to ensure I struck a balance and used care in my presentation of self and other. Simply said, despite the emotionality present in the narrative, I maintained control of my emotions and applied ethical considerations similar to ethnographies, and drawing on my experience as an ethnographic researcher (author cite).

4. Results.

Prior to the course, I had to obtain a Candidate Document Number (CDN; a unique number that Transport Canada awards to an individual to assist with their record keeping and document identification). The CDN number is required prior to the Seafarers Medical Examination – the second step for certification. I acquired my CDN number in March 2022. A week or so after, on March 23, I had my seafarers' medical. Given seafarers are at sea, and responsible for their safety and that of others aboard, it is essential that there are no pressing health concerns that may imped their safety and health on ship. The medical entailed some paperwork, and a quick physical examination – weight, height, BMI, an eye exam, blood pressure, and some abdominal poking. With a clean bill of health, I received my 'paperwork' and the doctor cleared me to go to sea.

On April 7, 2022, I started my Basic Safety STCW'95 course, which ran six days from 9:00 am to 4:30 pm, in my possession was my paperwork from the Medical, an employee participation form, and paperwork to for a fit test for the Scott AV3000 facemask. In the following narratives, I first provide the context around the research environment—the course and class. I then unpack the training material, fit testing, and practicum experiences, first practicum in the survival tank and then on the fire fields—always within the context of analyzing the role of seafarers in first response, survival, and the preservation of safety.

4.1. *Course Context.*

The course objectives are threefold, requiring students to achieve proficiency as per the IMO in personal survival techniques; fire prevention and firefighting; and personal safety and social responsibilities. The course aims are for all participants to be able to "Identify dangers at sea, Raise alarms and respond to associated emergencies, Minimize the risk of fire, to maintain a state of readiness, to fight fires on a vessel, Abandon a vessel and to survive in a marine environment, and Take part in rescue operations". The major topics covered include, but are not limited to, hazards, emergencies, emergency preparedness and response, pollution prevention, safe working practices, survival, effective human relations on boards ships, safe working practices, effective communication, firefighting theory, fire prevention and control aboard ships, shipboard firefighting organization and training, practical firefighting, use and care of firefighting equipment, and rescue.

To pass and receive the certification, required is 100 percent attendance, acceptable standards of performance and conduct in practical exercises, completion of practical exercises to the satisfaction of the instructor, and attaining at least 70 percent in a theoretical exam that covers the entire syllabus and consists of 50 multiple choice questions.

Our instructors were well versed in seafaring, survival, and firefighting. The class, including myself, had nine students, each unique in their reasons for completing the course. Some were recertifying after a lifetime boating, others headed to sea for the first time in hopes of a second career on a boat, and others were doing the class for the purpose of research projects that occur in the ocean – a diverse group with six self-identifying men and three self-identifying woman.

Of note, Covid-19 affected training. Staff at the OSSC were already reduced to skeleton crew at the start of the course, and fewer remained as the days progressed – Covid-19 was making its way through the instructors. All were positioned with physical distance and masks in the classroom and the OSSC modified some practicum exercises to maintain physical distancing between students (and instructors) in the field. Masks could only be removed on the fire field and when eating or drinking. To emphasize the impacts of Covid-19, on the second day, when another instructor tested positive, we almost had our practicum in the survival tank canceled. Rather than a cancelation, the remaining instructors reassigned their responsibilities to ensure we were able to complete the class.

4.2. Survival Instruction.

Despite the many hazards on ship (i.e., in the engine room, those in navigation, busy areas, on vessels, and in water), people are the key hazard, impacting of creating all other hazards. For example, someone designed the non-ergonomic vessel, someone decided to go into poor weather; thus, many accidents at sea result from human error. Transport Canada, we learned, publishes lessons learned based on accidents that happen, and the frequencies of such events.[2] I took to heart the survival lessons (e.g., wear a seatbelt in a lifeboat; know the Safety of Life at Sea (SOLA) regulations (particularly regulation 19)). It is through training in accident prevention that safety procedures and emergency responses are learned which address hazards, or at least reduces the possibility of the hazard becoming a situation or disaster. Seafarers, on ship, must know incident management, emergency response (muster points, etc.), the different alarms for different crises, and emergency drills – a shipboard exercise that practices correct procedures for abandoning, firefighting, mob recovery, injured person care, etc. To ensure proficiency, drills must be held on passenger vessels weekly or biweekly and prior to departing final loading port and monthly on cargo or fishing vessels over 150 tons and on all vessels, drills occur within 24 hours of departure if there is a 25 percent crew change. Drills are common, necessary given the first responder role of the crew, as through practice people become more comfortable and thus capable. During these initial lessons, I was surprised for lack of a better word. I recognized quickly that I was very uninformed about what going to sea entailed and unaware of the first responder role of seafarers. There is a degree of responsibility on ship among seafarers that I did not expected, although in retrospect this responsibility feels obvious—there is no one else to call for support or immediate assistance. Like any first responder, a seafarers foremost responsibility to survive in emergencies. Survival is very much dependent on self. Affecting survival are psychological factors, age, physical condition, fitness (body fat), and knowledge, as well as clothing, having a buoyancy apparatus, and a survival craft. The goal is to avoid cold-water shock and drowning. The enemies of survival being drowning, hypothermia, fatigue, seasickness, cold-water shock, injuries, psychological state, and dehydration. For survival, we learned how to pitch our noses while covering our mouth – which prevents grasping and inhaling water (and thus drowning)—as well as to stay on our backs and with our back to the waves (to further prevent water inhalation). Although one can survive with a lifejacket in 0 degrees water for some time (Hayward, Eckerson, & Collis, 1975), the objective should always be to get out of the water; a decision that may be hard but will save lives. Seafarers can use the Heat Escape Lessening Position (HELP), which extends survival time by 50 percent (Bailenson et al., 2008) and that, when in water with others, should huddle. To survive, we need to maintain body temperature within a narrow normal range (heat balance), body fluids (hydration), and energy levels. We learned the signs of hypothermia (e.g., violent shivering; blue-grey skin) and its treatment (e.g., horizontal rescue from water due to numb limbs) during rescue—which is the responsibility of the seafarer. We learned the need for "self-admittance, self-confidence, and self-control" as well as survival plans that include using the equipment and tools for survival (e.g., Class 1 EPIRB, the Search and Rescue Transponder (SART), flares, and the nuance of being rescued). Training included studying the three phases of marine abandonment: evacuation (e.g., getting clear of your ship without being hurt), survival (e.g., clock starts the moment one enters water), and rescue. We learned about the rigid and inflatable liferafts, the Davit (used for launching a survival raft), Personal Floatation Devices (PFD; which keep one afloat); lifejacket (i.e., which will keep your head out of water if your unconscious, has buoyancy under the chest, gives sizing, and has transport Canada requirements inside). I realized I will always choose a lifejacket over the "more fashionable PFD", because the lifejacket has buoyancy, ensures a stable face up floating position, and, being only black, orange or red, has enhanced detectability for rescuers.

4.3. An Afternoon in the Survival Tank.

Anticipation and nerves preceded the tank expedition. Thus, I would much have preferred to be in the tank in the morning, but this was impossible because we still required training. The training did little to reduce my anxiety – I like to be neither cold nor wet – and the learned exercises reinforced the first responder priority of survival. The survival tank is large and the water around 20 degrees, which may not sound as cold as it feels. On deck, we first donned our immersion suits, once to try them on and familiarize ourselves, next with the lights out and a two-minute timer to be sure we could get into the suits quickly and efficiently as well as in the dark of night. Next, we climbed down a three meter ladder, learned how to relax on our backs in our suits, and then how to be upright, turn 360 degrees and, afterward, we swam on our backs to the raft which we entered and exited. The amount of water sweeping into the suit was cold and filling up the suit rather quickly—I was not dry and I found the water daunting and much more difficult to push through (stepping to be upright) then if I was to do so in swimwear. The 360-degree spin was intended to look for rescuers, as being rescued was key to survival.

In the third exercise, we stepped out the edge of the tank into the water, hand over face as demonstrated to prevent water inhalation, and proceeded to climb up the three-meter rescue ladder. We ended our immersion suit training by optionally –

[2] We were told that the most frequent event was collision and most incidents occur on fishing vessels.

which I did despite my fear of heights – stepping off the three-meter platform. I was proud of myself for doing so, particularly given my nerves over heights and my reluctance with cold water immersion. I recall avoiding looking down, instead listening to the instructor and staring at the "would be" horizon. Next, after watching how to flip the lifeboat if upside-down, we enter the water with our clothing (mine already completely wet given the ill-fitting immersion suit) and lifejacket – each approved by transport Canada. The winds and waves in the tank, as well as cold rain, were activated as we learned how to float in the HELP position, which resembles the fetal position in the water, to preserve heat. The cold was near unbearable by this time, after sitting in wet clothes on the deck for nearly 30 minutes of instruction prior to the lifejacket immersion, all intensified by the winds and rain produced in the tank – a phenomenal facility by all means. I was keen to exit the water and to become warm—and never want to learn how long I would last in cold water. In the event of an emergency, a seafarer must first survive and then support others in their capacity to survive. In the water, this includes huddling and ensuring all "make it" onto a liferaft.

4.4. *Seafarers as first response.*

We started day three, a full day of in class lectures, with further unpacking – in essence – the first responder role of all seafarers, recognizing everyone in the crew plays a role in emergency response and hazard prevention. We started with a discussion of safe working practices, the importance brought home by the instructors recounting two persons who they know who died at sea – both on the gangway. To be safe, one must familiarize themselves with the ship – the hazards of the gangway and safety net, the main deck (especially cargo operations), hold and hatches (falling), forecastle and poop deck (i.e., forward and back of the vessel), windlass anchors and winches, cranes and derricks, manifold and deck pipeline system, accommodation, bridge, and engine room. Hazards on ships are many, from weather to oxygen, to gases, to chemicals, pirates and stowaways, fire, or ship movement and unsecured equipment. We learned that cargo ships are among the most dangerous ships to work on – when loading and uploading – while the safest vessel is a tanker, as a tanker is both deeper in the water and has a clear deck.

Enclosed spaces, unintended or designed for human occupancy, are only entered with the permission of a supervisor. Examples of such spaces are forepeak, chain locker, cofferdams, topside tanks, cargo tanks, ballast tanks, duct keep, aft peak tank, bunker tank, pump room. The main lesson here was about preventing anoxia – absence of oxygen – with symptoms including giddiness, breathlessness, unconsciousness, coma and death may occur or permanent brain damage, memory loss, mental instability, and paralysis. To enter an enclosed space, precautions are necessary, including the strict following of the entry permit system, to ventilate the space, and confirm atmospheres by testing oxygen levels with 20.9% being necessary. Personal protective equipment (PPE) is also necessary, as well as staying alert, monitoring the atmosphere, observing safety precautions while job is underway, and being neither over confident or negligent – proper clean up afterwards, all these items are considered in the Entry Permit.

We learned when hot work permits were necessary (e.g., doing anything that generates heat or sparks hot or intense enough to ignite a flammable gas-air mixture requires a person watching), the challenges of working aloft (e.g., at a height), locking or tagging out equipment, about engine room watchkeeping and maintenance, and how good housekeeping can prevent accidents. We studied the Safe Working Practices Regulations from Transport Canada and Maritime Occupational Health and Safety Regulations. There are two manuals aboard any ship: the lifesaving equipment manual and the vessel fire safety regulations.

As we discussed anti-exposure work suits (e.g., needs to be with a functional zipper, suit clean and dry, attachments in good condition, SALAS tape in good condition, should be rinsed with fresh water after use and dried carefully, keep free of grease and stains) and line throwing devices, the complex role of seafarers as first responders to all hazards was reinforced in the training.

Fatigue, a state of feeling tired, weary or sleep that results from prolonged mental or physical work, extended periods of anxiety, exposure to harsh environments or loss of sleep, can be particularly dangerous in the marine industry. We learned how fatigue can result in human error and impact decision making processes. As first responders, to prevent accidents, seafarers must be rested to be safe watchers but rest can be difficult on ship as the ship is always operational, and like a prison, impacts sleep caused by stress, excessive workload, environmental factors, and sea/port rotations—to name just a few factors (e.g., also included are crew specific, management, and ship specific actors). We discussed the biological clock and circadian rhythm, learning the internal clock can only be adjusted by an hour or so a day, which is complicated in international waters where time zones are passed through.

We also learned of the first responder role of seafarers in pollution prevention, including of oil and plastics. Pollution from ships tends to arise from stranding and collisions, lightering operations, unchecked garbage and sewage disposal, tank cleaning, washing and line flushing, unchecked chemical disposal, and deballasting. Lectures ended with discussion of social responsibilities, recognizing seafarers rights are protected under the Maritime Labour convention of the ILO, which Canada has ratified under the *Canadian Shipping Act* and the *Canada Labour Code*. All seafarers have the right to know, be trained, and refuse dangerous work. On ship, the minimum age of employment is 18, and standardized employment agreements include many details, such as the minimum required hours of rest (6), rightful pay of wages, paid annual leave, repatriation at the end of a contract, medical attention onboard a vessel, food rations and shelter, overall workplace safety, and present the efficient method for filling a complaint. We discussed the zero tolerance for drugs on ship, including legalized marijuana, as Canadian rights do not apply on board a vessel in foreign waters, thus there is a need to follow the laws of waters.

4.5. Firefighting Training.

Our firefighting training started with basic safety, which includes knowing the location of firefighting appliances and emergency escape routes. To protect against structural fires, we studied the SOLAS and Canadian requirements aimed at: preventing the occurrence of fire and explosion, reducing risk to life and that of damage, how to contain, control, and suppress fire and explosion in compartment of origin, and how to provide adequate and readily accessible means of escape for passengers and crew. We discussed escape routes, in B' and C' class divisions and that the procedures for dealing with fire are consistent at sea or in port – sound the emergency alarm, try to extinguish, and emergency party must be mustered. We discussed automatic fire detection systems (automatic alarms), fire zones (e.g., ships are divided into zones to contain fires), about being vigilant (e.g., prevention requires preparedness, fire watch, maintenance of equipment, constant vigilance, proper watch keeping duties of officers and monitoring of equipment) and the duties of Firewatch as well as fire hazards (e.g., engine room, galley).

Reviewing the fire triangle or tetrahedron (heat, fuel, oxygen), flash point (e.g., the lowest temperature at which a fuel will emit an ignitable vapor), three ways for heat transfer (e.g., conduction, convection (transfer of heat through vapours) and radiation (through air), rates of combustion, and the classes of fire (A, B, C, D, and K; class A leaving ashes and B able to smoother)—recognizing that fires burn differently thus have to be classified, we learned the seafarers role in fire prevention, reduction, and extinguishment.

We unpacked the public safety role of seafarers in learning the ins and out of fire extinguishers and extinguishing principles (e.g., a 10B extinguisher puts out 10 square feet of a class B (fuel, liquid) fire), for instance when to apply an extinguishing agent applied directly versus indirectly for boundary cooling. We reviewed the procedures (e.g., raise alarm, never pass a afire to get an extinguisher, ensure you have correct extinguisher for type of fire, keep low while fighting the fire, never turn your back on a fire even when backing away) for fighting fires and thus for avoiding accidents/disasters and ensuring the crew and civilians remain safe. We studied the SCBA (self contained breathing apparatus), to ensure we would be proficient on the fire field and in case of adverse events that included the hazardous atmospheres for respirations: elevated temperatures, smoke, toxic gases, and oxygen deficiency – indeed, superheated gases can cause pulmonary edema, smoke can damage eyes and the respiratory system, and gases can result in hydrocarbon narcosis and oxygen deficiency. The IDLH atmosphere, where the concentration of oxygen, flammable or toxic contaminants would cause a person without respiratory protection to be fatally injured or cause irreversible side effects, needs to be managed with care, efficiency, and to eliminate the source of threat. Again, seafarers are responsible for their survival and the safety and rescue of all on board.

To wear the SCBA, there are physical, mental, and medical needs, however there are always limitations to all equipment (e.g., increased weight, air supply, visibility, decreased ability to communicate, decreased mobility). The SCBA in hard labour last 20 minutes and in mild labour 30. The physical condition of user, degree of physical exertion, emotional stability of user, condition of apparatus, cylinder pressure before use, and training and experience of user all affect the duration of the air supply. After reviewing components of the SCBA, we learned the most common on ship is Scott 2216 psi – rated for 30 minutes / 1270 L and weighing about 24 pounds. The low pressure alarm, which indicates end of service, activates when pressure falls below 25 percent (in models manufactured prior to 2013) or 33 percent (sets manufactured after 2013) of the cylinder capacity—the sounding alarm means leave the IDLH environment immediately.

As first responders, we learned that rescue, required when conditions prevent self-evacuation or when victims are directly threatened, is first priority but exposure protection or fire extinguishment may be needed to perform a rescue. Factors affecting rescue include the size of space, personnel available, equipment available, ease/difficulty of access, size of victim, fire and smoke conditions, and if the victim pinned or trapped. We learned how to remove causalities, either alone (e.g., clothing/blanket drag, cradle in arms life/carry, incline drag) or with a team member (e.g., lift/carry, extremities lift/carry, chair life/-drag) both always facing the same direction.

In fire theory, we covered all core elements of how fires burn and extinguish as well as the theory behind firefighting, including with flashovers (i.e., everything ignites) and rollovers (e.g., gases can into adjacent spaces and ignite when mixed with air). We discussed decay (e.g., when available fuel in the compartment is consumed by fire, amount of fire begins to diminish and temps begin to decline, temps in compartment may remain moderately high for some time), backdraft – which can lead to injury or death and venting to clear the gas. Always reiterated was to become competent and confident with all duties assigned on muster list and to know the location of all needs and to read the ship specific firefighting plan. Given the crew are first responders, they must engage in regular training and drills, practice preparedness for any fire emergency, have knowledge of actions to take when called to fire stations and of escape routes, as well as of dangers of smoke and toxic fumes. We learned of deck foam systems, and machinery space foam suppression systems as well as when to use high expansion foam.

4.6. Fit Testing.

On day four of training, we started at 8:00 am with fit testing for using the SCBA. The fit test, a compliance measure for the provincial occupational health and safety legislation. We don the mask and a machine tells us if the mask fits our face. The fit test is necessary to make sure you have a good seal in your mask—it is recommended annually. One cannot consume coffee, gum, or juice within 30 minutes of the fit test and men have to be clean shaven for the fit test. The fit test was rather quick, donning the mask, we then breath normal, talk while wearing the mask, bend and turn our heads among other exercises until we “pass”.

4.7. Fire Practicum.

I felt confident enough in my abilities to shy away some, but not all, nerves and anxiety. We first collectively enter the fire training facilities, collect our gear, first boots, then coveralls sized to fit, pants and turnover jackets, hoods and gloves. The gloves were bulky and the boots are designed for someone with big toes. We walked down to the firefield, where we learned about extinguishers. First, we used an extinguisher for a class B fire (one made of gas fuel), one at a time using a sweeping motion to extinguish the fire – learning to eliminate the fire at the source, but not advance to closely or the fuel will spread and thus the fire too will spread. We employed PASS, as learned in class: Pull the pin, Aim the nozzle, Squeeze handle, Sweep nozzle. The strategy here was to extinguish by inhibiting chemical chain reactions, where we smothered or blanket the fire to reduce the temperature and source. Next, we each extinguished a three part class B fire – one at the ground level, and two more elevated. The winds made the fires roar slightly at times. Finally, we used a foam extinguisher to fully cease the fire, comparing how that made the fire impossible to relight due to the foam, whereas the class A extinguisher, water canister, just exacerbated the fire, enhancing its flames.

Our second fire practicum, day five, started with a quick but efficient change into our bunker gear with our SCBAs, all fit and tested, a practice we did repeatedly, ensuring each time we donned our mask the fit was snug and no air was entering or exiting. To achieve this, I pulled on the facepiece with my chin in first, tightened the straps, and then put my hand over the airway to check for a seal. Next, we would test the positive air pressure by fitting the regulator to the facepiece and holding our breath while turning our head side to side. This process would exposure any leaks in air. Once tight and fitted we could start the activities, reading to go on air when necessary. Checks included of the bypass valve, a "built in emergency backup" for any failure to the facepiece regulator—the valve can bypass the facepiece regulator by controlling a direct airline from the 1^{st} stage regulator in the event that the 2^{nd} stage regulator fails (e.g., the valve should only be used for emergency). The air pressure inside the facepiece is higher than the air pressure outside, not surprisingly, I did feel lightheaded, even flushed, after use. We checked our Personal Alert Safety System (PASS), which provides an audible means to locate a firefighter that has stopped moving, lost, trapped, or incapacitated.

We first entered the smoke filled "ship", with no visibility. Divided into two groups, I led my team as we kept our right hand to the wall as we navigated the spaces and small rooms to find a casualty – which I identified after sweeping my leg across a small space – who I kicked accidently in trying to rescue and identify. There is no visibility in smoke. What became pronounced is how you cannot just "run in and save a person", it is black and you're navigating a new space unsure of the nooks and structures as you try to find the source of the fire and any unaccounted for individuals. We worked as a team, proceeding cautiously, trying to stay in constant communication which is hard given the SBCA and sound of air combined with awareness of each breath. We followed the walls, recognizing and checking the probable areas for a causality (e.g., inside doors, behind doors, close to windows, closets, ends of passageways, shower stalls, under beds, under tables, under stairs, stairwells). Once a room was searched, we indicated it, closing doors to confine the fire, always alert for trapped victims in our comprehensive search. I found the blackness mildly disorienting, particularly in the small area search, where one member of my team stayed at the door and I searched, staying in constant verbal communication. My team member at door occupied the door space, which allows for quick search and quick recognition if a causality tries to exit the door.

I felt the confinement of the facepiece difficult at times, questioning my own ability to use the SCBA, which was proficient and fine, but the awareness of breathing with the apparatus on, in the dark, was new. I was aware of every breath and my reliance on the air provided by the cylinder—knowing full well equipment can malfunction.

The cylinder, combined with bunker gear, did become heavy over the course of the day. Today I still feel it in my shoulders and next, the efforts and strains of a day of wear and activity. We started on hoses, learning how to hold the hose for those on the nozzle, but also being they at the nozzle and learning how to command the different spray patterns – for a wall of protection versus for extinguishing. We practiced fog stream patterns, straight, narrow fog (15-45), wide fog (45-80) and using water as a protective cover. The class moved through the different positions, and all of us put out a fire. For my fire, I use the hose with foam, after a quick adjustment of the hose to add the pipping to allow the foam to be diluted into the waterline for the hose. I followed the rules for foam, understanding the foam suppression system (which can be pump, water main, form proportioned and associated piping, foam concentrate storage tank). The firefighting was physically taxing but rewarding once extinguished. I also recognized the team reliance inherent to fighting fires, when on the nozzle, the person behind you – your support – determines how much strength to maneuver the hose is necessary. A person holding the weight behind you provides you with additional freedom to direct the water and sweep fully, a person light on the weight makes the task at the nozzle much more challenging and the exertion of energy, in my experience, felt doubled.

We cleaned up the hoses, laying them out and rolling once flattened, into perfect circles of hose – a technique I will now use with my garden hose. After cleaning up the propane fire field, a luxurious training space, we did a quick change and drop of our SBSA – keeping it ready for the next day.

Suited up in the morning for a final day of training, again with air checks and ensuring our facepieces were snug, we started with being on a hose and getting comfortable with the type of nozzle most commonly found on ship. Next, we climbed to the second tier of the boat structure. There was a fire in the switch room, and we were to prop the door open with our shoulder and extinguish it, checking after to ensure it was out. We rotated through the different positions on the hose and nozzle, practicing each. I started in the third person position, holding the hose and pulling it forward to help ease the burden for those in position two (supporting the hose for the person on the nozzle) and position one – on the nozzle. Next, I moved into position two, I recall being on my knees and willing myself to stand given the extra weight of not just bunker gear and SBSA but also the water and hose. In first position, on the nozzle, I relied on my trainer, propped the door open with my shoulder when all were ready, calling out to the team to confirm, and extinguished the fire. I closed the door when it was out (I could see the fire but nothing else and not for long as my mask and the shield of my helmet quickly blackened), and then re-propped open the door to ensure it was out. My pants and gloves wet from water, but feeling proud of my learning.

We continued to do a scenario, where we divided into two groups, one group to put out the fire (my group) in the engine room and the second group to search the cambers (cabin, galley, etc.) to find the casualty. We approached the fire, I was in position three with the hose, entered the dark space and my team member on the nozzle extinguished the fire. We learned about maneuvering a hose in the dark and through closed (and close) quarters. The other team was successful in identifying the casualty and conducting the search. We returned to our muster and counted anew to ensure all persons were accounted for in the muster – a practice we had become very familiar with since our days in the tank. During the search, we had access to a Thermal Imaging Camera (TIC), which allow fire teams to see sources of heat through darkness and thick smoke. The cameras are used to locate victims and hidden fires but cannot see through walls, water, or glass or anything reflective. They are not a replacement for searching, only a complement.

We ended the practicum by learning how to launch a smoke and handheld flare. The smoke flair being least effective (it cannot be seen in the dark) and the handheld a precaution as it is burning metal and thus will burn even in water (and clearly a hole through the liferaft if dropped).

4.8. The Exam.

After a night and morning of studying, I failed to feel prepared for the exam. I read the manual, but recognized, testing makes me terribly nervous – especially multiple choice and when I feel personal pressure to succeed. The exam was at the end of day, nerves were collectively high and failed to dissipate while we awaited the grading. All passed and certificates were then handed out, however, I still questioned how I received 86 percent, knowing I was unclear on some answers and felt not yet prepared for taking on an emergency response role on ship. Almost ironically, I demonstrated full and thorough knowledge yet still did not feel confident; thus further emphasizing my appreciation of seafarers as public safety personnel.

Discussion and Conclusion.

My focus in the current article has been to unpack what basic safety and survival training (STCW-95) means for future or current seafarers. Pronounced is the role of the self in survival, something all first responders must recognize, as all first responders must first keep themselves alive and recognize their own limitations to preserve the life of others. I recognized my limitations – often strength and size – and learned to request help when necessary or I too would compromise my safety and that of the crew. I employed a reflective, experiential, and analytical (auto) ethnographic study of safety and survival training that brought to light and then reinforced the need to recognize seafarers as first responders. In learning survival and safety (e.g., hazards, fire), I developed a deeper understanding of what it means to be the crew on ship, the role of self in evacuation and abandonment, and the role of the collective in rescue and safety. There is a need for vigilance on ship, comradery—a seafarer is dependent on the crew for safety, rescue, and survival—and interdependence. Through this relationality, I learned how to do first response in emergency situations and how to prevent a hazard, albeit human, pollution, or otherwise, from becoming a disaster.

Survival training was intimidating but possible. For example, firefighting training was vast and complex, incorporating chemistry with safety, and response with survival. Causalities are heavy, rescue is exciting but challenging, and the gear was heavy, ill-fitting, and cumbersome. Future research, here, is necessary to understand if the gear is cumbersome and ineffective for all women or select and to understand the necessary modifications for immersion suits to actually provide an opportunity for survival to all wearers. Research also on the bulkiness of firefighting clothing is necessary or if its design has never accounted for the smaller stature and body of women. Moreover, research is necessary from the perspective of seafarers'; namely. do they recognize their role in first response? In survival? And how does this underlying risk impact their self, mental health, and families?

Society is dependent on seafarers, marine industries are vast and contribute significantly to the economy, yet the recognition of the risk inherent to being on ship are limited. Seafarers are clearly first responders, yet society, policies, and practices have yet to fully recognize and interpret seafarers as such. Thus, there is a need for inclusive policies that protect the seafarers, there is a need for danger pay, for accommodation for their first responder role and the inherent risk—including of death—tied to the profession. On ship, the crew is responsible for rescue, for emergency response, and for preservation of life; however this truth is largely removed from dialogue around seafarers. Ships are dangerous work locations with many hazards and key is to continue to create constructive and logical policies that ensure the safety and survival of those at sea.

Theoretically, I contribute to the incorporation of autoethnographic approaches with ethnographic participant observation. I reveal how experience can be reflected on to constitute research and put forth greater interpretations about a collective that can then be used to create policy, awareness, and modify practice. My objective is to reveal the complement between self-reflection and participant observation, where I pondered how my interpretations reflected on what I observed around me while undergoing training.

The current study is limited. Without conducting interviews, there was no opportunity to probe for collective understandings and interpretations. I only completed one course, and thus, on experience of training, thus the results, like in all qualitative research, may not be generalizable. I was reflective and analytical but this was my first venture into the world of seafarers and marine industry, thus I did not have scope of background to inform training or knowledge of policies – all was new to me. Overall, my reflections build epistemological and empirical knowledge that inform about the duties and less known training regiments of seafarers.

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Prospects for the Use of Autonomous Underwater Vehicles (AUV) to Solve the Problems of the Mineral Resources Complex (MRC) of the Russian Federation

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ABSTRACT

Autonomous Underwater Vehicles (AUV) are one of the most advanced areas of underwater robotics development. One of the acute industry problems of the Mineral Resource Complexes (MRC) is the insufficient geological study of the territory of Russia and its continental shelf. This paper demonstrates a review of the world's experience with using AUV to solve such tasks. Also, it considers the possibility of using AUV for exploration of the MRC and escorting their extraction in the water areas of the Russian Federation by using methods of system analysis and a mathematical model. The results show that in Russia there is a shortage of specialists in the development and creation of both AUV and AUV, as well as control systems. However, it should be considered that bringing Russian research to an advanced level of development in the fields of ocean research and the exploration of mineral resources requires a significant increase in funding. Besides, the development and establishment of AUV in Russia for the resolution of MRC problems is a pressing issue that must be addressed.

1. Introduction.

Recently, most research has been aimed at ensuring the sustainable development of companies in the mineral resource complex. A significant number of scientific studies are devoted to the study of the directions for solving this problem, among which the works of Fedoseev, Pashkevich, Tsvetkova, and Plotkin et al. can be noted (Fedoseev & Xia, 2015; Pashkevich et al., 2015; Tsvetkova & Katysheva, 2019; Plotkin & Khaikin, 2017). According to the forecast of long-term socio-economic development of the Russian Federation until 2030, the contribution of the country's mineral resource base to its GDP will not be less than 10%. This will be ensured, among other things, by the sustainable development of the energy sector (Tsvetkov & Fedoseev, 2020; Resniova & Ponomarenko, 2021).

Insufficient geological study of the territory of Russia and its continental shelf are sectoral problems. On this basis, and in accordance with the state program of the Russian Federation "Reproduction and use of natural resources," the following goals are formed:

- Ensuring an increase in the fine-scale geological study of the territory of the Russian Federation and its continental shelf by an amount not less than 7% per year.
- Ensuring an increase of up to 5 percent a year in exploration of promising areas of the Russian Federation and its continental shelf.

Fulfillment of the above conditions is supported by the RF mineral resource base development strategy up to 2035 and may make a significant contribution to the development of mineral resource complex companies. This document forms the following priorities in scientific and technological development in the sphere of geological study of the subsoil, prospecting, evaluation, and exploration of mineral deposits:

- Geological data collection and interpretation will move to more advanced digital, smart, and robotic technologies.

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- Geological and geophysical research needs help with technology on the Russian continental shelf, in the World Ocean, the Arctic, and the Antarctic (Gusev, 2022; Cherepovitsyn & Evseeva, 2021).

Studies on the problems of developing information and management systems that provide solutions to various problems in the exploration and development of offshore hydrocarbon fields using methods of structural-parametric synthesis correspond to the priorities formed and can make a significant contribution to the sustainable development of mineral resource complex companies. In the study conducted by Martirosyan and Ilyushin, some of the approaches to solving such problems are presented (Ilyushin, 2022; Martirosyan & Ilyushin, 2022).

One of the promising directions for solving the above tasks is the use of AUV. Based on the use of modern intelligent and digital technologies for building control systems, these vehicles are going through a period of rapid development as automated vehicles that can do a wide range of complex tasks on their own. Modern AUV are a separate class of robotic objects with inherent functionality, technological properties, and the composition of systems and subsystems (Ageev et al., 2000; 2005; 2003).

Currently, self-propelled AUV are subdivided into two main subclasses: non-autonomous and autonomous. The class of non-autonomous underwater vehicles includes those that are towable or use a cable for control and power. They are most referred to as teleoperated submersibles. One thing that makes them stand out is that there is a communication cable between the vehicle and the control point, which gives the vehicle power and lets the operator control it remotely.

AUV represent a class of self-propelled vehicles equipped with onboard power sources, wireless control, and communication channels. The classification of AUV by the criterion of autonomy is being developed in the process of their evolution. At present, autonomy means not only the availability of onboard power sources for the vehicle but also the possibility of independent control and even decision-making by its control system.

This study assesses the possibility of using AUV for exploration of mineral resources and escorting their extraction in the water areas of the Russian Federation. It also looks at how AUV have been used in other countries and what the future holds for research in this area.

1.1. Foreign and domestic experience in the use of AUV and AUV.

Currently, the leading positions in the development and production of AUV are occupied by the USA, Canada, Great Britain, France, Germany, Japan, and Norway (Ageev et al. 2005; 2003; Illarionov et al., 2008).

The majority of AUV and their projects are created for the purposes of these states' defense departments. For example, the US Navy currently has approximately 260–300 AUV in service. The greatest development priority is given to vehicles based on small-size AUV (up to 50–70 kg). The hardware and software used in such AUV make it possible to solve a wide list of scientific and practical tasks in the range of 10 to 3000 m.

AUV are classified by different classification criteria. The most popular and generalized classification by mass-dimensional characteristics and nomination of AUV is as follows: portable AUV of the micro and mini classes; light classes; heavy classes; big classes; civil classes; and military classes.

AUV have good dynamics of development. For the past 5 years, on average, about 70 new AUV projects have been under development annually. Most of the projects under development relate to small-sized AUV (with a mass of less than 50 kg).

The main purpose of AUV projects may be military, civil, double, or experimental. Because of the modular principle of modern craft construction, distinctions between their target designations have blurred. Practically all modern AUV designs are multi-purpose. They have different levels of automation and are used for examination and search for underwater objects, hydrological and oceanological scientific works, as well as for military missions. Most operations are performed at a depth of up to 1000 m. About 30% of the AUV can dive to depths of more than 1000 m. The rest of them are less than 1000 m; deep-water AUV (with an operating depth of 6000 m and more) are very few.

AUV have several considerable advantages over vehicles of other classes: they do not use telecontrol (cable-communication) with the supply vessel. They have higher functionality when performing tasks in hard-to-reach places, higher stealth, and better mobility. It is also worth mentioning that the cost of AUV operations is less than AUV operations, as AUV do not require the constant use of carrier ships or supply vessels with specialized equipment for lowering and lifting underwater vehicles.

The practice of AUV application in the solution of various tasks testifies that, by virtue of their functional capabilities, modern AUV can successfully perform the following underwater technical works (Ageev et al., 2000; 2005; 2003; Illarionov et al., 2008; Polenin, 2015).

- conducting a search and survey of sunken objects;
- placing bottom beacon responders in strategic locations;
- surveying the bottom edges of ice fields, figuring out how thick the ice is and what kind it is, and doing subglacial hydrology;
- search for minerals at great depths and preliminary determination of geological formations' chemical composition;
- inspection and maintenance of underwater cable lines, pipelines, and other facilities;
- search and identification of underwater objects with predetermined properties;
- work in combative media;
- special military tasks, like reconnaissance, fighting against submarines and mines, acts of sabotage, tracking objects on the surface and underwater, etc.

Currently, the level of equipment and technologies used in the development and creation of AUV does not allow for the realization of all the potential capabilities of vehicles of this class. Their autonomy is low due to the low power capacity of their power sources; their manipulator system is underdeveloped; and their artificial intelligence level in using their control systems is low.

It is believed that modern AUV should have high autonomy (up to 200 hours), a developed system of manipulators, a highly organized "intelligent" control system to be capable of solving a wide range of complex tasks and implementing such functions as pattern recognition, decision-making in conditions of partial and complete uncertainty, adaptation to external influences, etc.

Many different firms are involved in the creation of AUV. In the United States, they are involved in more than 36, united under the auspices of the Defense Advanced Research Projects Agency (DARPA). In Japan, more than 250 firms are engaged in similar tasks. AUV, XR-21 Sea Squirt (United States), DOLPHIN, DOGGIE (United Kingdom), RTV-KAM (Japan), and ARUS (European Consortium).

Here the basic properties and characteristics of the most typical AUV of the leading developers are discussed. One of the first American AUV is the vehicle "EX116," which is in service on anti-mine ships of the US Navy, as shown in Figure 1. This underwater vehicle is equipped with two high-resolution TV cameras: one is used for maneuvering near the target; the other is on top of the stern of the vehicle and is used when surfacing the vehicle for precise docking with a hoist, as well as for monitoring cable status. The apparatus is powered by a cable from the carrier. This allows for almost unlimited time to solve the problem (Ageev et al., 2000; 2005; 2003).

In 1988, the US Advanced Research Projects Agency (DARPA) signed a contract with the Draper Lab for a program that envisaged the development of two experimental samples of AUV designed for anti-submarine and anti-mine warfare in the Arctic basin at depths of up to 1000 m. The SSN-21 and USS Los Angeles (SSN-688) were the carriers of the AUV. Several other firms were contracted at the same time. Aero and Naval Systems Div. of Martin Marietta (USA) was awarded 14.8 million dollars for general concept development and for development of an upper-level control system with elements of artificial intelligence providing survey and framing of minefields, placement of bottom-responding beacons, towing of hydroacoustic antennas, pattern recognition, decision-making on maneuvering, and application of a long-range weapon.

This AUV is 11 m long, 1.12 m in diameter, and weighs 6.8 tons. The apparatus is equipped with photo and video recording equipment, a set of tactile sensors, sonars, and a TV camera with a laser illumination device. The power source is a silver-zinc battery with a total mass of 2.3 tons, which gives the AUV a range of up to 360 miles at 4.5 knots. The Massachusetts Institute of Technology, in conjunction with the Draper Laboratory, was commissioned by NOAA Sea Grant to develop the Sea Squirt, a small-scale AUV designed to be used as a test platform for the AUV's artificial intelligence system. The vehicle is shaped like a cylinder with an outside diameter of 22.1 cm and is equipped with two propulsion motors for longitudinal and one for vertical movements. A silver-zinc rechargeable battery is used as a source of electric power. The vehicle's working depth is 60 m, and its empty weight is 28.6 kg. According to foreign specialists, the use of AUV as platforms for testing different equipment and systems is of sufficient interest. Thus, navigation and communication equipment, as well as systems for controlling large AUV movements, are expected to be tested using the XR-21 AUV, developed in 1988 by Applied Remote Technology, Inc. (USA). XR-21 can operate in both autonomous and tethered versions. The XR-21 operates by radar from an above-water position and by program or other means from an underwater position. For example, using the module of the XR-21's automatic control system that is being tested. The U.S. Defense Advanced Research Projects Agency is developing Hydra (Figure 2). This vehicle is a carrier for aerial drones and AUV. "Hydra" has a special hull, structurally designed to accommodate drones of various purposes for their covert delivery to the area of operation. The AN/WLD-1(V)1 Remote Mine-Hunting System (RMS) Search and Destruction System consists of a semi-submersible vehicle and a towed AN/AQS-20 GASM, as shown in Figure 3. The apparatus has a mass of 7.3 tons and is 7 meters long. It is equipped with a 370-hp diesel engine. The mast has radio communication gear and a video camera that can be used to watch the surface visually.

Figure 1: AUV "EX 116".

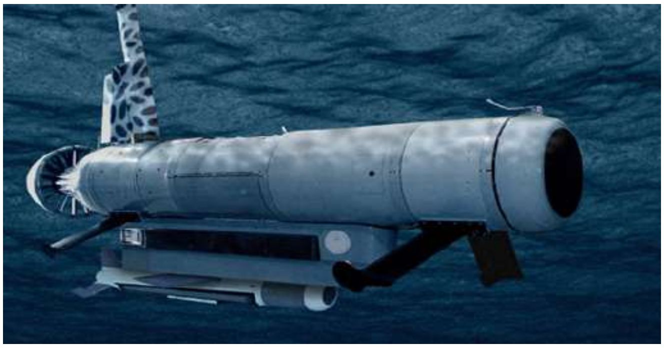
Source: Authors Archive.

Figure 2: Hydra, an unmanned underwater transportation vessel carrier.

Source: Authors Archive.

There are some communication subsystems for the detection of underwater objects and possible obstacles. Information from the communication subsystems is continuously transmitted via VHF broadband digital channel to the carrier ship, he-

Figure 3: Remote Minehunting System.



Source: Authors Archive.

licopter, or coastal control post. Transmission of information beyond the horizon line is carried out on a low-frequency broadband radio channel. In the future, it is planned to use KB and satellite communication channels for this purpose. The AUV gets control instructions through a digital communication line, but it moves on its own according to the program that was set. Figure 4 shows the Klavesin-1P maneuvering vehicle designed in Russia.

Figure 4: AUV ”Klavesin-1P”.

Source: Authors Archive.

The Clavesin-1P is intended for survey and search operations as well as the survey of bottom objects. The apparatus can perform a mission in the program control mode and with correction through the hydroacoustic communication channel from the ship. The apparatus is used to study the Arctic shelf.

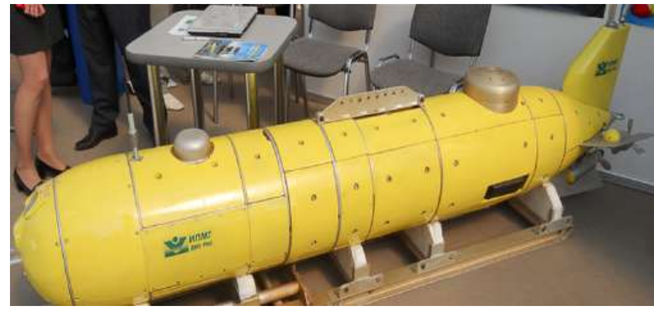
Figure 5 demonstrates a small, multi-purpose MT-2012 domestic AUV designed for deep-sea prospecting and measuring operations. It is easy to move around, has a smart control system on board, and can cover a large area.

SANPA is an autonomous unmanned solar-powered underwater vehicle (SAUV) shown in Figure 6 that has a long range and autonomous operating time in the ocean. One recharge of the batteries gives a run of 20–50 km. It is used to collect oceanological and hydrological information, meteorological observations, and environmental monitoring.

Domestic AUV are not inferior to their foreign counterparts in terms of technical characteristics, but their large weight and ”monolithic” design limit the list of possible solutions.

An example of a multifunctional AUV of modular design

Figure 5: AUV MT-2012.



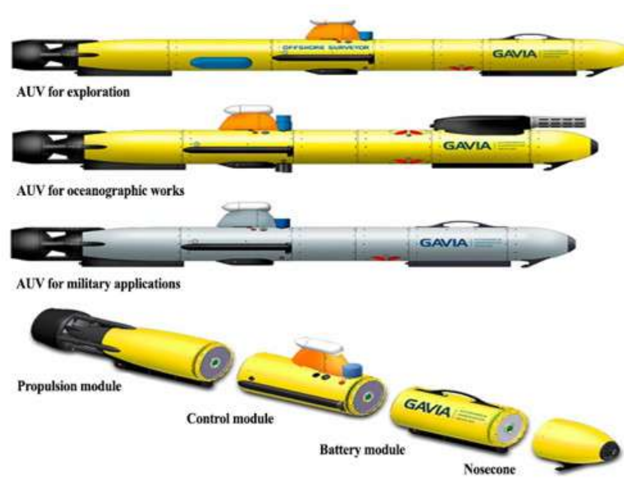
Source: Authors Archive.

Figure 6: ”SANPA” autonomous unmanned solar-powered underwater vehicle (SAUV).

Source: Authors Archive.

is the vehicle ”GAVIA” of Icelandic manufacture presented in Figure 7. The modular design of the AUV allows flexible re-equipment of it for the performance of various tasks.

Figure 7: Possible modifications of the ”GAVIA” AUV.



Source: Authors Archive.

The peculiarity of the vehicle is its autonomy and the possibility of over-the-horizon control (using the Iridium satellite communication system), as well as the considerable operational depth of immersion (up to 1000 m) at the low weight (from 49 to 79 kg) and volume (length not more than 2.7 m) of the AUV. Table 1 shows comparative tactical and technical characteristics (TTX) of the UVVs considered above.

Table 1: AUV Technical Specifications Comparison.

Country	Klavesin-1P	MT-2012	SANPA	GAVIA	Talisman L	RMS	Hydra
	Russia			Iceland	Russia		
Weight (kg)	2500	300	120	49-79	40	7000	-
Speed (knots)	3	5	2	8	5	10-16	8
Diving depth (m)	6000	3000	1000	1000	100	-	6000
Sailing autonomy (h)	48	24	6	7-10	12	24-40	-

Source: Authors.

Depending on the purpose of the vehicle, the AUV's basic performance characteristics are presented in Table 1, and the priorities in the choice of performance characteristics can be adjusted.

According to the results of the analysis, the following conclusions can be made: At present, the USA is a leader in the development and availability of operating AUV samples. Canada, France, and Japan are actively engaged in AUV development. Foreign units have more up-to-date technical equipment as compared with domestic ones, but Russian AUV are inferior to them in terms of technical characteristics. They perform a wide range of military and civilian missions. Multitask AUV with modular designs will be the most applicable and prospective soon. Currently, there are several UVV samples in operation, solving tasks in the interests of ISS. Thus, the study conducted by Gladyshev & Tamkov describes a portable complex that includes an underwater teleoperated robotic complex that can assess the ecological state of the seas and their bioresources in the context of carbon deposit development (Gladyshev & Tamkov, 2021). From the point of view of ecology, AUV are an indispensable tool to search for oil and other chemical pollution (Hwang et al., 2020a; 2020b; Tonacc et al., 2015; Wei Li et al., 2006). These devices were used to track the oil plume during the oil spill in the Gulf of Mexico (Camilli et al., 2010). Also, with the help of AUV capable of traveling long distances, they detected pollution in the Arctic (Kukulya et al., 2016). Studies of AUV to solve problems related to finding ways to use water resources in a smart way are interesting right now. Operations under ice are dangerous, so they require more thorough preparation. In a study conducted by Brito et al., the method of risk analysis was based on the experience of AUV developers, with the use of which successful works in the Antarctic were carried out (Brito, 2010). The AUV Theseus AUV is shown in figure 8. AUV have been repeatedly used in the investigation of aircraft crashes in the ocean. With their help, black boxes at great depths have been found (Sun et al., 2020). There is a unique development of glider-type AUV with a moving battery used to control them (Joo & Qu, 2015).

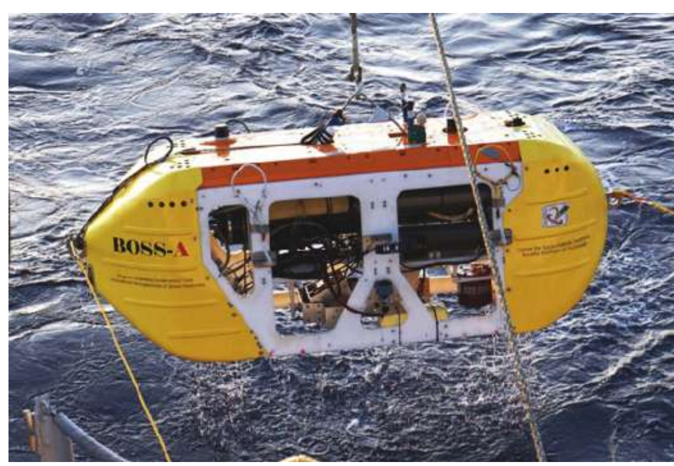
Figure 8: AUV Theseus under the ice in the Arctic.

Source: Authors Archive.

One cannot ignore the wide use of AUV by different countries (Wakita et al., 2010) for geological prospecting (Yoshida et al., 2013), the search for mineral resources (Yokota et al., 2018), seabed mapping, and seismic explorations (Martynova, 2017). It is also possible to use a camera and an acoustic sensor installed on the vehicle to detect rocks and determine the thickness of the rock (Nishida et al., 2015). Also, depending on the task, a hyperspectral camera can be used instead of a regular camera (Sture et al., 2013).

During the planning of the gas pipeline "South Stream," AUV were used for geological exploration (Lyakhov et al., 2017). One of such vehicles is shown in Figure 9.

Figure 9: AUVBOSS-A with a visual-acoustic device for inspection of manganese crusts located at 1,000 to 2,400 m depths.



Source: Authors Archive.

Thus, based on summarizing the practice of using AUV in solving tasks in various areas of application, their status, capabilities, and development trends as automated means capable of solving in autonomous mode a wide range of complex tasks. Based on the introduction of modern intellectual and digital technologies, it is possible to formulate a set of functions to be performed by AUV when exploring mineral resource complexes and supporting their production in water areas of the Russian Federation, as presented in Figure 10.

2. Materials and Methods.

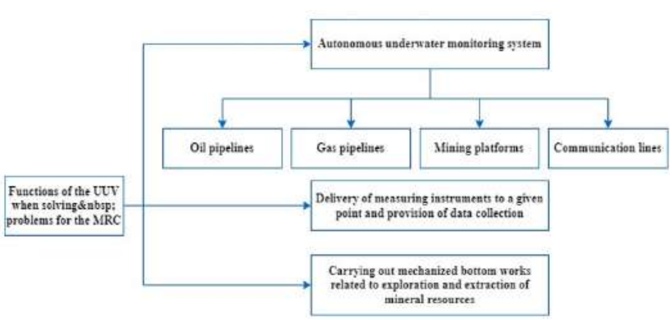
Currently, AUV are one of the most promising areas of robotics development (Bakharev et al., 2015). However, the current state of the technologies used in the development of AUV, and the modern methodology of their design do not allow for the implementation of all possible functions of AUV. The main problem associated with the development of AUV is the lack of research results on the creation of control systems that meet modern requirements for the quality of the tasks being solved.

According to experts, the most promising direction in AUV automation is a wide range of research in the field of the application of artificial intelligence in control systems.

AUV should steadily and effectively perform specified functions in an uncertain environment, which may be both partially and completely undetermined. At the same time, regardless of the functional purpose of the control system, it must fully ensure:

- quick, efficient decision-making during the problem-solving process;
- superior pattern recognition;
- choosing the best routes to take;
- correcting decisions based on the circumstances;
- complete transparency and accountability for actions taken;
- return to the beginning of the program's execution.

Figure 10: Functions of AUV when solving problems for the mineral resource complex.



Source: Authors.

Many maritime research laboratories are developing systems that will enable long-range underwater navigation in the future. Another important direction is the creation and development of small control and communication systems and power modules.

The urgency of the development and implementation of the AUV in Russia is determined by several essential factors:

- the vast, ice-covered areas of the northern seas, which are full of raw (mostly energy) resources.
- insufficient study of these territories.
- the need for scientific and practical proof that Russia is allowed to extend its economic zone into the north.
- the requirement for hydrographic support to expand the use zone of the Northern Sea Route and ensure its reliable operation.
- the prospects and feasibility of commercial development in Arctic marine territories, as well as their protection, among other things.

In a study conducted by Bozhenov, he reveals the problem of the lack of implementation of developed Russian AUV technologies and gives an overview of the use of AUV in developed western countries. He also describes the experience of their use in mapping the territory under the ice through sampling and emphasizes the fact that in Russia these areas are not developed (Bozhenov et al., 2011). The conclusions of Bardachevsky and Bezsudnov note that at present there is a high shortage of specialists in the field of the development of AUV and control systems for them in Russia (Bardachevsky et al., 2013). In another study, Laverov et al. note that Russia lags developed countries in the issues of shelf exploration and point out the lack of resources, technologies, and specialists for carrying out seismic surveys (Laverov et al., 2011).

3. Results.

Let the goal of developing a system of exploration and support for mineral resource production (SESMRP) in Russia's water area equipped with the AUV to provide solutions to tasks in Russia's mineral complex be defined.

The SESMRP may include all or part of the existing organizational structures, including organizational and technical systems, including the AUV that perform the functions of direct executive elements. The appearance of these structures and systems may be changed if necessary. Besides, the formation of new organizational structures and development of new organizational-technical and technical systems, as well as complexes, are possible for inclusion in the SESMRP. It is required to determine the appearance of such a SESMRP, which best corresponds to the set goal in the given constraints.

Mathematically, the problem of the synthesis of SESMRP is written in the following form (Mesarovich et al., 1973):

$$V^* = Arg \min_{V \in \{V_\partial\}} C(V, U); \quad (1)$$

$$\{V_\partial\} = \{V : W(V, U) \geq W_{mp}; R(V, U) \subseteq R)\},$$

where $C(V, U)$ is a function of the costs (expenses in monetary terms) for the creation, maintenance, and application of the future SESMRP, the minimum value of which corresponds to the customer's ideas about the best option of SESMRP V^*;

$\{V_\partial\}$ – the set of admissible variants of the SESMRP V_∂;

$W(V, U)$ – the performance indicator of the solution of tasks by the SESMRP Vvariant in the conditions of U;

W_{mp} – the required efficiency of solving the tasks of the SESMRP.

$R(V, U)$ – the resource required to develop, maintain, and implement a variant of the SESMRP V in in the presence of U;

R – specified resource constraints (energy, space, time, etc.) $R(V, U)$ required for the creation and application of the variant SESMRP V.

It is practically impossible to directly solve the problem of synthesizing SESMRP (1) due to its structural complexity and large dimensionality. The method of hierarchical decomposition of the problem by aspects, levels, and synthesis stages is the main method for solving this problem, as the experience of synthesizing such systems shows. Hierarchical decomposition of the SESMRP synthesis problem (1) allows not only unbundling the problem based on the "whole-part" relation but also realizing the "right of intervention of the upper level" and "dependence of the upper level on the lower levels" (Yoshida et al., 2013).

The represented image of SESMRP $V = (V^D, V^S, V^X)$as a set of descriptions of functions V^D, structureV^S, and a set of characteristics V^X is described here, i.e., as a set of organizational, functional, structural, and parametric images of SESMRP.

Depending on the state of development of the SESMRP and the goals of the research, different hierarchical relationships between the aspects of its synthesis can be established. For the case where the upper level is occupied by the organizational and functional aspect of SESMRP synthesis (that is, the main process is the organizational and functional synthesis) and the lower level is the technical aspect of synthesis, the decomposition of the general problem of SESMRP synthesis (1) will look like this:

a) The task of organizational and functional synthesis

$$V^{D^*} = Arg \min_{V^D \in \{V^D_\partial\}} C(V^D, \tilde{V}^{S^*}, \tilde{V}^{X^*}); \quad (2)$$

$$\left\{V^D_\partial\right\} = V^D : V^D \in V = (V^D, \tilde{V}^{S^*}, \tilde{V}^{X^*}),\ W(V, U) \geq W_{mp,}\ R(V, U) \subseteq R;$$

b) The problem of systems synthesis

$$V^{S^*} = Arg \min_{V^S \in \{V^S_\partial\}} C(\tilde{V}^{D^*}, V^S, \tilde{V}^{X^*}); \quad (3)$$

$$\left\{V^S_\partial\right\} = V^S : V^S \in V = (\tilde{V}^{D^*}, V^S, \tilde{V}^{X^*}),\ W(V, U) \geq W_{mp,}\ R(V, U) \subseteq R;$$

c) The problem of technical (parametric) synthesis

$$V^{X^*} = Arg \min_{V^X \in \{V_\partial\}^X} C(\tilde{V}^{D^*}, \tilde{V}^{S^*}, V^X); \quad (4)$$

$$\left\{V^X_\partial\right\} = V^X : V^X \in V = (\tilde{V}^{D^*}, \tilde{V}^{S^*}, V^X),\ W(V, U) \geq W_{mp,}\ R(V, U) \subseteq R,$$

where the symbol «~» indicates the solutions obtained from the previous iteration step. Problems of organizational-functional, system-technical, and technical synthesis (2), (3), and (4) are solved together. When it is impossible to obtain an acceptable solution to any one of these problems, the solutions to the other problems, as well as the constraints and conditions, are specified. The sequence of solutions arising because of such an iterative process will converge on the variant $V^* = (V^{D*}, V^{S*}, V^{X*})$, which is the solution to the general problem of synthesizing SESMRP (1).

At the same time, by solving particular problems of synthesis by aspects, intermediate variants are searched in advance $\{\tilde{V}^*\}^D, \{\tilde{V}^*\}^S, \{\tilde{V}^*\}^X$, as a result of repeated cyclic transitions from one aspect to another, these solutions are specified, and when "stable" sets are obtained, the iterative process stops. As a result of such a complex forward and backward movement by and within each type of decomposition, a cyclic iterative process with a non-stationary hierarchical structure is formed, which provides a gradual justification of the properties, characteristics, and order of functioning of the future SESMRP and the achievement of ideas about its expedient appearance as a result.

4. Discussion.

As stated previously, the scientific field of control systems for AUV was briefly explored.

Currently, the main vector of research in the field of AUV is the application of artificial intelligence for information and control systems (AUV). As a result, research possibilities include the following:

- integration of neural networks into the decision-making system;
- application of pattern recognition-based systems for object search and navigation;
- implementation and improvement of SLAM (simultaneous localization and mapping) algorithms;
- development of adaptive control systems.

There is little research on the modeling of both the AUV and its modules. Due to the difficulty of testing hypotheses on a real vehicle, this field of research can be considered promising in real-world conditions.

Separate research is required to review and design control systems to solve environmental problems related to the development of methods for the rational use of water resources.

Research in these areas will expand the range of AUV operations, make development cheaper (due to the appearance of multifunctional vehicles), and bring Russian research to the advanced level of development in the fields of ocean research and mineral resource exploration.

Conclusions and Recommendations.

Existing scientific achievements in the field of AUV development show great interest on the part of researchers in this field of human activity. The most elaborate areas of AUV creation and application are:

- navigation systems;
- propulsion systems and vehicle hulls.
- power supply systems;
- crafts proper for operation in middle latitudes.

These directions are well developed because of the borrowing and usage of scientific developments, schematics, and technical solutions from allied spheres of application, such as systems of submarines and manned and remotely controlled underwater vehicles.

The poorly studied areas of AUV research could include:

- control systems;
- vehicles for use in northern latitudes and under the ice.

Also, it is necessary to note the big deficiency of experts and technologies in Russia in the field of development, both in terms of actual AUV and the control systems for them.

As a result of the analysis, the following conclusions were drawn:

1. At present, research aimed at ensuring the sustainable development of MRC companies is urgent.
2. Research on the problems of developing parameters for information-management systems for the exploration and development of sea hydrocarbon fields using methods of system analysis and synthesis can significantly contribute to the sustainable development of the MRS companies.
3. One of the acute industry problems of the MRC is the insufficient geological study of the territory of Russia and its continental shelf.
4. AUV today are one of the most advanced areas of underwater robotics development.
5. The state of current technologies used in the development of AUV, and modern design methodologies do not allow for sufficient realization of all possible functions of the devices in this class.
6. Due to their autonomy, AUV are promising tools for the exploration of offshore hydrocarbon deposits, especially in ice-covered areas of the ocean.
7. The development and establishment of AUV in Russia, both for the resolution of MRC problems and those of other industries, is a pressing issue that must be addressed.
8. There is currently a shortage of specialists in the development and creation of both AUV and control systems for them in Russia.
9. AUV are currently being researched as a tool for solving problems associated with the development of methods for the rational use of water resources.
10. Bringing Russian research to an advanced level of development in the fields of ocean research and the exploration of mineral resources requires a significant increase in funding.

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National Competitiveness of Indonesian Warship Industry: A Qualitative Study by Using Porter Diamond Model

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ABSTRACT

The objective of this research is to find out the competitiveness of the Indonesian warship industry in the warship industry competition in ASEAN and East Asia. This research is a participant observation ethnographic research, the results of the research shows that the competitive advantage of the Indonesian warship industry is still not on the top level and left behind by the other countries. Warships produced by the Indonesian warship industry are almost entirely for local consumption, even though they are using by the Indonesian Navy not because their quality meets the qualifications set by warship user, but because of government's policy which obliges users to prioritize the use of the national produced warships. The outcomes should be used as input for the government and related stakeholders in determining policies to increase the competitive advantage of the warship industry in Indonesia. Based on the research, the Porter Diamond Model for the Indonesian Warship Industry can be proposed. Several recommendations were given to the government and related stakeholders to increase the competitive advantage of the Indonesian warship industry.

1. Introduction.

Historical facts show that during the kingdom's era, the Majapahit and Sriwijaya kingdoms were two great maritime kingdoms and able to unite the Indonesian archipelago (Pramono & Changming, 2019). By having the capability to apply the right and up-to-date technology due to the era, the Majapahit and Sriwijaya became a superior maritime power in the ASEAN (Rosyidin, 2021). The predecessors of the Indonesian were aware that by having a great sea power fleet glory would be achieved (Bueger, 2015). During his early days of his reign, Indonesian President Joko Widodo invited all Indonesian to return Indonesia as a maritime country and make Indonesia as the world's maritime axis. To realize this idea, a strong maritime force is needed not only to support the idea but also to support other national interests.

Although in Indonesia there are various shipyards competent in producing patrol boats or warships, only PT PAL Indonesia (Indonesian Shipyard Company) capable to produce large warships and able to export Strategic Sealift Vessel (SSV) to the Philippines Navy and signed contracts for the procurement of Strategic Sealift Vessel (SSV) to the Philippines Navy and signed contracts for the procurement of Landing Platform Dock (LPD) with the Government of the Philippines and the Government of the United Arab Emirates (UAE). The level of dependency on foreign products is still high, such as on shipbuilding technology, weapons technology, sensors, ship engines, ship electronic systems, raw materials and human resources (Bachtiar et al., 2021; Buana Ma'ruf, 2014).

2. Literature Review.

2.1. Porter Diamond Model.

Diamond model is a term used to refer the determining factors as a system consisting of several determinants, interrelated and mutually reinforcing. The Diamond model assert that the

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Table 1: Indonesian Warships Manufactured by the Indonesian Shipyards.

Name of ships	Type	Manufacturer
Allugoro	Submarine	PT PAL & DSME
R.E Martadinata	Frigate	PT PAL & DNSN
I Gusti Ngurah Rai	Frigate	PT PAL & DNSN
Golok	Fast Missile Boat (FMB) 60M	Lundin Industry Invest
Sampari	FMB 60M	PT PAL
Clurit	FMB 40M	Palindo Marine
Terapang	FMB 40M	Citra Shipyard
Makassar	LPD	PT PAL
Banjarmasin	LPD	PT PAL
Teluk Kendari	LST	Dock Kodja Bahari
Teluk Bintuni	LST	Daya Radar Utama
Teluk Weda	LST	Bandar Abadi
BRP Davao Del Sur	SSV	PT PAL
BRP Tarlac	SSV	PT PAL

Source: Logistics Staff of the Indonesian Navy Headquarters and PT PAL Indonesia.

competitiveness of a country is depends on the level of productivity of their local companies (Kharub & Sharma, 2017). Porter (1990) explained the diamond model emphasizes four attributes of a country's competitiveness, namely factor conditions, demand conditions, related and supporting industries, and firm strategy, structure and rivalry. These factors can also be supported by the government and chance determinant.

Erboz (2020) states that the diamond model is one of the analysis tools in qualitative research, which serves to provide a process view for the value chain. According to Chung (2016), the diamond model is a primary analysis tool because it can provide many decent results in identifying indices that have an impact on a nation's competitiveness. To be able to increase the competitive advantage, the industry can carry out an analysis using the theory of strategic management, business strategy and business models. Shapiro (1989) stated that one of the most attractive aspects of business strategy, is its flexibility in analyzing various business strategies. Stewart and Zhao (2000) in Morris et al., (2005), Hedman & Kalling (2003); Teece (2010) explain that a business model is a term often used to describe a key component of a business.

2.2. *Porter's Diamond Model and Competitive Advantage.*

According to Porter (1990) competitive advantage can be produced from goods and services that are different and better than the same products produced by competitors. And to create competitive advantage, innovation is needed (Distanont & Khongmalai, 2020). Competitive advantage can be achieved if a company is able to utilize technology strategically, synergistically and able to adapt quickly (Gunasekaran et al., 2017). Intellectual capital can be seen as equivalent to competitive advantage, and competitive advantage comes from creating appropriate strategies for company advantage (Yu et al., 2017).

2.3. *Warship Industry.*

Competitiveness comes from the Latin's word "competer" which means involvement in business competition (Momaya, 2004). The definition of competitiveness varies and depends on the scale, context and intended use (Fang et al., 2018). According to Fainshmidt et al., (2016), national competitiveness refers to the ability of a nation to produce and distribute services and goods in international competition. Porter (1990) mention that a nation's competitive advantage is determined by the strength of their factor conditions, demand conditions, the competitiveness of corporate strategy, structure, and competition in the industrial world.

3. Methodology.

This research is a participant observation ethnographic research, and in this study the researcher was involved as a participant observer. In determining the samples, the researcher use a saturated sampling technique, where sampling is based on whether or not there are still new findings obtained by researchers from interviews conducted (Purwohedi, 2022). The research is focused on PT PAL Indonesia and for other primary data, research also be carried out at the Indonesian Ministry of Defence, defence Industry Policy Committee (KKIP), Logistics Staff of the Indonesian Navy Headquarters, Staff of the Indonesian Navy Procurement Service and Daewoo Shipbuilding and Marine Engineering (DSME) representative in Indonesia.

4. State of the Art.

From literatures used as references, no research has been found examined the condition of the competitiveness of the warship industry in Indonesia especially by using the Porter Diamond Model. Therefore, the state of the art of this research is there is an opportunity to conduct research on the competitiveness of the warship industry in Indonesia by using the Porter Diamond Model.

5. Findings.

5.1. *Analysis of the Conditions of the Indonesian Warship Industry Seen from the Porter Diamond Model Factors.*

a. The Development of the Indonesian Warship Industry.

The role of a defense industry has a very important meaning for a nation (Lund & Karlsen, 2020), each country shows its existence through the strength and superiority of its defense industry. The Defense Industry Policy Committee (KKIP) was formed by the Indonesian government to formulate strategic national policies in the defense industry. Furthermore, based on the mandate that has been given, KKIP compiled seven priority programs; namely the development of warships, fighter aircraft, medium tanks, rockets, missiles, propellant and radar programs. The preparation of the seven priority programs was carried out by compiling a road map for the development of Main Armament System (MAS), which was divided into three stages; stage one mastery of design from 2010 to 2014, stage two mastery of technology from 2015 to 2019 and stage three perfection in 2020-2024 (KKIP, 2023).

b. PT PAL Indonesia.

PT PAL Indonesia, which is the main warships manufacturer in Indonesia has a strategic role in the Indonesian shipbuilding industry, but in producing warships especially large-sized ships, PT PAL has not fully been able to carry out the production process independently. In the process of making frigate, PT PAL Indonesia still has to cooperate with Damen Schelde Naval Shipbuilding (DSNS) Netherlands. While in the manufacture of submarines, PT PAL Indonesia also still depends on Korea's DSME. In accordance with the initial agreement, South Korea's DSME produce two units of submarines in Korea and assist PT PAL Indonesia to assemble the third unit in Indonesia (Muji Nisa & Rahaju, 2019; Nugroho et al., 2021; Sulistijono, 2017).

c. The Condition of the Indonesian Warship Industry Seen from the Factors of the Porter Diamond Model.

1. **Factor Conditions.** The availability of Indonesia's national natural resources is sufficient to meet the needs for raw materials to produce warships, but due to the limited ability and technology from related industries cause not all of the needs can be supported domestically.
2. **Demand Conditions**. The Indonesian government are quite satisfied with the warships produced in Indonesia, but for the global market warships produced by the Indonesian shipyards are not widely known, the warships produced in Indonesia have only been used by the Philippines.
3. **Related and Supporting Industries**. Supports provided by related industries in Indonesia are very limited. The government, the Indonesian Navy and the warship industry hoping that domestic industries able to fulfill all the needs of the national warship industry.
4. **Firm Structure and Strategies**. The competitive strategy of the Indonesian warship industry is good enough to face all challenges, however delays in project completion are often complained by the buyers. The more domestically produced warships used by the Indonesian Navy, the more it will provide benefits to the warship industry as well as being the best promotional ways to increase the competitive advantage of the Indonesian warship industry.
5. **Government**. The Indonesian government has supported and still committed to advancing the warship industry in Indonesia. The opportunity given by the Indonesian government to the national warship industry to comply the necessity of warships, is also consider as a great chance to the Indonesian shipyard. However, the Indonesian warship industry has not been able to take full advantage of the supports.
6. **Chance**. The occurrence of geopolitical changes and the war between Russia and Ukraine, made governments and people in the world realize that the potential for war could occur at any time, that makes Indonesia need a strong defense system to maintain the territorial integrity of the Unitary State of the Republic of Indonesia.

5.2. *The Competitive Position of the Indonesian Warship Industry Among the Warship Industries in ASEAN and East Asia.*

a. **China's Warship Industry.**

China as one of the biggest warship producers in the world has succeeded in making various types of warships, which are mostly used by the Chinese Navy.

According to Xi (2021) the development of Chinese warships had started since the era of Ming Emperor. At that time the ships of the Chinese Royal Navy were divided into four types, namely Big Jung, Fuchuan, Guangchuan, and Niaochuan. While Dangfeng Cao in Khanna (2019) mentioned that China's shipbuilding capabilities are developing very rapidly, in 2018 the Chinese warship industry able to make 27 new warships and successfully completed the process of building the second aircraft carrier. Jaquith (2021) said if the domains of the United States and Russian Navy are being threatened by the Chinese Navy, which is developing very rapidly including the development of aircraft carriers, submarines, destroyer, frigates, corvettes and amphibious ships.

Aside from the government's supports, China's ability to imitate various products including military equipment is also a catalyst in modernizing its military capabilities (Gilli & Gilli, 2019). The increasing of the China's warship industry also supported by China's economic and political situation which has changed drastically (Carlson, 2020), and supported by the ability to reduce cost production, and carry out technological transitions based on innovation (Ming Cheung, 2018).

b. **South Korean Warship Industry.**

South Korea is a place of the fourth largest shipyard in the world, namely Hyundai Samho, Samsung Heavy Industry, Daewoo Shipbuilding & Marine Engineering (DSME) and Hyundai Heavy Industry (Chuanran, 2019). The ability of the South Korean warship industry to produce several types of submarines, shows that Korea is an industrial country, able to produce various warships and as a major player in the world warship market (Bitzinger, 2019). The total income derived from South Korean warships export reached 41.1% of South Korea's total exports of military equipment (Jang et al., 2019). Several countries such as Indonesia, the Philippines and Peru are importing countries of South Korean warships (Bitzinger, 2019). The increasing of South Korea's military industry

Table 2: Chinese Warships Manufactured in China.

Name/Class	Type	Manufacturer
Liaoning	Aircraft Carrier	Dalian Shipbuilding Industry
Shangdong	Aircraft Carrier	Dalian Shipbuilding Industry
Yuan 041	Submarine	Wuhan Changxing Island Shipyard
Song 039	Submarine	Wuhan/Jiangnan Shipyard
Jin 094	Submarine	Bohai Shipyard
Qing 032	Submarine	Wuhan Changxing Island Shipyard
Shang 093	Submarine	Huludao Shipyard
Han	Submarine	Bohai Shipyard
Ming	Submarine	Wucan / Jiangnan Shipyard
Luyang I 052B	Destroyer	Dalian Shipyard
Luyang II 052C	Destroyer	Jiangnan/Changxing Island Shipyard
Luyang III 052D	Destroyer	Wuhan Changxing Island Shipyard
Luhai 051B	Destroyer	Dalian Shipyard
Renhai D55	Destroyer	Changxingdao/Jiangnan Shipyard/Dalian Shipbuilding
Luzhou 051C	Destroyer	Dalian Shipyard
Luhu 956E	Destroyer	Dalian Shipyard
Jainghu II 056	Frigate	Hudong-Zhonghua / Huangpu Shipyard
Jiangkai I 054	Frigate	Hudong-Zhonghua / Huangpu Shipyard
Jiangwei II 053H	Frigate	Hudong-Zhonghua Shipyard
Jianghu V 053H	Corvette	Hudong-Zhonghua Shipyard/Jiangnan Shipyard
Jiangdao 056A	Corvette	Hudong-Zhonghua Shipbuilding
Houjian 037	Corvette	Hudong-Zhonghua Shipbuilding
Houbei 22	Missile Boat	Hudong-Zhonghua Shipbuilding
Haiqing 0371	Submarine Hunter	Quixing Shipyard
Yushen 075)	Landing Helicopter Dock	Hudong-Zhonghua Shipbuilding
Yuzhao 071	Amphious Transport Dock	Hudong-Zhonghua Shipbuilding
Yuting III 072	Landing Ship Tank	China Shipbuilding Industry Corporation
Yukan 072	Landing Ship Tank	Wuhan Shipyard
Yunshu 073	Helicopter Landing Ship	Zhonghua Shipbuilding Co.Ltd
Houbei 022	Fast Missile Boat	Various Shipyard
Yuzhao 071	Fast Missile Boat	Hudong Zhonghua Shipyard

Only big size warships listed in the table.

Source: Carlson (2020); Collins (2013); Khanna (2019); Ming Cheung (2018); Xi (2021).

Table 3: Korean Warships Manufactured in Korea.

Name/Class	Type	Manufacturer
Dosan Ahn Changbo	Submarine	DSME/Hyundai Heavy Industries
Sohn Wonyil	Submarine	DSME/Hyundai Heavy Industries
Changbogo (KDX-III)	Submarine	DSME /Hyundai Heavy Industries
Chungmugong Yi Sunshin	Destroyer	DSME /Hyundai Heavy Industries
Kwanggaedo the Great	Destroyer	DSME
Daegu Class	Frigate	DSME /Hyundai Heavy Industries
Incheon Class	Frigate	Hyundai Heavy Industries/STX offshore and Shipbuilding
Uhsan Class	Frigate	DSME /Hyundai Heavy Industries
Pohang Class	Corvette	Hanjin Heavy Industries/Korea Tacoma
Yoon Youngha Class	Killer Guided Missile	Hanjin Heavy Industries/ STX offshore and Shipbuilding
Chamsuri (PKMR-211)	Killer Medium Rocket	Hanjin Heavy Industries
Chamsuri (PKM-268)	Patrol Killer Medium	Hudong/Zhonghua Shipbuilding
Dokdo Class	Landing Transport Helicopter	Hanjin Heavy Industries
Cheonwangbong Class	Landing Ship Tank	Hanjin/Hyundai Heavy Industries
Gojungbong Class	Landing Ship Tank	Hanjin Heavy Industries/Korea Shipbuilding Corp
Solgae (LSF-631)	Landing Ship Fast	Hanjin Heavy Industries
Nampo Class	Mine Layer Ship	Hyundai Heavy Industries
Yangyang Class	Mine Sweeper Hunter	Kangnam Corp
Hansado Class	Training Ship Helicopter	Hyundai Heavy Industries

Only big size warships listed in the table.

Source: Bitzinger (2019; Kwon (2018); Weitz (2013).

to produce various types of military equipment is also intended to counterbalance the aggressiveness of China and North Korea (Harper, 2018).

c. **SWOT Analysis of Indonesian Warship Industry.**

In the warship industry, SWOT analysis can be used to evaluate the strengths, weaknesses, opportunities and threats to the business, a SWOT analysis can be determined for the Indonesian warship industry among the warship industries in ASEAN and East Asia (Hossain et al., 2017). In qualitative research, strengths are defined as advantages associated with internal organizational programs, weakness is defined as a limitation related to an organization's internal program that might hinder the success of the program. Opportunities are defined as external environmental factors to increase the success of a program, threats are defined as any environmental factor that may act as a barrier to the program (Wang & Wang, 2020).

(1) **Strengths.**

i. The competitive strategy has been sufficient, but delays in project completion must be concerned by Indonesian warship industry.
ii. The organizational structure able to answer all the challenges faced.
iii. Government?s policy obliges users to prioritize the use of domestic warships.
iv. There are efforts to comply the MAS to support the Minimum Essential Force for the TNI.
v. The existence of transfer of technology program.

(2) **Weakness.**

i. Limited quality and quantity of human resources.
ii. The warships produced in Indonesian warship industry are not yet globally well known.
iii. Limited raw material supported from related industries.
iv. There is a dependence on high-tech materials from other countries.
v. The use of machines with conventional technology and facilities.

(3) **Opportunities.**

i. There is a positive appraisement from the Indonesian government.
ii. Availability of Indonesia's natural resources to support the production process of warships.
iii. There is support in the form of policies and facilities from the Indonesian Government.
iv. Indonesian strategic geographical position, to support the competitive advantage of the Indonesian warship industry.

v. Support and involvement of educational institutions to the Indonesian warship industry.
vi. The existence of geopolitical changes, spurring the procurement of defense equipment's.

(4) **Threats.**

i. Limited quality and quantity of raw materials in Indonesia.
ii. The increasing quality of warships produced by other countries, causing the competitive advantage of warships produced by Indonesia increasingly left behind.
iii. The existence of Covid-19 and war between Russia and Ukraine, caused the prices of materials become increasingly expensive and difficult for them to enter Indonesia.

6. Strategies Must be Carried Out by the Indonesian Warship Industry to Increase the Competitive Advantage in Global Competition.

The use of SWOT analysis in qualitative research can help to formulate strategies, plans and overcome problems (Baez-Leon et al., 2022) and formulate strategic plans to make decisions, develop plans and strategies to be implemented by analyzing the current situation (Topuz et al., 2021; Wang & Wang, 2020). The results of the SWOT analysis will determine the best strategies (Sariisik et al., 2011).

Based on the results of the SWOT analysis of the Indonesian warship industry, several strategies can be recommended to increase the competitive advantage of the Indonesian warship industry:

a. **Factor Conditions.**

1. Improvement of HR capabilities in related industries and in the warship industries.
2. Transforming conventional facilities and technology with modern onesTransforming conventional facilities and technology with modern ones.

b. **Demand Conditions.** Indonesian Warship industry to be more professional by meeting ship delivery deadlines.

c. **Related and Supporting Industries.** Related industries must comply and support the needs of Indonesian warship industry.

d. **Firm Structure and Strategies**. Improving the quality of the warships.

e. **Government.** The Indonesian warship industry must take full advantage of all the government's supports.

f. **Chance.** Utilizing and responding to geostrategic changes by producing quality warships.

7. Conclusions.

The conclusion of this research shows that the competitive advantage of the Indonesian warship industry is behind other warship producer countries. Warships produced by the Indonesian warship industry are almost entirely for local consumption, not because the quality in accordance with the specifications set by the warship user, but because of Indonesian Government policy obliges users to prioritize the use of domestic warships. Warships produced by the Indonesian warship industry are still not globally well known and unable to compete at the global market.

8. Recommendations.

Based on the research, the following recommendations can be made:

1. Optimizing all the determinants in the Porter Diamond Model related to the warship industry in Indonesia, through:

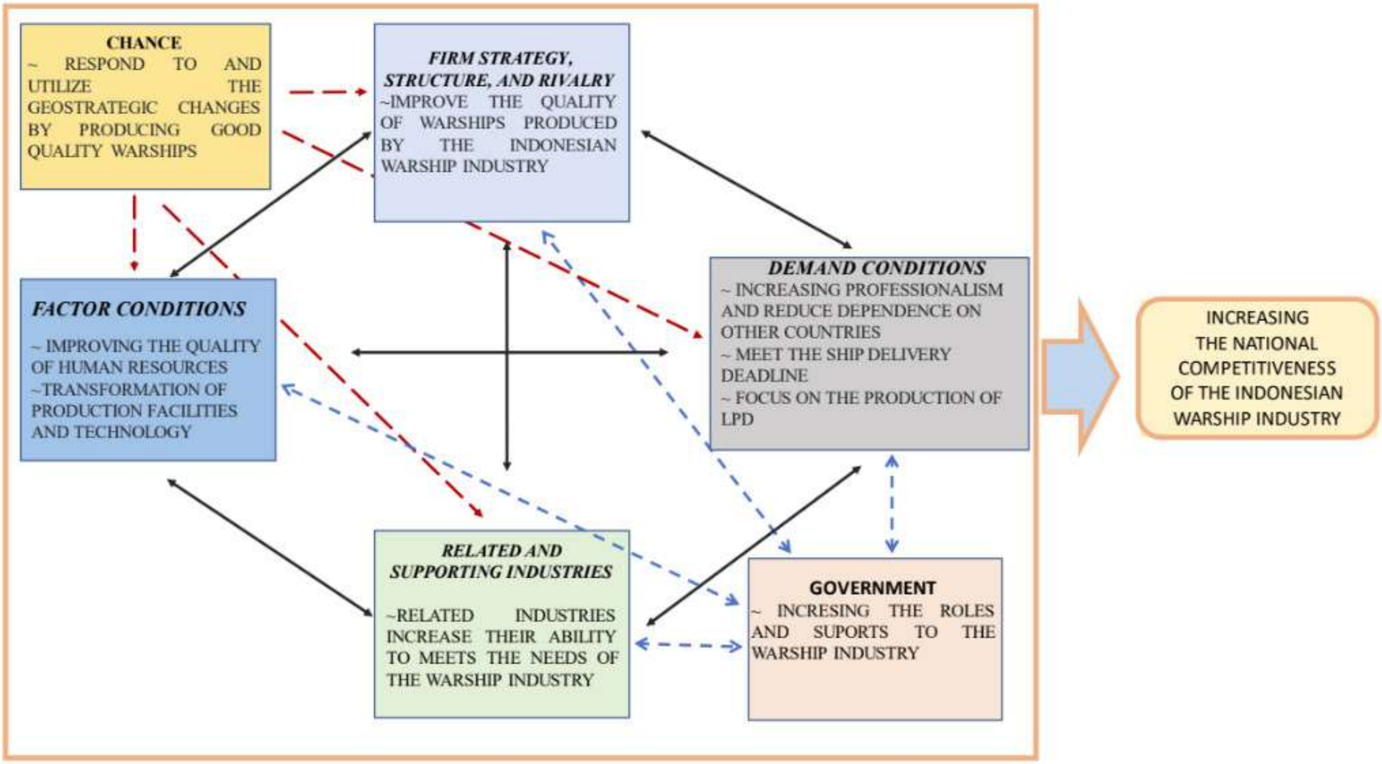
   (a) Increasing the ability of human resources in the warship industry.
   (b) Transforming conventional facilities and technology with modern ones.
   (c) Increasing the professionalism of Indonesian shipyards to be more compliant with ship delivery deadlines
   (d) Increasing the ability of supporting industries in Indonesia to meet the needs of the warship industry
   (e) Increasing the government's supports for the Indonesian warship industry
   (f) Encouraging the Indonesian warship industry to take full advantage from all the supports provided by the government, and respond the geopolitical changes to increasing the competitive advantage of the Indonesian warship industry.

2. Indonesian shipyards must improve the quality of warships and promote warships intensively. Observe, imitate and modify (OIM) techniques carried out by industries in China can be chosen as an option. With OIM techniques, China's industry has grown very rapidly and has become one of the biggest industry countries in the world.

3. Indonesian warships industry focus on the LPD. If the Indonesian warship industry focus on the LPD and continues to innovate to maximize the excellence and quality, then the LPD can become the flagship product of the Indonesian warship industry and also increasing the competitiveness of the Indonesian warship industry in the global competition.

Based on the research, the Porter Diamond Model for the Indonesian Warship Industry can be proposed.

Figure 1: Maniur Pane's Model for Increasing the Competitiveness of the Indonesian Warship Industry Based on the Porter Diamond Model.



Source: Prepared by authors.

Model's description.

In accordance with the diamond model theory developed by Michael Porter, all determinants in the diamond model are interrelated and influence each other, but sometimes some determinants have stronger influence than others (Figure 1). The black arrow lines shows that firm strategy, structure and rivalry (FS), demand conditions (DC), related and supporting industries (RS) and factor conditions (FC) influence and strengthen each other. The blue dotted arrow lines shows that government influence and can also be influenced by FS, DC, RS and FC. Meanwhile, the red dotted lines illustrate that chance can influence FS, DC, RS and FC, but on the other hand chance cannot be influenced by other determinants because chance comes only from outside of the warship industry.

If the Indonesian warship industry and all related stakeholders optimize all the determinants by responding to and utilizing geostrategic changes, improve the quality of warships, increasing professionalism and reducing dependence on foreign products, meeting ship delivery deadlines, focusing on the production of LPD type warships, increasing the roles and supports of the government, related industries increase their capabilities to support the needs of the warship industry and if the Indonesian warship industry improves the quality of human resources and carries out transformations in production facilities and technology, then the competitiveness of the Indonesian warship industry will increase and be able to compete not only at the regional but also at the global market.

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Numerical analysis of a barge collision with bridge pier by using finite element method

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ABSTRACT

This study investigates the structural response of bridge piers to collisions with vessels, focusing on factors such as impact stress, pier displacement, and kinetic energy. Using finite element analysis (FEA) simulations, the study considers various barge velocities and pier material properties. The results show that at lower impact velocities (up to 2 knots), the pier undergoes elastic deformation, while at higher velocities, plastic deformation and potential collapse occur. The material's yield strength is crucial, and high tensile steel may be necessary for velocities exceeding 2 knots. The study emphasizes the importance of accurate modeling and considers alternatives for enhancing pier resilience, contributing to the development of safer maritime structures.

1. Introduction.

The examination of the response of structures to various impact loads using analytical methods and the exploration of finite element analysis are central themes in the study conducted by Woelkea et al. [1]. The study presents a brief overview of analytical methods used to determine the loads and energies associated with ship impact. A linear relationship between the volume of deformed steel and the energy dissipated in the deformation process is established. Additionally, a discussion on a set of empirical expressions for calculating bow collision forces, maximum penetration, and impact duration is included. Another study, conducted by Hu et al. [2], focused on the finite element analysis of the nonlinear collision between a 300k DWT VLCC and a bridge pier. The study accurately simulates the strongly nonlinear process of ship-bridge collision by considering the bridge pier as a rigid body and accounting for the surrounding flow. The analysis includes examining the time history curve of impact force, energy absorption, and damage condition. A comparison is then made between the results obtained from given standards and empirical formulae and those from finite element simulation. The findings highlight the complexity of the collision as a nonlinear dynamic process with significant energy exchange in a short time.

The work conducted by PINTO et al. presents a study on a flexible protection system for a bridge-pier model, where the barge was modeled nonlinearly [3]. The protection structure was derived through a separate nonlinear pushover analysis, represented by its equivalent load deflection curve and mass. The methodology employed to assess the energy absorption capacity of the protection structure involved the development of a nonlinear numerical model. The study simulated and examined a pier made of rigid concrete material using a numerical approach, and the obtained results were compared with previous findings [4]. In 2011, Lin conducted a study, providing a comprehensive investigation based on trials [5]. However, the experimental study reported no structural damage, potentially attributed to the relatively small energy of the conducted collision.

Zhang et al. develops semi-analytical methods for analyzing plate crushing and ship bow damage in head-on collisions [6]. The study compiles and compares existing experimental and theoretical research on the crushing analysis of plated structures. Simple formulae are derived to determine the crushing force, force-deformation curve, and damage extent of a ship

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bow for longitudinally stiffened oil tankers and bulk carriers with a length of 150 meters and above. These formulae are expressed in terms of ship principal particulars. Kameshwar and Padgett investigates the barge impact performance of bridge piers, considering various design parameters and the free length of the pile, which may be due to design or scour [7]. The study includes a preliminary analysis to evaluate the post-collision safety of bridges under traffic loads. Metamodels are developed to estimate force demands and fragility for bridge piers subjected to barge impact, aiding in the design and management of bridges with diverse design and geometric parameters. Non-linear dynamic analysis is performed to assess maximum shear force, moment, shear strain, and curvature in the columns. After the dynamic analysis, vertical load analysis is conducted to determine the post-collision stability of bridges under vehicular loads. The models developed in this study are applied to a case study bridge, illustrating the variation in demands and fragility as bridge parameters, free pile length (scour depth), and collision conditions are altered.

In this research, a study is conducted to investigate and analyze the behavior, impact forces, and structural responses associated with collisions between vessels and bridge piers. The study aims to find out the following structural behaviors:

i. To determine impact stress with respect to time in case of a barge pier collision.
ii. To investigate pier displacement corresponding to different barge velocities.
iii. To evaluate the progression of impact energy considering different barge velocities.

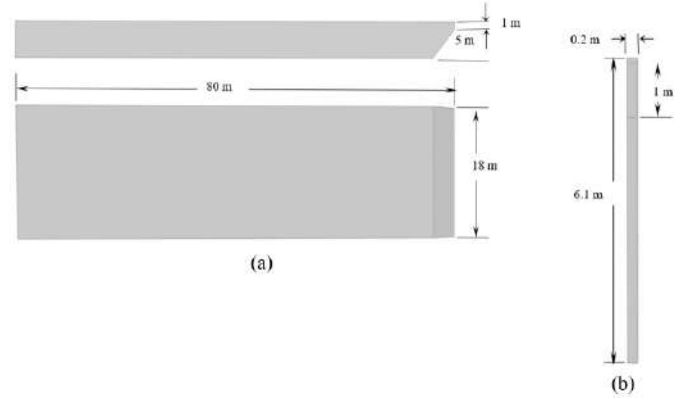
This investigation is carried out with the assumption that the pier material is high carbon steel with a yield strength of 585 MPa. Opting for higher-grade steels, such as high tensile steel, could render the dynamic response, endurance, and material behavior more vulnerable to more severe collision scenarios. Through this study, the aim is to propose improved design criteria and material selection, especially applicable to heavier bridge piers.

2. Model Geometry.

2.1. Modeling the barge and the pier.

In this study, a steel barge and pier are modelled using ABAQUS software. The barge dimensions are 80m x 18m x 5m with a head log portion which directly collides with the pier. The head log has a rectangular cross section with a height of 1m. The deadweight of the barge is taken as 1723 tons. For modelling the steel pier, dimensions from real steel piers were adopted with regards to specifications of Southern Forest Products Association, United States. The pier structure has a square cross section of 0.2m x 0.2m and length is 6.1m. During analysis, the barge collides with the pier with its head log portion, that has a height of 1m. Since the width of the pier is 0.2m, the area under impact load becomes 0.2m x 1m or, $0.2m^2$. The schematic diagram of the barge and pier is shown in Figure 1.

Figure 1: Schematic diagram of the (a) barge, and (b) pier.



Source: Authors.

The properties of the steel for the pier are shown in Table 1 [4].

Table 1: Material properties of steel pier.

Material properties	Magnitude
Mass density	7865 kg/m3
Young's modulus	207 GPa
Yield strength	505 MPa
Poisson's ratio	0.27

Source: Authors.

2.2. Assigning loads on the pier.

Two types of loads are considered in the analysis; a gravity load on the top of the pier with regard to the weight of the walkway of bridge, taken as 1 ton; and the impact loads for corresponding barge velocities.

Both loads are assigned as pressure force. So, the pressure force due to gravity is calculated as:

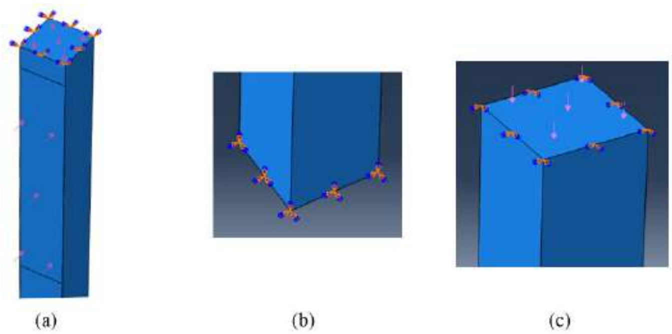
1 ton = 1000 Kg
= 1000 x 9.8 N
= (1000 x 9.8)N / (0.2 x 0.2) m^2
= 245,000 Pa
= 245 MPa

Loading conditions are depicted in Figure 2, with assigned load values for each simulation in the same direction, maintaining a consistent angle of impact.

2.3. Boundary conditions on the pier.

The lower surface of the pier is supported by the ground, implying no movement along any axis. Consequently, the bottom surface of the pier was constrained in all three axes, resembling an 'encastre' condition in the software. In ABAQUS software, the 'encastre' condition is defined as fully built-in (degrees of freedom 1,2,3,4,5,6 = 0). However, the top surface is solely supported by the bridge, allowing the pier to deform along the z-axis while restricting movement along the x and y axes. Thus, the boundary conditions are specified as x and y restricted and z unrestricted.

Figure 2: (a) Loads assigned on the pier, (b) boundary condition at the bottom surface of the pier, x, y and z axis restricted, and (c) boundary condition at the top surface of the pier, x and y axis restricted.



Source: Authors.

3. Basic Formulations.

In accordance with AASHTO specifications [8], the impact force was computed using the subsequent formula:

$$P_{bow} = 0.12 V_0 \sqrt{DWT} \tag{1}$$

where,
P_{bow} = maximum bow collision load [MN]
V_0 = initial ship velocity [m/s]
DWT = deadweight of the vessel in metric tons
This equation was employed to input impact loads for various velocities and deadweights in the simulations performed in this research. According to this equation, the load imposed by the bow is directly proportional to the barge velocity, leading to a stress input that is also proportionate to the impact velocity. Nevertheless, in the simulation conducted with ABAQUS software, an algorithm for determining von-Mises stress at the structure's most vulnerable region was also examined [9].

In generating output for von-Mises stress, it is important to recognize that von-Mises stress is a geometric combination of all stresses (normal stress in three directions and all three shear stresses) acting at a specific location. If the von-Mises stress at a particular location surpasses the yield strength, the material yields at that point. If the von-Mises stress exceeds the ultimate strength, the material ruptures at that location. The failure criterion asserts that the von-Mises stress σ_{mises} should be lower than the yield stress (σ_y) of the material. In its inequality form, the criterion can be expressed as:

$$\sigma_{mises} \leq \sigma_y$$

The von-Mises stress σ_{mises} is given by,

$$\sigma_{mises} = \sqrt{I_1^2 - 3I_2} \tag{2}$$

where I_1 and I_2 are given by,

$$I_1 = \sigma_x + \sigma_y + \sigma_z \tag{3}$$

$$I_2 = \sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_z\sigma_x - \tau_{yz}^2 - \tau_{xz}^2 - \tau_{xy}^2 \tag{4}$$

4. Results and Discussion.

4.1. Von-Mises stress analysis.

The von-Mises stress against seed size for different barge velocities are shown in Table 2 to Table 4.

Table 2: Maximum stress values for a barge velocity of 1 knot:

Table 2: Maximum stress values for a barge velocity of 1 knot.

Seed size (m)	von-Mises stress (GPa)
0.055	0.622
0.05	0.573
0.04	0.541
0.03	0.509
0.02	0.477

Source: Authors.

The von-Mises stresses resulting from the barge impact on the pier at a velocity of 1 knot have been consolidated in Table 2. For the largest considered seed size, namely 0.055, the induced stress was 0.622 GPa. Upon reducing the seed size to 0.05, the stress experienced a decline to 0.573 GPa. Subsequently, with a seed size of 0.04, the maximum stress reached 0.541 GPa. Further reductions in seed size to 0.03 and 0.02 led to stress values of 0.509 GPa and 0.477 GPa, respectively. It is noteworthy that the yield strength of high-strength steel is 0.505 GPa. Consequently, the stresses generated for seed sizes of 0.05 and 0.055 surpass the yield strength limit of the pier material, entering its permanent deformation range.

The generated von-Mises stress for a barge velocity of 2 knots exhibited a similar trend with varying seed sizes, as outlined in Table 3. The stress reached its maximum value of 1.29 GPa with a seed size of 0.055, followed by a subsequent decrease to 1.03 GPa for a smaller seed size of 0.05. A further reduction in stress was observed with a seed size of 0.04. The smallest stresses were recorded for seed sizes of 0.03 and 0.02, measuring 0.68 GPa and 0.54 GPa, respectively. Therefore, for a barge velocity of 2 knots, elevated stresses were noted when using seed sizes of 0.03 and above, surpassing the yield strength of the pier. Consequently, the pier may undergo plastic deformation if subjected to a barge impact at a velocity of 2 knots.

Table 3: Maximum stress values for a barge velocity of 2 knots.

Seed size (m)	von-Mises stress (GPa)
0.055	1.29
0.05	1.03
0.04	0.89
0.03	0.68
0.02	0.54

Source: Authors.

Table 4: Maximum stress values for a barge velocity of 3 knots.

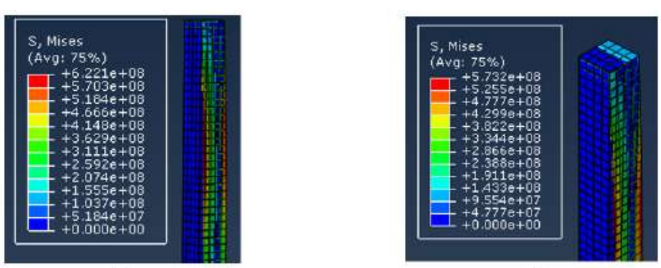
Seed size (m)	von-Mises stress (GPa)
0.055	3.03
0.05	2.09
0.04	1.89
0.03	1.74
0.02	1.66

Source: Authors.

When considering a velocity of 3 knots, the von-Mises stresses exhibited an increasing trend with growing seed sizes, as detailed in Table 4. Starting with a seed size of 0.055, the pier experienced a peak stress of 3.03 GPa. Subsequently, a notable decrease was observed for a smaller seed size of 0.05, registering at 2.09 GPa. Another decrease in stress was noted with a seed size of 0.04. Finally, the smallest seed sizes, 0.03 and 0.02, yielded the minimum stresses at 1.74 GPa and 1.66 GPa, respectively. With the increase in barge velocity to 3 knots, even higher stresses were generated. Given that high strength steel has an ultimate tensile strength of 1.20 GPa, it is evident from the table that all von-Mises stresses exceed this value. Consequently, the pier is prone to cracking, crashing, or collapsing if impacted by a 1723 DWT barge at a velocity of 3 knots.

The analysis of von-Mises stress against seed size for different barge velocities are shown in Figure 3 to Figure 5.

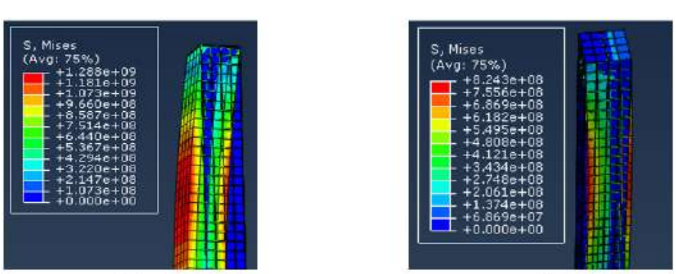
Figure 3: Von-Misses stress for (a) seed size 0.055m, and (b) seed size 0.05m, considering 1 knot barge velocity.



(a) (b)

Source: Authors.

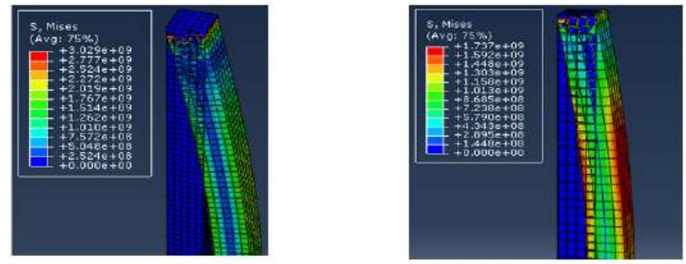
Figure 4: Von-Misses stress for (a) seed size 0.055m, and (b) seed size 0.04m considering 2 knots barge velocity.



(a) (b)

Source: Authors.

Figure 5: Von-Misses stress for (a) seed size 0.055m, and (b) seed size 0.03m considering 3 knots barge velocity.



(a) (b)

Source: Authors.

4.2. Pier displacement analysis.

The displacement against seed size for different barge velocities are shown in Table 5 to Table 7.

Table 5: Maximum displacement for a barge velocity of 1 knot.

Seed size (m)	Displacement (mm)
0.055	65.90
0.05	58.15
0.04	34.42
0.03	17.71
0.02	10.24

Source: Authors.

Table 5 illustrates pier displacements corresponding to various seed sizes obtained from the simulations. When a seed size of 0.055 was employed, the pier exhibited a peak displacement of 65.90 mm. Subsequently, with a seed size of 0.05, the displacement reduced to 58.15 mm. Opting for a smaller seed size of 0.04 resulted in a displacement of 34.42 mm. Further reductions in seed size to 0.03 and 0.02 yielded displacements of 17.71 mm and 10.24 mm, respectively. Hence, the pier displacement demonstrated a consistent trend, where decreasing seed size led to smaller displacement values.

Table 6: Maximum displacement for a barge velocity of 2 knots.

Seed size (m)	Displacement (mm)
0.055	70.21
0.05	63.28
0.04	51.02
0.03	39.55
0.02	23.50

Source: Authors.

Table 6 presents pier displacements corresponding to a barge velocity of 2 knots for various seed sizes. Using a seed size of 0.055, the pier exhibited a peak displacement of 70.21 mm. Subsequently, with a seed size of 0.05, the displacement reduced to 63.28 mm. Opting for a smaller seed size of 0.04

resulted in a displacement of 51.02 mm. Further reductions in seed size to 0.03 and 0.02 yielded displacements of 39.55 mm and 23.50 mm, respectively.

Table 7: Maximum displacement for a barge velocity of 3 knots.

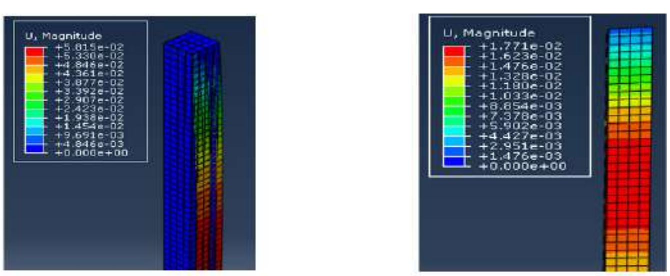
Seed size (m)	Displacement (mm)
0.055	165.6
0.05	133.8
0.04	111.8
0.03	64.48
0.02	58.37

Source: Authors.

Table 7 displays pier displacements corresponding to a barge velocity of 3 knots for various seed sizes. Using the largest seed size of 0.055, the displacement measured 165.6 mm. With a seed size of 0.05, the pier exhibited a peak displacement of 133.8 mm. Opting for a smaller element seed size of 0.04 resulted in a displacement of 111.8 mm. Further reducing the element seed size to 0.03 led to a pier displacement of 64.48 mm. The smallest seed size of 0.02 yielded a displacement of 58.37 mm. It is noteworthy that the displacements for seed sizes 0.03 and 0.02 are quite close, indicating mesh convergence.

The analysis of pier displacement against seed size for different barge velocities is shown in Figure 6 to Figure 8.

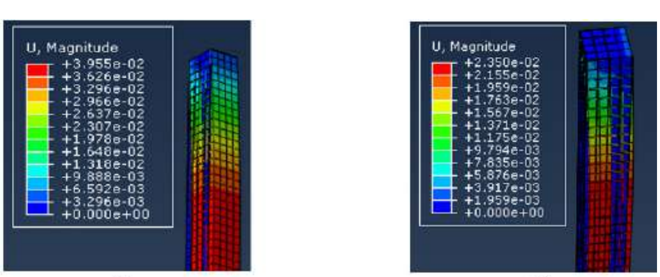
Figure 6: Displacement for (a) seed size 0.05m, and (b) seed size 0.03m with 1 knot barge velocity.



(a) (b)

Source: Authors.

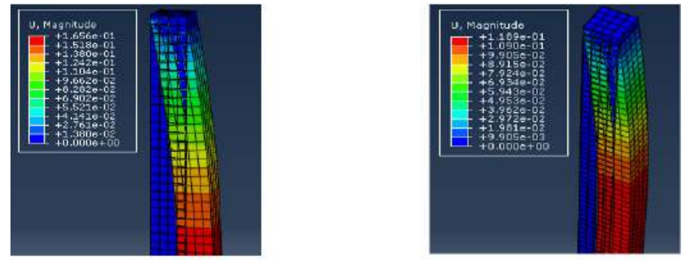
Figure 7: Displacement for (a) seed size 0.03m, and (b) seed size 0.02m with 2 knots barge velocity.



(a) (b)

Source: Authors.

Figure 8: Displacement for (a) seed size 0.055m, and (b) seed size 0.05m with 3 knots barge velocity.



(a) (b)

Source: Authors.

4.3. Kinetic Energy Analysis.

From the first two plots in Figure 9, it is evident that the impact energy vs. time curve exhibits a broader amplitude at a higher velocity of 2 knots compared to 1 knot. This indicates that the impact energy fluctuates on a larger scale when the barge velocity is increased. Similarly, when comparing impact energy for different seed sizes while maintaining a velocity of 3 knots as shown in Figure 10, a wider amplitude has been observed for the smaller seed size.

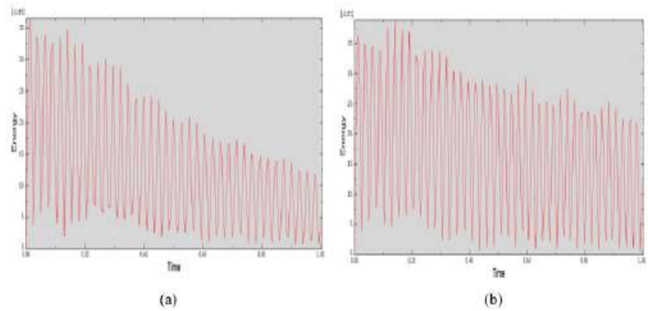
A consistent pattern observed in all the plots is the gradual decay of energy over time. This occurs because the maximum energy transfer takes place at the moment of collision between the barge and the pier. As time progresses, the energy is dispersed into the surrounding water, resulting in a reduction in the associated kinetic energy. To further confirm the diminishing trend and decrease in the amplitude of the energy curves, findings were examined from the research conducted by Sha and Hao [4]. In their study, the researcher plotted the impact force vs. time duration curve using LS Dyna, revealing a maximum impact force at the time of collision, with the associated impact energy dissipating as time advances [4]. The plotted impact forces reached a maximum value at a velocity of 4.11 m/s and gradually declined, reaching the minimum peak impact force for a velocity of 0.51 m/s.

Figure 9 and Figure 10 clearly show that the impact force reaches its peak immediately after the collision. Evidently, the kinetic energy also peaks during the same time duration. As time progresses, the impact energy diminishes, leading to a sharp downward curve with a reduction in amplitude. A similar pattern was identified in this study, where the curves exhibited both trends for all the simulations. Consequently, the results are corroborated and validated.

4.4. Maximum stress for different barge velocities.

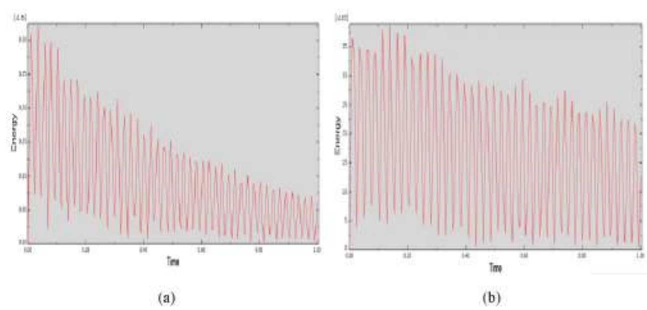
To determine the maximum stress generated in collisions at each velocity condition, peak values from analysis results were gathered and plotted against corresponding seed sizes. For example, the von-Mises stress generated as the pier was struck by the barge with a velocity of 1 knot. From this analysis, the maximum stress of 0.477 GPa was selected to plot against a mesh size of 0.02m in the graph.

Figure 9: Kinetic energy with time using (a) seed size 0.055m for 1Knot barge velocity, and (b) seed size 0.04m for 2 knots barge velocity.



Source: Authors.

Figure 10: Kinetic energy with time using (a) seed size 0.055m, and (b) seed size 0.04m for 3 knots barge velocity.



Source: Authors.

For each barge velocity, maximum stress values were extracted for mesh sizes of 0.055m, 0.05m, 0.04m, 0.03m, and 0.02m, and these values were plotted in a graph. More precise stress values were observed for smaller mesh sizes, resulting in a flattening of the graph in the smaller mesh region. The accuracy of the results was thus verified through the mesh convergence of the plots.

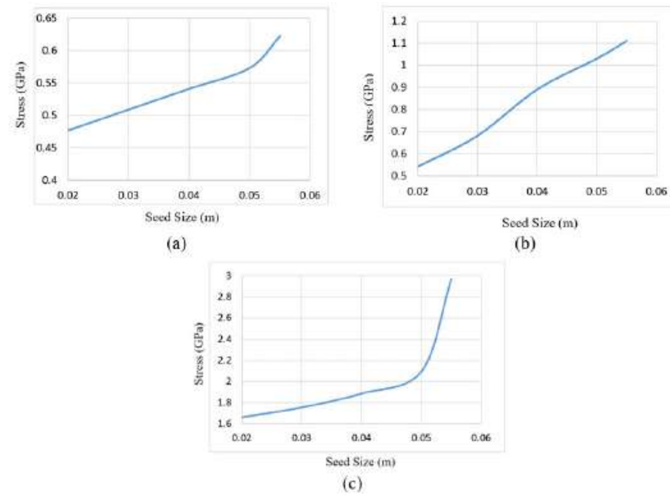
As evident from the result from Table 2 to Table 4, stresses remained within the yield strength limit of steel when the barge velocity was up to 2 knots. However, as the velocity increased to 3 knots, the stress reached 0.54 GPa, surpassing the yield strength of steel.

To validate the trends observed in the analysis, research work conducted by Liu et al. [10] was considered. In this study, the authors designed optimal manufacturing structures and investigated patterns for von-Mises stress and displacement under dynamic loading conditions [10].

In this research, the researcher considered the smallest inner side with 1.3 mm and the maximum inner side with 5.4 mm. The maximum von-Mises stress for the smallest seed size was 42.23 MPa, and the maximum von-Mises stress for the maximum seed size was 160.3 MPa. For the smallest seed size, the maximum displacement was 0.167 mm, and for the largest seed size, the maximum displacement was 0.508 mm.

The results indicate that as the number of seed size increases, the inner wall width (mesh size) decreases, leading to a reduction in the maximum von-Mises stress of the structure. Similarly, the maximum displacements are minimized for smaller seed sizes. This suggests that, in their study, a graph would exhibit a downward pattern as well [10]. In other words, a smaller mesh size results in more accurate outcomes, i.e., lower stress and displacement, confirming the simulation results obtained in this study.

Figure 11: Maximum stress vs. seed size in case of steel piers under a fully loaded barge with an impact velocity of (a) 1 knot, (b) 2 knots, and (c) 3 knots.

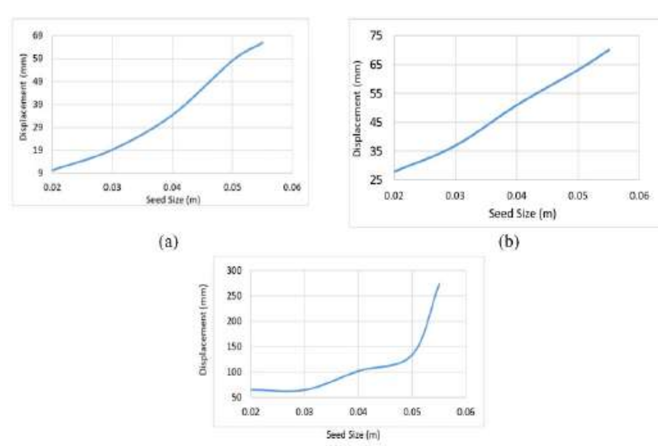


Source: Authors.

4.5. *Maximum displacement for different barge velocities.*

Likewise, peak displacement values were extracted for mesh sizes of 0.055m, 0.05m, 0.04m, 0.03m, and 0.02m. These values were then plotted in graphs corresponding to each analyzed velocity condition, as illustrated in Figure 12.

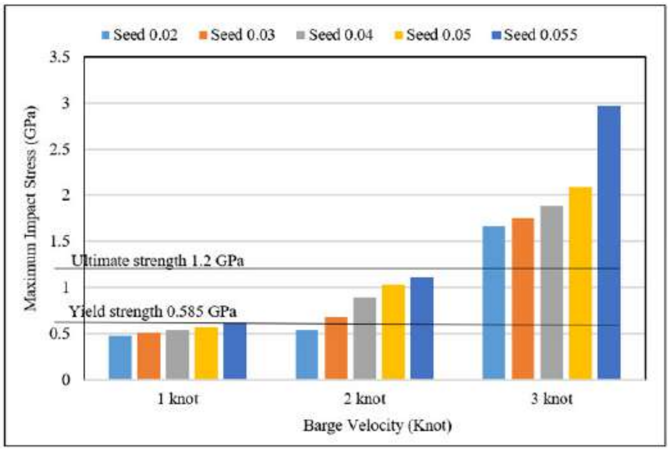
Figure 12: Displacement vs. seed size for a barge velocity of (a) 1 knot, (b) 2 knots, and (c) 3 knots.



Source: Authors.

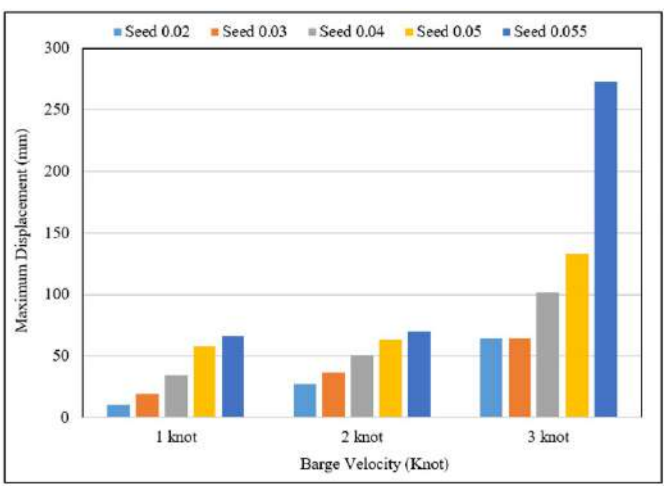
4.6. Comparative Analysis.

Figure 13: Maximum impact stress plotted against seed size for different barge velocities.



Source: Authors.

Figure 14: Maximum displacement plotted against seed size for different barge velocities.

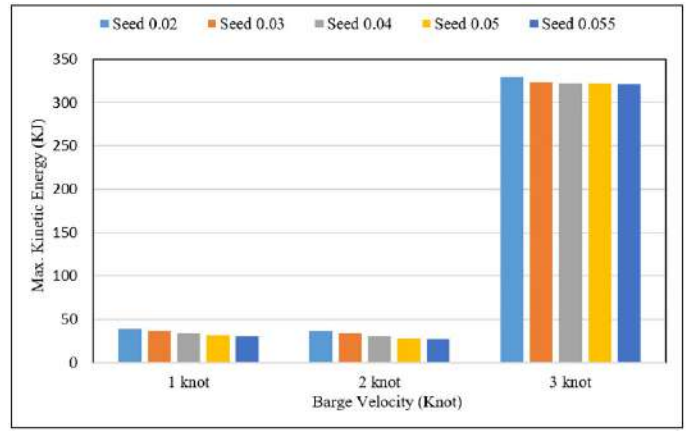


Source: Authors.

Figure 13 provides a clear indication that a steel pier, given its specified weight and dimensions, will not undergo permanent deformation in the event of a collision with a barge traveling at a maximum velocity of 2 knots. At a barge velocity of 1 knot, the maximum impact stress remains within the yield strength of the chosen material, ensuring no permanent deformation. However, when subjected to higher barge velocities exceeding 2 knots, the pier is prone to collapse due to the maximum impact stress surpassing the ultimate strength threshold of the material.

In Figure 14, the plotted data for maximum displacements reveals a discernible trend. As the seed size decreases, indicating a finer mesh resolution, the displacement values exhibit a reduction. Concurrently, as the velocity of the barge increases,

Figure 15: Maximum kinetic energy plotted against seed size for different barge velocities.



Source: Authors.

the corresponding displacement values tend to rise. This observation implies that the likelihood of the pier surviving a collision with the barge diminishes as the barge velocity increases. The inverse relationship between seed size and displacement, coupled with the direct correlation between barge velocity and displacement, underscores the importance of finer mesh resolution for accurate assessments of pier survivability under varying collision scenarios.

In Figure 15, the depicted trend illustrates the maximum kinetic energy across various barge velocities. Notably, a reduction in seed size corresponds to a decrease in the maximum kinetic energy, while an increase in barge velocity is associated with an elevation in kinetic energy values. Remarkably, at 1 and 2 knots barge velocities, the maximum kinetic energy is lower compared to the 3 knots barge velocity scenario. This observation is significant, as higher kinetic energy levels are indicative of increased potential for deformation in the pier structure. Thus, the trend underscores the critical role of kinetic energy considerations in assessing the extent of pier deformation resulting from collisions at varying velocities.

Conclusions.

This study delved into the structural response of a pier in diverse collision scenarios involving barges. Employing FEA, a comprehensive examination of parameters such as material properties, geometry, boundary conditions, and impact velocities was conducted. The study focused on a steel pier model to investigate the impact of pier material and barge velocity on stress, displacement, and associated energy during collisions. The results underscore the significance of considering bridge pier material properties in understanding barge-pier collision responses. Findings reveal that at lower impact velocities, the pier experiences elastic deformation, recovering its position post-collision. However, at higher impact velocities, plastic deformation and complete damage are observed.

The study limited the barge velocity to 3 knots, acknowledging that practical scenarios might involve higher velocities during collision, resulting in greater impact force, stress, kinetic energy, and displacement. Consequently, the examined high carbon steel piers, given their weight and dimensions, can only withstand barge collisions with a maximum velocity of 2 knots. Beyond this threshold, the pier exhibits nonlinear deformation, and the likelihood of collapse increases with escalating barge velocity. For situations where the pier faces potential collisions exceeding 2 knots, alternative materials or pier dimensions should be considered.

Two primary alternatives emerged from the study. First, designing the pier with larger dimensions can prevent stress from surpassing the yield strength of the steel. The ultimate alternative involves designing the pier with a material of higher strength, such as high tensile steel, where the yield strength exceeds the maximum impact stress in worst-case collision scenarios. This study emphasizes the importance of design considerations using FEM as a tool for enhanced structural consciousness.

The simulations provided precise insights into dynamic behavior, deformation patterns, and stress distribution within structures, crucial for optimizing barge and pier design, enhancing safety, and ensuring durability. The study underscored the significance of considering impact velocity, material properties, and boundary conditions in assessing collision response, influencing structural behavior, and necessitating effective mitigation strategies. Additionally, accurate modeling and validation of FEA simulations were emphasized through comparison with theoretical material behavior, ensuring reliability. In conclusion, the study's findings contribute to safer and more resilient structures in maritime transportation, serving as a foundation for future research to refine modeling techniques, incorporate additional factors, and explore dynamic behaviors in various maritime structures under collision scenarios.

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Forecast of Major Port Throughput in Malaysia by using Multiple Linear Regression Model

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ABSTRACT

Malaysia strategically located between East and West serves as a crossroads for the global marine trade and is a key player in the industry of transporting cargo within Southeast Asia. Between 2000 and 2010, Malaysian container ports saw a more than threefold increase in throughput on a yearly average basis. This phenomenon has caused port congestion, preventing ships from loading or unloading because the terminal is already full. Consequently, they can only queue up and wait in line for their turn at the port. This affects port efficiency by having ships waiting longer at the berth while more vessels keep joining the queue. This research attempts to develop the need for port capacity growth. In this study, the data will be extracted using Microsoft Excel and analyzed by Multiple Linear Regression using Minitab Software. The analysis's possible findings indicate that seaports rise in response to trade expansion, forcing the development of effective ways to lessen logistical pressures at Malaysian seaports. The potential significance of this study provides a recommendation for the strategies of seaports for capacity augmentation and creating effective distribution networks to satisfy growing needs.

1. Introduction.

Seaports are an essential element of the supply chain that facilitates the continuous movement of freight through the transportation system. Malaysia is a well-known country having some of the busiest ports in the world. The volume of maritime trade has increased to nearly 10.7 billion tonnes, with Southeast Asia accounting for about half of it (UNESCAP, 2019). Malaysia's maritime sectors contributed 2.9% to the export of transportation services consisting of 84,384 million US dollars in 2019 (UNCTAD, 2021). Malaysian ports had experienced an average gain of 3% in cargo throughput across decades. Malaysia is a favored entry point for Southeast Asians due to its strategic position and excellent connections.

Container traffic has increased by 400 percent in the last two decades at the ports (Heide, 2019). In Malaysia, there are now ten managed ports. They include the Port of Tanjung Pelepas, Port of Klang, Port if Penang, Port of Johor, Port of Kuantan, Port of Bintulu, Port of Kuching, Port of Miri, Port of Rajang, and Port of Sabah. The Sabah and Sarawak state governments are in charge of the ports in East Malaysia. Apart from these ports, Malaysia also has several privately operated port services and jetties, particularly in the oil and as sector including those at Port Dickson and Lumut (Ministry of Transport Malaysia, 2022).

The most significant ports are the Port of Klang and Port of Tanjung Pelepas, which accounted for 64% of all cargo throughput of Malaysia in 2018. The entirety of transshipment from Malaysia comes from these two ports (Port of Klang and Port of Tanjung Pelepas).

1.1. Problem Statement.

Port congestion is a circumstance when a ship arrives at a seaport for the loading or unloading of goods or for other purposes but does not able to berth and must wait outside at anchorage for a berth to open up. According to (Pioneer Freight, 2022), in container ports all throughout the world, there is a lot

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of port congestion, which attribute to the 1452.68% increase in cargo vessels during the previous 50 years. Container rollovers-which are required when a container is unable to load aboard the intended cargo vessel that it be accommodated on the subsequent ship. The port traffic has resulted in significant cargo disruptions for about 2 to 3 weeks, which have had an impact on the supply chain and therefore will ultimately affect businesses and customers throughout the world (Azman, 2021).

In the first ten months of the year, the Malaysian port has seen a 980 percent spike in blanked sailings. Port of Klang had the greatest rollover rate in 2021 with 58.45 percent, up 37.94 percent from the previous year (Murugiah, 2021). For import and export containers, Port Klang has a storage capacity of 120,000 TEUs, which it is currently using 60% of its capacity (Port Klang Authority, 2018). In 2021, global supply networks will face a number of big disruptions, with port traffic among them. Vessel schedule disturbances, which include surges of up to 45 percent in the ratio of cargo rollovers, longer passage, as well as more void sailings, are triggering shipment disruptions and global supply chain disturbances. Furthermore, yard inventory for import containers at Penang Port was 45 percent prior to MCO, and it increased to roughly 58 percent to 60 percent during the first week. The usual yard occupancy for imports at Penang Port was around 40%, but this has recently been increased to 50%. Most of the recent vessel purchases were in the middle of 2023, with an estimated 60,000- 70,000 containers entering service around mid-2022 (Shah, 2020).

1.2. Background of Ports.

This chapter aims to review the related literature of the research through the major ports in Malaysia.

1.2.1. Background of Port Klang.

Port of Klang is situated in Peninsular Malaysia which is about 40 kilometers from the country's capital, Kuala Lumpur (Britannica, 2020). A government decision made in 1993 enabled the development of the Port of Klang into the National Load Centre and eventually a center for the area. Port of Klang has used a variety of load-centering and hubbing techniques, and as a result, its amenities and services are now considered to be on par with those of top-tier ports. The port conducts business with more than 120 countries and has connections with more than 500 ports worldwide (Port Klang Authority, 2018).

From January to November 2019, the Port of Klang handled 12.32 million TEUs containers. With a cumulative cargo volume of 12.32 million TEU containers, the Port of Klang ranked 13th in terms of container port traffic behind Rotterdam. More than half of the cargoes handled in the Port of Klang are transshipments, although the port currently handles 2.39 million TEUs of all Malaysian container-based sea-borne imports and 2.35 million TEUs of all Malaysian container-based maritime (Murugiah, 2021). Over the past 5 years, the throughput of cargo has climbed by 3.6%, with a major decline of 9% in 2017 as a result of restructuring in sea freight alliances that led some large clients to move their business to another country. Westports aims to increase throughput by 50% in the next twenty years achieving 30 million TEUs (Donnelly, 2017). After getting preliminary approval from the Malaysian government, a preliminary design for the construction of the container terminal is expected to be finished by 2019. Westports is looking into novel designs and automation solutions for the new terminals.

1.2.2. Background of Port Tanjung Pelepas.

PTP had excellent terminal growth after achieving a record-breaking total throughput of 9.8 million TEUs in 2020, marking an increase of more than 8% above the 9.1 million TEUs recorded in 2019. Port of Tanjung Pelepas (PTP) remains operational under some limitations as a sector that provides crucial services and strategic assets to Malaysia. This port is responsible to ensure that trade and the flow of logistics are running smoothly without any interruption (Bakar, 2021). On the other hand, PTP has expanded its port expansion plans and is now building another berth for RM750 million to increase capacity by 2022 (Donnelly, 2017). PTP has secured more additional property in Tanjung Bin in front of terminals to transform into the area of the seaport. In the future, the Port of Tanjung Pelepas will become a desirable port with a high level of efficiency among industrial businesses (Heide, 2019).

1.2.3. Background of Johor Port.

Overall, Johor Port operates in three phases:

- Phase I: When the port first opened in 1977, it carried break bulk and liquid edibles.
- Phase II: In 1986, with the addition of dry bulk and liquid to the activities.
- Phase III: In the year of 1993, the operation began when the port installed a container terminal.

The container dealt at Pasir Gudang is mostly imported and exported, owing to the large industry that surrounds the seaport, which isn't present at PTP. The seaport's free trade zone houses the biggest palm oil terminal, with a storage capacity of nearly 460,000 metric tonnes. It is also one of the main ports in the region for non-ferrous metals hubbing, and was designated known as a London Metal Exchange (LME). Currently, it is rated 6th in the world for LME freight, out of 35 countries (Keetrax, 2018). Johor Port has gained a stable client base of significant multinational businesses including Pacorini Metals, Henry Bath, and Metro International Trade Services as a result of its efficiency and capacity. Among the other international clients are Shell and Chevron.

1.2.4. Background of Penang Port.

Port of Penang, Malaysia's oldest and longest- established port, has carved out a niche for itself by serving as the main entryway to Malaysia's northern region and south of Thailand, covering the basins of the Straits of Malacca (Penang Port, 2022). Port of Penang's core operations including the operation of cargo together with North Butterworth Container Terminal (NBCT) serves as the pivot. The first container discharged at this wharf is in 1974 marking the beginning of Port of Penang's relationship with containers. The Port of Penang has grown from a single dedicated berth in a multi-purpose terminal to a sophisticated dedicated container terminal that caters to the region's ever-increasing volume of container commerce (Penang Port, 2022).

1.2.5. Background of Bintulu Port.

A multi-purpose port, Bintulu Port has 3 general cargo wharves, a bulk cargo wharf, a container terminal, and numerous LNG jetties. Currently, there are about 400TEUs and 70 million tonnes of annual capacity. In 1981, Bintulu Port Holding Bhd was given operational control when the Port of Bintulu Authority was founded (Heide, 2019). Port of Bintulu serves as the import and export gateway for Sarawak and Brunei, which includes Brunei, Indonesia, Malaysia, and the Philippines. It served as East Malaysia's largest cargo port, the only Liquefied Natural Gas (LNG) export gateway in the country, and one of the world's largest Liquefied Natural Gas (LNG) export facilities. The number of containers obtained from the countryside will rise as the Sarawak Corridor for Renewable Energy (SCORE) initiatives are put into action, with more shipments of downstream timber, agro produce and product, fertilizer, manganese, silicon, pulp and paper, aluminum and other commodities arriving at the dock (Idris, 2019). In anticipation of this rise in freight, Bintulu Port has property south of its current port that is planned to be extended into a port area. A business that specializes in bulking facilities for raw and refined palm oil, edible oils, vegetable oils, fats, and their by-products is called Biport Bulkers Sdn Bhd.

1.2.6. Background of Kuantan Port.

Port of Kuantan is a cargo deep seaport that faces the South China Sea. Port of Kuantan has grown into an important cargo terminal supplying the east coast of Peninsular Malaysia due to its advantageous location on the country's eastern shore and close to the petrochemical industry's center. Port of Kuantan is known as an outstanding seaport of its facilities and services, extensive market reach, and robust network of global shipping links, and will serve as an agitator for the fast-growing n of industrial and manufacturing enterprises along the East Coast Industrial Corridor. After the New Deep-Water Terminal (NDWT) is finished, the Port of Kuantan is anticipated to serve as both the main entryway to China and the Far East as well as a transshipment hub for smaller ports in the area.

1.2.7. Multiple Linear Regression Analysis.

Based on the research paper Studying the Determinants of University Student Success Through Multiple Linear Regression and Factor Analysis (Abuhassan et. al., 2020). This study uses data from a random sample of students at a Palestinian institution to analyze the factors that contribute to academic performance. To forecast the association between the variables and compare these models across staff groups and student seniority in the school, this study used multivariate inferential data analysis methodologies, such as factor analysis and multiple linear regression. The findings indicate a connection between high school and college success. The findings also indicate that "getting scholarships," "English language skills," and "school attendance" are the next most significant predictors of university success, with variables measuring psychological well-being, gender, type of residence, and smoking habits having a minor influence. Additionally, it has been demonstrated that there are significant differences between faculties and student seniority levels in the relationship between the majority of these predictor variables and academic success. While these same variables are not consistently connected with academic achievement in other fields of study, they are in some areas. Based on research into multiple linear regression analysis (Uyanik & Guler, 2013). The purpose of the study is to determine whether or not the KPSS score, the dependent variable, was significantly predicted by the five independent variables in the conventional model, specifically, the academic psychologist, curriculum development, guidelines, and methods of teaching. The main goal of the research is to illustrate the stages of multiple linear regression. In this research, the 2012-KPSS score and the lesson (assessment and evaluation, developmental psychology, program development, consultation, and teaching methodologies) scores of Sakarya University Education and Faculty students are used as the data sources for multiple linear regression analysis. The regularity, linear, lack of absolute values, and analysis of missing value assumptions of multilinear regression analysis were looked. Multiple regression was used to check the data that supported the hypotheses, and the KPSS was estimated for each of the following categories: instructional methods, counseling, program development, and educational psychology.

2. Methodology.

This chapter discuss the techniques and methodologies needed to gather and analyze data in order to predict the analysis model of major ports in Malaysia. Sections of the chapter include the area of study, collection of data, and methods for analysis and presentation.

2.1. Area of Study.

This research is conducted on 10 major seaports in Malaysia which are Port of Klang, Port of Penang, Port of Johor, Port of Kuantan, Port of Bintulu, Port of Kuching, Port of Miri, Port of Rajang, Port of Sabah and Port of Tanjung Pelepas. These seaports give a general overview of the capacity of Malaysia's seaports to determine port efficiency indicators, such as the number of containers (export, import, transshipment, ship calling).

2.2. Data Collection.

Secondary data is collected in order to predict the number of containers in the future, which is the goal of this work. The information was gathered from credible secondary sources. For use in their own research, researchers might use material already obtained via original documents as secondary data. It is a type of information that has already been obtained. A researcher may have gathered data for a particular study and then made it accessible for use by other researchers.

As a result, this study relies on secondary data gathered from reputable sources, such as the Ministry of Transportation Reports from 2018. Because government records are an actual source of reliable data, this source is considered trustworthy. They contain a wide range of information that can be applied to study in the humanities, administration, social sciences, and advertising. The majority of secondary data sources are publicly accessible to academics and can be obtained via online devices. The number of containers in Malaysia's major ports is calculated using data from the Ministry of Transportation's 2018 reports. Port of Klang, Port of Penang, Port of Johor, Port of Kuantan, Port of Bintulu, Port of Kuching, Port of Rajang, Port of Sabah, and Port of Tanjung Pelepas are the ten seaports that participated in this study.

2.3. Data Analysis.

The data were evaluated using multiple linear regression. The total number of containers at major ports in Malaysia was first predicted using multiple linear regression for the ten ports. The data for the multiple linear regression was gathered from dependable secondary sources, including official data statistics from the Ministry of Transportation (2018). As a result, this strategy is appropriate for this study because it forecasts the model based on historical trends.

If Malaysia follows a growth pattern dictated by the government's port infrastructure strategy, the overall seaport capacity of the seven major seaports will increase. The total cargo throughput of the ten major seaports was forecasted during a 10-year period from 2009 to 2018 and was matched to port capacity increase. In order to anticipate the number of containers that major Malaysian seaports will need to predict the number of containers in the long term, this study will use a multiple linear regression method. Furthermore, the outcomes of these assessments will identify the further steps are needed for these seaports to remain competitive in the shipping industry.

The relationship between the dependent variable (Gross Register Tonnage (GRT)) and the independent variable (Import, Export, Transshipment, Ship calling) is represented by the below equation in multiple linear regression, where there are p acts as independent variables:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_nX_n \qquad (1)$$

Where:

Y = the predicted value of the dependent variable.

B_0 = the y-intercept (value of y when all other parameters are set to 0).

B_1X_1 = the regression coefficient (B_1) of the first independent variable.

(X_1) BnXn = the regression coefficient of the last independent variable.

Simple Linear Regression (SLR) can be considered as an extension of multiple linear regression when p predictor variables are present, or multiple linear regression can be considered as a particular example of simple linear regression when p=1. In Multiple Linear Regression (MLR), the term "linear" refers to the assumption that the dependent variable (Gross Register Tonnage (GRT)) is linearly connected and related to a linear combination of the explanatory variables. Analysis such as simple linear regression and correlation prevents us from making conclusions about the cause of an incident, but it does allow us to look at the relationship between a dependent variable (Gross Register Tonnage (GRT)) and independent variables (Import, Export, Transshipment, Ship calling). The null hypothesis or H0, states that there is no correlation between the independent variables (x) and dependent variable (y) in a simple linear regression. In other words, the independent variable and the dependent variable have no relationship. The

B_2 = -428,

X_2 = Export,

B_3 = 12.1,

X_3 = Transshipment,

B_4 = 4226,

X_4 = Ship calling.

Alternative hypothesis H1 states that the x variable and y variable are not equal to zero or there might be some relationship between x and y. Therefore, the null and alternative hypotheses can be expressed as follows:

Null hypothesis: There is no correlation between the congestion factors (Import, Export, Transshipment, and Ship Calling) and Gross Register Tonnage (GRT) at a major port in Malaysia. Alternative hypothesis: There is a relationship between the congestion factors (Import, Export, Transshipment, and Ship Calling) and Gross Register Tonnage (GRT) at a major port in Malaysia.

3. Results and Discussion.

The regression equation of regression analysis is as follows:

$$\begin{aligned} GRT = &-13206340 + 548\ (Import) - 428\ (Export) + \\ &12.1\ (Transshipment) + 4226\ (Shipcalling) \end{aligned} \qquad (2)$$

Where:

Y = Gross Register Tonnage.

B_0 = -13206340.

B_1 = 548, X_1 = Import.

B_2 = -428, X_2 = Export.

B_3 = 12.1, X_3 = Transshipment.

B_4 = 4226, X_4 = Ship calling.

Table 1: Output for Multiple Linear Regression.

Predictor	Coef	SE Coef	T	P
Constant	-13206340	3750502	-3.52	0.001
Import	548.47	86.84	6.32	0.000
Export	-427.91	94.15	-4.55	0.000
Transshipment	12.150	2.050	5.93	0.000
Ship Calling	4225.7	683.4	6.18	0.000

Source: Authors.

A p-value is a numerical representation of the likelihood that the data occurred by chance (i.e., The null hypothesis is true). The statistical significance level is usually expressed using the p- value, which has a range of zero to one. The null hypothesis should be rejected if the p-value is higher. Statistical significance can be interpreted as a p- value below 0.05(usually ≤ 0.05). This implies strong evidence against the null hypothesis and that the outcomes are random because there is only around a 5% chance that it is accurate. Therefore, the null hypothesis is rejected, and accept the alternative hypothesis.

Interpretation of Standardized Regression Coefficients (Beta):

1. For every one-unit increase in Gross Register Tonnage (GRT), the total cargo that was imported was predicted to increase by 548.47 in the raw score unit.
2. For every one-unit increase in Gross Register Tonnage (GRT), the total cargo that was exported was predicted to decrease by 5427.91 in the raw score unit.
3. For every one-unit increase in Gross Register Tonnage (GRT), the total cargo that was transshipment was predicted to increase by 12.150 in the raw score unit.
4. For every one-unit increase in Gross Register Tonnage (GRT), the number of ships calling was predicted to increase by 4225.7 in the raw score unit.

Table 2: Model Summary.

S=	R-Sq =	R-Sq(adj) =
24439512	95.8%	95.6%

Source: Authors.

The Multiple Correlation, known as Multiple R, between the Independent Variables (Import, Export, Transshipment, Ship calling), and the Dependent Variable (Gross Register Tonnage (GRT)), is shown in the Model Summary in the Table. (It is the relationship between the fitted Y (i.e., *Y*) values and the actual Y values): *corr (Y, Y)* The proportion of variance in Y that is accounted for by fitting (i.e., **Y**) is shown by the coefficient of determination known as R-square, which is the square of the multiple correlations. Values of R and R-square range from zero to one. R- Square (coefficient of determination) = 95.8% / .958 R- Square (adj) = 95.6% / .956 The model explains 95.8% of the variation in the dependent variable (Gross Register Tonnage (GRT)). When the sample size is lower and there are more predictors, R-square is positively skewed (as a population R-square estimator). Based on the sample group and the number of Independent Variables (Export, Import, Transshipment, Ship calling) in the model, the adjusted R-square offers an adjustment to the R-square. The gap between R-square (95.8%) and the Adjusted R-square (95.6%) in this output is really small. Shrinkage is the gap between the R-square and the adjusted R-square.

Table 3: Analysis of Variance, ANOVA.

Source	DF	SS	MS	F	P
Regression	4	1.55967E + 18	3.89917E + 17	652.81	0
Residual Error	115	6.86883E + 16	5.67290E + 14		
Total	119	1.62836E + 18			

Source: Authors.

The level of significance of the R-squared value in the Model Summary Table is analyzed using the analysis of variance. The population R-square is equal to zero, which is the null hypothesis. According to the ANOVA results, the entire model is significantly effective in describing Gross Register Tonnage (GRT) [F(A,115) = 3.89917, P < .000].

$$F = \frac{R^2/k}{(1-R^2)/(n-k-1)} \tag{3}$$

Or alternately based on ANOVA summary table:

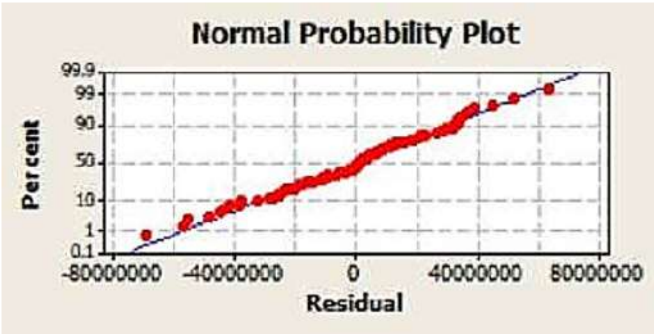
$$F = \frac{SS_{reg}/df_{reg}}{SS_{res}\ /\ (n-k-1)} \tag{4}$$

Where k = number of predictors, n= sample size.

3.1. Normality of residuals values.

A graph of residual normality was generated to assess the regression model's normality (Fig.1). It makes it possible to visually inspect the residuals' compliance with the normal distribution. If there are any points along the straight line that means it supports the residual distribution's normality. The first and last findings may be subject to some objection because they deviate somewhat from the line, but the normality of the residual values is unaffected by this deviation. The same details are provided by the histogram of the residuals (Fig.2). It is clear that things are going well because the normal line (the black line on the graph) crosses the top edge centers of the columns.

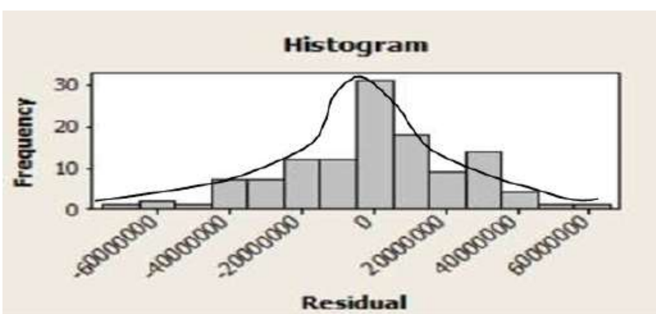
Figure 1: Normal P-P of Regression Typical Residual.



Source: Authors.

The standardized residuals' normality can also be evaluated using the normal P-P plot. This plot shows the disparity between the observed regression and those estimated under the assumption of normality. More evidence of normality is present when the observed residuals are closer to the regression line. This evidence of normally distributed residuals is well supported by this plot.

Figure 2: Regression Standardized Residual.



Source: Authors.

One of the assumptions of linear regression is that the residuals are normal in distribution. An automatic histogram of the standardized residuals will be generated by Statistical Package for Social Sciences (SPSS). A histogram of the standardized residuals is shown here. The mean of the unstandardized and standardized residuals is zero, and both have the same skewness and kurtosis shapes. Their standard deviations vary, which makes them different. In this case, there is only a slight deviation from normality in the residuals. Conceptual Point: The difference between Y and predicted Y is used to calculate unstandardized residuals. The ratio of the unstandardized residuals (above) to the standard deviation of those residuals is used to calculate the standardized residuals.

4. Recommendations.

Some of the recommendations for increasing seaport capacity is that these ten seaports need an operational approach to deal with this issue. By supplying more external capacity for seaports outside the region, the linkage of these seaports with external logistics centers like port terminals will provide produce an appropriate strategy. More parties will use these external amenities that are close to the manufacturing region because dry ports offer almost all of the services that a seaport provides. This will increase the seaport's capacity, which may subsequently be set aside for transshipment needs, particularly at the Port of Tanjung Pelepas and Port of Klang. Malaysian ports are more competitive than those of their opponents due to the growth of ports, which helps ports' capacity.

However, due to high port fees, if the government keeps rising capital expenditures for port improvement in Malaysia every 5 years, it will have a lower favorable effect on the attractiveness of Malaysian seaports among logistic lines. Considering increasing port charges is the most suitable course of action for the terminal authority to adopt when making up for the cost which has been spent previously, seaport fees will rise continuously with the amount of capital investment. An increase in port charges will be required since the significant capital expenditure in port infrastructure demands a longer repayment time, even though the high fleet frequency and continuous cargo traffic volume will help with cost reimbursement. This condition affects how appealing Malaysian seaports are to shipping lines, as well as providing several advantages to competitors. The nation benefits greatly from dry ports' support in terms of transportation.

In order to enhance seaport performance, the establishment of the seaport-dry port corridor must be put into action. By creating a port-dry port corridor, traffic might be less congested and the seaport will be more accessible. Both of these elements will increase the efficiency of Malaysian seaports, particularly in terms of enhanced access to the hinterland, quicker vessel response times, and longer freight stay times. From a regional perspective, the development of seaports within the port system increases local residents' employment. A wide range of alternatives is available for local business owners to deliver their goods to their various clientele on time due to the improvement of the infrastructure, a well-rounded transport system, and the introduction of numerous modes of transportation. In addition, because dry ports are supported, seaports may handle more containers and will not have to invest as much in expanding their capacity. These approaches have been put into practice in China, where seaports have been set up to relieve tension on port capacities and also provide cheaper port fees. The Malaysian government could therefore use the same amount of money to improve the efficiency of the transportation system, particularly the rail system by upgrading the connectivity of the seaports-dry ports-stakeholders corridor and increasing accessibility to and from the seaports, with the assurance of long-term profits.

Conclusions.

In order to determine the container ports' throughput performance, this study suggests a prediction analysis model of the major ports in Malaysia. The outcome of this application has been utilized to simulate the performance of Malaysian ports recently. The method is especially beneficial for policymakers and service providers in tracking competitiveness and organizing the expansion of container ports. The number of containers in Malaysian ports is predicted to rise, and this development is anticipated to exceed the seaport's actual capacities.

Nevertheless, if seaports are unable to increase their capacity, it will undoubtedly result in some additional negative effects of various kinds, particularly congestion, lengthy turnaround times for both vessels and containers, and a decrease in the effectiveness of the supply.

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Bottom Sediment Analysis at Lhok Seudu Beach, Aceh Besar

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ABSTRACT

The research with the title Basic Sediment Analysis of Lhok Seudu Beach, Aceh Besar was conducted from March to April 2023. Lhok Seudu Beach is a bay beach in the area affected by the 2004 tsunami. This study aims to determine the characteristics of sediments as a basis for geological oceanography studies. The method used serves to analyze the shape of the bottom sediment with granulometric analysis. Granulometric analysis itself uses the sieve analysis method or multilevel screening to determine the results. The results of this study are the largest mean sediment of each station in each grain size is the type of medium sand with an average percentage of 0.2794029% and the smallest mean is the type of coarse silt with an average percentage of 0.05309625%. The conclusion obtained in this study is the divergence of the sediment in each station. The conclusion obtained in this study is that the differential found at EBA and WBA is influenced by topography and sediment transportation on sediment characteristics.

1. Introduction.

Indonesia with the title of the largest country in Southeast Asia also has a large maritime area. There are 17,000 islands owned by Indonesia as an archipelago with a sea area covering 5.8 million km^2 with a division of sovereign sea area and Exclusive Economic Zone area. As a maritime country, Indonesia itself has a coastline of around 81,000 km, supporting resources through coastal areas (Mutaqin et al., 2021).

The Lhok Seudu area is a coastal area in Leupung District, Aceh Besar Regency. This area was affected by the earthquake and tsunami disaster on December 26, 2004. Geographically Lhok Seudu is located at coordinates 5°21’30.2”- 5°21’34.3” LU and 95°13’52.9”- 95°13’58.9” East. The majority of the Lhok Seudu community are farmers and fishermen with a match of geological conditions in the area. This proves the dependence of the community on the conditions of the region, namely marine products and rice field management (Sitta et al., 2021).

Granulometric analysis can be used to determine the type of bottom sediment (Poizot et al., 2008). Granulometric analysis is divided into two, namely sediment grain size analysis and sediment type naming analysis. To determine the analysis of sediment grain size distribution, a statistical approach is taken using mean, kurtosis, sorting, and skewness. Naming sediments can be done by referring to the sediment triangle. The condition of the distribution of bottom sediments in a body of water can be known from analyzing the relationship between bottom sediments and current movements obtained from information on sediment distribution analysis, granulometric analysis, and observations of oceanographic parameters (Hadyan et al., 2015).

Sediment particle size is one of several physical parameters used to test sediment quality. The unit of sediment size is expressed in mm. Sediment particle distribution is the percentage of grains that pass the sieve of a certain size depicted in the form of a curve, the unit is expressed in percent. This data is an important parameter in the investigation of sediment problems. Differences in the size of sediment particles can indicate differences in transportation methods and sources (Zhang et al., 2021). Sediment particle size data is widely used for various purposes, including to calculate the specific gravity of sediment deposited in the reservoir, as well as to calculate the amount of sediment transport, supporting the calculation of erosion rates

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and soil erodibility factors (BSN, 2018).

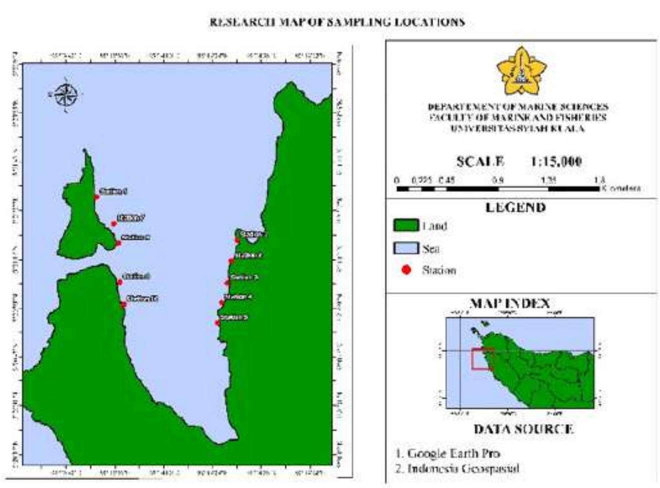
The treatment of sediment in the identification process with granulometric analysis is carried out using the Wentworth scale, (1922). This scale shows information in the form of classification of clastic sediments. On this scale, Wentworth also has many similarities in his classification with Udden (1914), so many researchers have combined their classifications under the name Udden-Wentworth Grain Size or U-W Grain Size. This classification also does not have an absolute standard to use because it is adjusted to the topic or case of the research to be carried out while still referring to Udden, Wentworth, or both.

This research aims to characterize sediments as a basis for geological oceanographic studies which provide benefits for decision making in development policies in the area.

2. Materials and Methods.

This research was conducted at Lhok Seudu Beach, Layeun Village, Leupung District, Aceh Besar Regency, Aceh Province.

Figure 1: Research Location Map.



Source: Authors.

2.1. Location Point Determination.

Determination of station location points in the Lhok Seudu Coastal Waters area, determined as many as 10 station points spread by following the coastline. Sampling was carried out by dividing into 2 areas (Wahab et al., 2016), namely the East Bay Area / EBA area consisting of 5 stations (st1, st2, st3, st4, st5) and the West Bay Area / WBA area consisting of 5 stations (st6, st7, st8, st9, st10). The distance between stations was randomized at each station.

2.2. Sampling.

Samples taken in this study using the coring technique using a 3.5-inch diameter PVC pipe with a sample layer thickness of 15 cm.

2.3. Granulometry Analysis.

Granulometric analysis is a grain size analysis performed on siliciclastic sediments. Sediment analysis is carried out using the graded sieving method (sieve analysis). This method uses a multilevel sieve tool. This analysis serves to show information on sediment grains at the research site.

In using granulometric analysis using the multilevel sieve method, the Udden-Wentworth scale is used as a reference in sediment classification (Wentworth, 1922). The purpose of using the Udden-Wentworth scale is to identify the type of sediment at each station. The following is a classification table using the Udden-Wentworth scale.

Table 1: Udden-Wentworth Scale.

mm	Phi (φ)	Udden-Wentworth Scale Grain Size Classification	
4096-256	-12 till -8	Chunks	
256-64	-8 till -6	Crust	Gravel
64-4	-6 till -2	Gravel	
4-2	-2 till -1	Grain	
2-1	-1 till 0	Very Coarse Sand	
1-0.50	0 till 1	Coarse Sand	
0.50-0.25	1 till 2	Medium Sand	Sand
0.25-0.125	2 till 3	Fine Sand	
0.125-0.0625	3 till 4	Very Find Sand	
0.0625-0.031	4 till 5	Coarse Silt	
0.031-0.0156	5 till 6	Medium Silt	Silt
0.0156-0.0078	6 till 7	Fine Silt	
0.0078-0.0039	7 till 8	Very Fine Silt	
0.0039-0.00006	8 till 14	Clay	Mud

Source: Authors.

3. Results and Discussion.

Table 2 shows the sieve results consisting of all stations taken in the East Bay Area (EBA) and West Bay Area (WBA) at the Lhok Seudu Beach location using a multistage sieve with the dry sieve method. Based on the Udden-Wentworth scale shows the overall percentage of the station is sand. The dominance of sediments in the average cumulation (mean) of each station in each sieve size (fraction) is topped by sediments with medium sand type with an average percentage of 29.84%, followed by coarse sand type with an average percentage of 19.1 %, then very fine sand type with an average percentage of 16.002 %, then fine sand type with an average percentage of 15.558%, there is also a type of very coarse sand with an average percentage of 7.6815%. Gravel is in the next order with the type of

Table 2: Weight distribution of sediment samples at Lhok Seudu Beach.

Station	Percentage of Sediment Weight by Fraction Size (%)								Type (Dominant)
	>2 (mm)	2-1 (mm)	1-0.5 (mm)	0.5-0.25 (mm)	0.25-0.125 (mm)	0.125-0.063 (mm)	0.063> (mm)	Total	
1	9.5	10	38	20.5	0.08	16.44	5.48	100	Sand (Coarse Sand)
2	3.5	9	22.5	31.5	2	23.61	7.89	100	Sand (Medium Sand)
3	7	10.5	26	29	4.5	17.3	5.7	100	Sand (Medium Sand)
4	5	9.5	29	28.9	7	15.85	5.15	100	Sand (Coarse Sand)
5	2.5	1.5	5	8.5	47.5	26.25	8.75	100	Sand (Fine Sand)
6	1.5	2.5	7.5	56.5	6	19.5	6.5	100	Sand (Medium Sand)
7	16	24.5	29.5	7.5	2	15.375	5.12125	100	Sand (Coarse Sand)
8	4.5	5.5	15.5	38.5	27.5	6.4	2.1	100	Sand (Medium Sand)
9	0.48	0.315	15	42	45	8.045	2.655	100	Sand (Medium Sand)
10	15.5	3.5	16.5	35.5	14	11.25	3.75	100	Sand (Medium Sand)
Average	6.548	7.6815	19.1	29.84	15.558	16.002	5.309625	100	

Source: Authors.

sand with an average percentage of 6.548 %, while in the last order there is silt in the form of silt with an average percentage of 5.309625%.

In Table 2, it can also be seen information in the form of sediment types from each station by looking at the dominance of the sediment type classification in the sieved samples. At station 1, the type of sediment produced in the measurement is coarse sand. At station 4, coarse sand type is produced again followed by fine sand type at station 5. At station 6, medium sand sediment type was produced followed by coarse sand type at station 7. The medium sand type dominates at station 8, station 9, and station 10.

The information shown in Table 3 are the results of the granulometric method representing the summit (st1, st2, st3, st4, st5). The mean weight or average value of each sieve size (fraction) at the summit is highest for the coarse sand type with an average percentage of 24.1%, followed slightly by the medium sand type with an average percentage of 23.68%. The very fine sand type ranks third with an average percentage of 19.89%, followed by fine sand with an average percentage of 12.216%. The very coarse sand type with an average percentage of 8.1% ranks fifth, just above silt with an average percentage of 6.594%. The lightest average percentage is in the grain type gravel with a result of 5.5%. From this information, it can be concluded that the sedimentary summit with coarse sand type dominates the area.

Table 4. displays information that represents WBA (st6, st7, st8, st9, st10). The results of the mean weight or average value of each sieve size (fraction) at WBA are the highest average in the medium sand type with an average percentage of 36%, followed by the fine sand type with an average percentage of 18.9%, and the coarse sand type ranks third as the most dominant type with coarse sand type with an average percentage of 14.1%. The very fine sand type with an average percentage of 12.114% and the gravel type in the form of grains with an average percentage of 7.596% come next. The very coarse sand type comes next with an average percentage of 7.263%, followed by the last category of silt with an average percentage of 4.02525%. From this information, it can be concluded that in the WBA sediments with medium sand type dominate the area.

According to (Yasin et al., 2016), the sediment distribution process is influenced by topography, sediment material sources and sediment transportation mechanisms. The differences found in the East Bay Area and West Bay Area show the resulting influence seen from topography and sediment transportation on Lhok Seudu Beach.

Conclusions.

The largest average (mean) sediment of each station in each grain size (fraction) is sand-type sediment in the form of medium sand with an average percentage 29.84% and the smallest average (mean) sediment of each station in each grain size (fraction) is silt-type sediment in the form of silt with an average

Table 3: Weight distribution of sediment samples at Lhok Seudu Beach, East Bay Area (EBA).

Station	Percentage of Sediment Weight by Fraction Size (%)								Type (Dominant)
	>2 (mm)	2-1 (mm)	1-0.5 (mm)	0.5-0.25 (mm)	0.25-0.125 (mm)	0.125-0.063 (mm)	0.063> (mm)	Total	
1	9.5	10	38	20.5	0.08	16.44	5.48	100	Sand (Coarse Sand)
2	3.5	9	22.5	31.5	2	23.61	7.89	100	Sand (Medium Sand)
3	7	10.5	26	29	4.5	17.3	5.7	100	Sand (Medium Sand)
4	5	9.5	29	28.9	7	15.85	5.15	100	Sand (Coarse Sand)
5	2.5	1.5	5	8.5	47.5	26.25	8.75	100	Sand (Fine Sand)
Average	5.5	8.1	24.1	23.68	12.216	19.89	6.594	100	

Source: Authors.

Table 4: Weight distribution of sediment samples at Lhok Seudu Beach, West Bay Area (WBA).

Station	Percentage of Sediment Weight by Fraction Size (%)								Type (Dominant)
	>2 (mm)	2-1 (mm)	1-0.5 (mm)	0.5-0.25 (mm)	0.25-0.125 (mm)	0.125-0.063 (mm)	0.063> (mm)	Total	
6	1.5	2.5	7.5	56.5	6	19.5	6.5	100	Sand (Medium Sand)
7	16	24.5	29.5	7.5	2	15.375	5.12125	100	Sand (Coarse Sand)
8	4.5	5.5	15.5	38.5	27.5	6.4	2.1	100	Sand (Medium Sand)
9	0.48	0.315	1.5	42	45	8.045	2.655	100	Sand (Medium Sand)
10	15.5	3.5	16.5	35.5	14	11.25	3.75	100	Sand (Medium Sand)
Average	7.596	7.263	14.1	36	18.9	12.114	4.02525	100	

Source: Authors.

percentage 5.309625%. East Bay area (EBA) is dominated by coarse sand and medium sand type sediments. West Bay area (WBA) is dominated by medium sand type sediments. Differentials in EBA and WBA are influenced by topography and sediment transport on sediment characteristics.

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Numerical analyses of underwater pipe sections under falling objects

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ABSTRACT

Underwater and land pipelines are generally modelled under the environmental loads. In addition to these mentioned loads, pipelines are subjected to destructive sudden loads due to accidental drops, ship anchors, rock falls, trawlers fishing and military attacks. In this study, numeric analysis of the same pipe section has been carried out according to the sudden loads caused by falling objects both underwater and on land. Abaqus finite elements analysis software is used in the analysis. While the interaction of pipe-falling object is modelled in the analysis of the pipeline on land, the interaction of pipe-falling object-water is modelled in the underwater pipeline. Bidirectional fluid-structure interaction (FSI) analysis is utilized in the water-pipe-falling object interaction modelling. A fully nonlinear free surface simulation is performed by Coupled Eulerian Lagrangian (CEL) technique in the FSI analysis. Impact parameters such as accelerations, velocities, displacements and impact forces, are determined for both land and underwater pipe sections at the end. Thus, while determining the effect of water on the impact behaviour, the free surface movement of the water in the course of impact is also obtained.

1. Introduction.

Pipelines are important structures built at sea and on land, formed by the combination of multiple pipe sections. The importance of pipelines is due to the fact that that they carry out vital activities such as clean-waste water, oil, natural gas transmission, energy and communication lines.

During their service life, the pipelines are faced with environmental loads such as earthquakes, waves, currents, as well as damage threats that may occur due to storms, landslides, soil liquefaction and accidental impact loads. Ship collisions on marine pipelines (Yu et al. 2016), and rock falls on land pipelines (Pichler et al. 2006) can be given as examples of impact loads.

Impact effect from sudden falling objects changes mechanical properties of structural members due to dynamic effects. Stress values change because of these effects at the strike moment. Damage expands beyond the impact point during such crushing events. For this reason, extensive damage and losses may be observed. Various experimental (Kishi et al. 2002: Zhu et al. 2018: Erdem, 2014:) and numerical studies (Erdem and Gücüyen, 2017: Odina, Hardjanto and Walker, 2018: Zhou and Zhang, 2022: Kawsar et al 2015: Zhang, Liang, and Han, 2014) have recently been developed by many scientists to facilitate better understanding of these complex impact-related situations. On the other hand, similar computer simulations have been performed to compare the experimental and the numerical studies (Zeinoddini et al. 2013: Zhou and Zhang, 2023: Gau et al 2020).

As different from the pipelines on land, investigation of marine pipelines under falling impact loads is performed by considering fluid-structure interaction (FSI) analysis. FSI analysis is unidirectional when the force transfer occurs from the fluid to the structure only. However, bidirectional analysis is when the force is transferred from the fluid and the displacement is transferred from the structure. Finite element analysis is applied for both analyses. Finite elements supported FSI analysis can be generated by either Eulerian technique (Martínez, 2009) or Lagragian technique (Gücüyen, Erdem and Gökkuş, 2016). On the other hand, both techniques can also be used in Arbitrary Lagragian Eulerian (ALE) (Korobenko et al. 2017)

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and Coupled Eulerian Lagrangian (CEL) analyses (Gücüyen et al. 2018). Abaqus finite element software is widely used in the interaction modelling (ABAQUS User's Manual, 2015). In ALE and CEL analyses, the structure and the fluid are modelled by Lagrangian and Eulerian techniques respectively. The CEL technique which is implemented in the software Abaqus and uses an explicit time integration scheme is a large deformation finite element method coping with the deficiencies of the pure Lagrangian and Eulerian techniques.

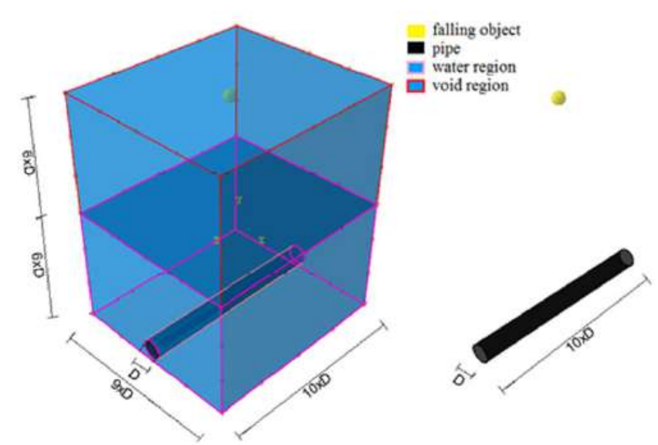
In the literature survey, it is seen that the CEL technique has been used in a few studies in modeling the behavior of underwater pipes under the effect of sudden falling objects (Jiang and Dong 2020: Jiang et al. 2019: Jiang and Dong 2022). In these studies, while CEL technique has been utilized in soil-structure interaction modeling, the submerged unit weight of soil is used to consider the seawater pressure. In the study in which bidirectional fluid structure interaction is generated under the effect of a sudden falling object (Kristoffersen et al. 2014), the behavior of the water in the pipe under the impact effect is modeled. The origin point of this study is the limited number of studies in which the free surface movement of the water surrounding the pipe under the impact of impact is modeled and the bidirectional fluid structure interaction is carried out.

This paper aims to numerically investigate the dynamic behaviour of underwater and land pipes impressed by falling objects. CEL technique is utilized by Abaqus software in the numerical analysis. While the pipe and falling object are modelled by Lagrangian procedure, water environment is modelled by Eularian procedure. Impact parameters such as accelerations, velocities, displacements and impact forces, are determined for both land and underwater pipe sections in the end.

1.1. Numerical Models.

In this study, the effect of the environment of the pipes under sudden falling objects on the behaviour of the pipe has been investigated. For this purpose, above ground pipe models seen on the right of Fig. 1 and underwater pipe models on the left have been created. The situation only under the effect of free falling where the pipe is not in use is modelled in the software.

Figure 1: Numerical models and dimensions.



Source: Authors.

The numerical model belongs to underwater pipe, has 4.5 x 5 m base dimensions with a height of 6 m. While width of the water part is determined as nine times of the diameter (D) of the pipe (9 x D), length of the region is taken as equal to ten times of pipe diameter (10 x D). In addition, the height value is twelve times of pipe diameter (12 x D). While the drop height is 5 m, the mass of the striker is taken to be 140 kg in the analyses. Void region with the height of 3 m is set above the water region, which is used to describe the potential water flow on the free surface during the simulation process.

Properties of the fixed supported pipe which is used to model both land and underwater pipe under falling object effect are seen in Table 1. While the underwater pipe model has three parts; pipe, water and falling object, the land pipe model has two parts; pipe and falling object.

Table 1: Geometric and material properties of the pipe and water parts.

Parts	Geometric Properties		Material Properties	
Pipe part	Length (m)	5	Yield Stress (MPa)	240
	Diameter (m)	0.50	Young's modulus (GPa)	210
	Thickness (m)	0.016	Mass density (kg/m^3)	7850
Water part	Length (m)	10	Density (kg/m^3)	998
	Width (m)	4.5	Dynamic viscosity (Ns/m^2)	0.0010
	Height (m)	6	Velocity of sound (m/s)	1480

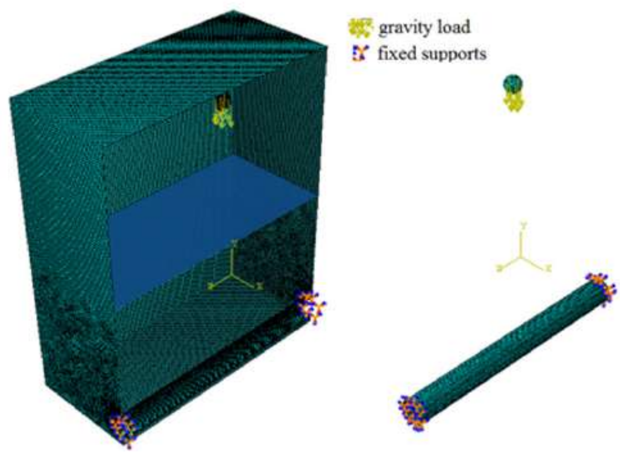
Source: Authors.

Once the models are created, the element types, material properties of related sections, proper step and mesh sizes, connection between surfaces of elements, correct boundary, and initial conditions are provided. Time steps have an important effect on the results of impact analyses. For this purpose, both step and total time spans are checked consistently. Time steps are determined from beginning to the end of the drop movement of the falling object. While the time increments have been defined as 0.060 seconds before the contact point, they have been set to 2x10^{-8} seconds when the contact between the falling object and the pipe has started.

Finite elements models should be separated into small pieces, known as meshing, so that the analyses can be performed correctly. Mesh structure and load-support conditions of the models are seen in the

Fig. 2. While the left side of the figure belongs to underwater pipe, right side belongs to land pipe. C3D8R (three dimensional, 8-node linear brick, hexahedron) typed elements are used in pipe parts, C3D10M (10-node modified tetrahedron) typed elements are used in falling object parts so the element assignment of the Lagrangian parts is realized. Element assignment of the Eulerian part is realized by assigning EC3D8R (8-node linear eulerian brick, reduced integration, hourglass control) typed elements to water part. Distance between nodes in pipes and falling object is 0.016 m, same as thickness of the pipe. In water part, the node distance is 0.016 m on the contact regions with pipe and on the rest of geometry the node distance is 0.025 m. Thus, the whole finite elements model is constituted by 87144 nodes and 49840 elements in Lagrangian part and 10314717 node and 10169600 elements in Eulerian part.

Figure 2: Mesh structure and load-boundary conditions of the models.



Source: Authors.

As the problem is related to the free falling movement, only gravity load is applied to the system. Pipes are fixed supported in both ends. In the underwater pipe model, pipe and dropped object are interacting with water. Due to this interaction, fluid structure interaction (FSI) analysis shoud be performed in underwater model.

2. FSI Analysis.

Fluid-structure interaction analysis of the underwater pipe under dropped object effects is performed by Abaqus finite element analysis software (ABAQUS User's Manual, 2015). Lagrange and Eularian procedures are followed through CEL technique in the numerical analysis. Mathematical definition of this technique is presented in the following sections.

2.1. Mathematical Definition of CEL Technique.

Formulation of CEL technique that is used by Abaqus is described by the equations below. Eqs (1-3) are the mass, momentum and energy Lagrangian conservation equations respectively.

$$\frac{D\rho}{Dt} + \rho\nabla \cdot v = 0 \tag{1}$$

$$\rho\frac{Dv}{Dt} = \nabla \cdot \sigma + \rho b \tag{2}$$

$$\frac{De}{Dt} = \sigma : D \tag{3}$$

In the Eqs (1-3), material velocity, density, the Cauchy stress, the body force and the internal energy per unit volume are represented by v, ρ, σ, b and e respectively.

$$\frac{D\varphi}{Dt} = \frac{\partial\varphi}{\partial t} + v \cdot (\nabla\varphi) \tag{4}$$

By using the Eq. (4), governing equations for Lagrangian technique are determined in the general conservation form for Eularian procedure as follows.

$$\frac{\partial\varphi}{\partial t} + \nabla \cdot \Phi = S \tag{5}$$

φ is the arbitrary solution variable, Φ is the flux function and S is the source term in the Eq. (5). This equation can be written as two separate equations as follows.

$$\frac{\partial\varphi}{\partial t} = S \tag{6}$$

$$\frac{\partial\varphi}{\partial t} + \nabla \cdot \Phi = 0 \tag{7}$$

Eq. (6) is hence identical to the standard Lagrangian formulation if the spatial time derivative is replaced by the material time derivative on the fixed mesh. The deformed mesh is moved to the original fixed mesh, and volume of material transported between adjacent elements is calculated to solve the Eq. (7). The Lagrangian formulation variables such as the mass, energy, momentum, stress and others are then adjusted to account for the flow of the material between adjacent elements by the transport algorithms.

2.2. CEL application to mentioned model.

While water region constitutes the Eularian part, pipe region constitutes the Lagrangian part in the underwater pipe model. Eularian part is composed of void parts with and without assigning material as it can be seen in the figure. The CEL approach assists various materials (with the inclusion of voids) in the single element. The fowing material along the mesh is followed by the Eulerian Volume Fractions (EVF) symbolizing the ratio as the material is filled with the Eulerian elements. If a material entirely fills the element, the EVF is equal to 1; if there is no material in the element, the EVF is considered as 0.

After generating Eularian and Lagrangian parts in the software, material characteristics are defined to these parts. Material properties of Eularian and Lagrangian parts have been given in Table 1. The environment of the pipe is modelled as EOS materials with the velocity of sound in water. Boundary conditions are defined in the next step of the numerical analysis. Velocity components are set to zero at Bottom of water part is set to wall boundary condition where all of the velocity components equal to zero. Velocity component in the related axis are set to zero on the lateral surfaces. Horizontal movement of the falling object is restrained. It can only move vertically.

3. Results.

Acceleration values from 100 mm distance from the impact point, maximum displacements and impact load values are obtained after performing numerical analyses. The results are given in Table 2 for the land and underwater pipes.

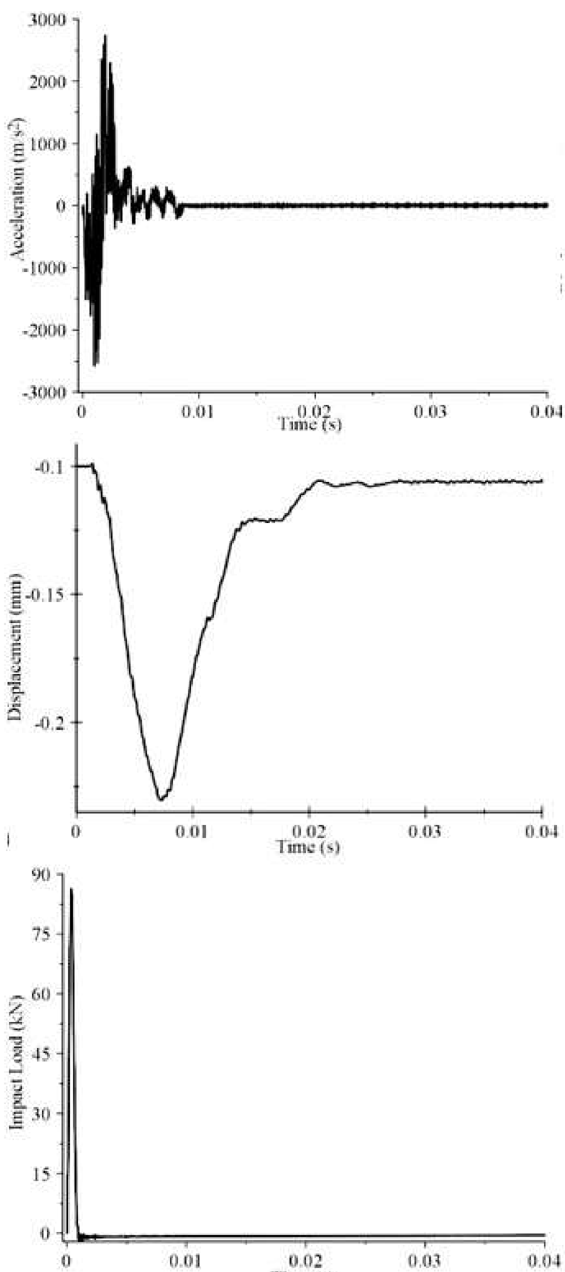
Table 2: Numerical results.

Pipe model	Acceleration (g)	Displacement (mm)	Impact Load (kN)
land	-5638,6243	2,9866	198,7
underwater	-2574,2975	0,2302	86,4

Source: Authors.

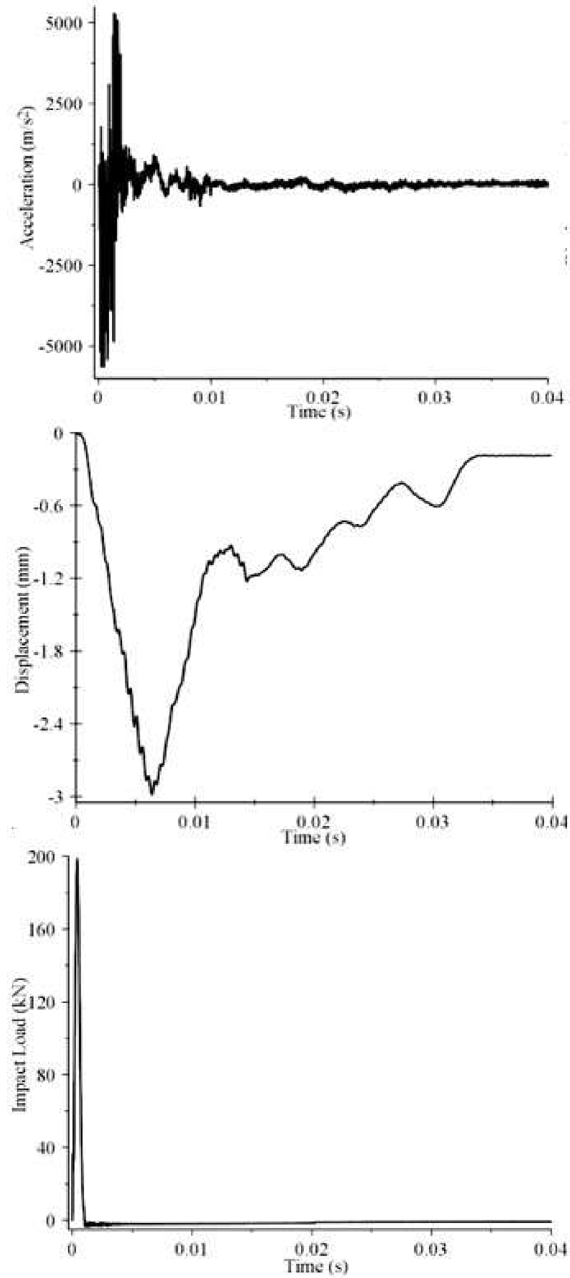
Time histories of acceleration, displacement and impact load values are obtained from the software. Graphs of these outputs are visually presented in the Figs. 3 and 4.

Figure 3: The graphs for underwater pipe model.



Source: Authors.

Figure 4: The graphs for land pipe model.

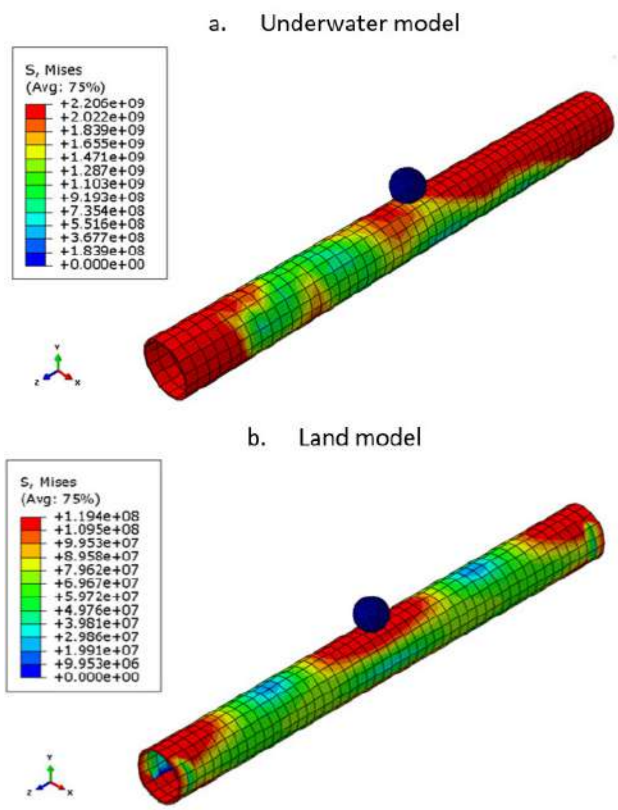


Source: Authors.

After performing finite element simulations, Von-Mises stress distributions are determined when impact loading is completely applied on the pipes. In addition, the variation of the pipe external pressure over time from the moment the falling object contacts with the water is given in Fig. 6 for the contact area.

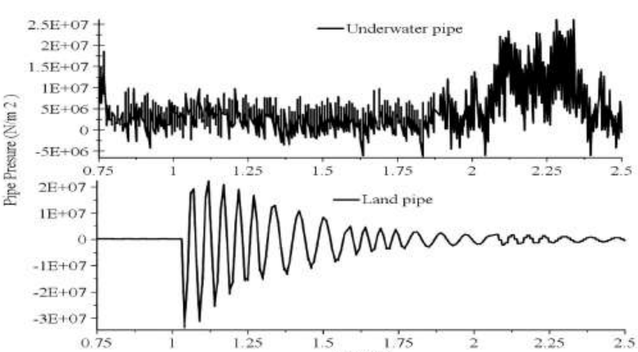
The variation of the time varying external pressure of the above-ground pipeline for the same time interval is also seen in the same figure.

Figure 5: Stress distributions for the pipes.



Source: Authors.

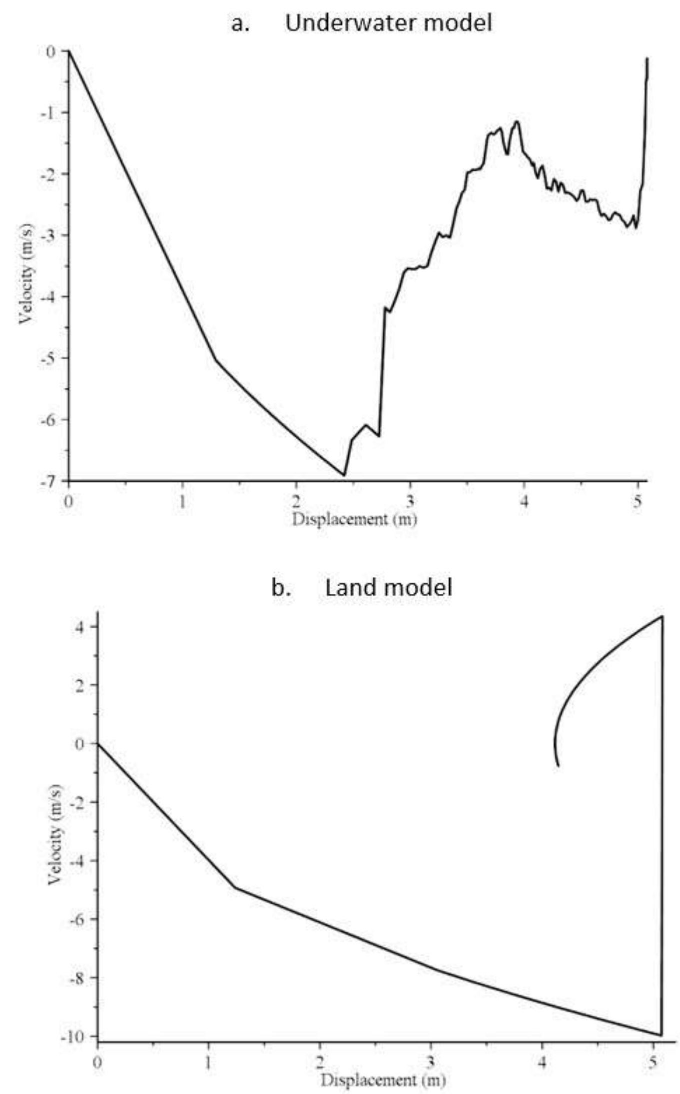
Figure 6: Time varying external pressure values of pipes.



Source: Authors.

Decelerating effect of water on the falling object can be seen in the Fig. 7 by velocity-displacement graph. Simultaneously, values of velocity varying with displacement are obtained for land pipe model to reveal water effect. The sudden decrease in the velocity of the object that passes 2.69 m, which is the vertical distance between the lower point of the falling object and the water surface, is seen in Figure 7.a. In the above-ground pipe model, where the water is not considered, the sudden decrease in the velocity of the falling object occurs only after passing as far as the drop height. The distortion in linearity seen after the first meter in both graphs occurs at the time of passing from the first step to the second step.

Figure 7: Velocity-displacement graph of falling object.



Source: Authors.

Numerical values of velocity varying with displacement for land and underwater models are given in Table 3. Negative sign represents the movement of the falling object in the –y direction. The slowing effect of water started to be seen after -2.5m.

Interaction of falling object, pipe and water is seen in the Fig. 8 from the moment the falling object touches the water until it strikes the pipe.

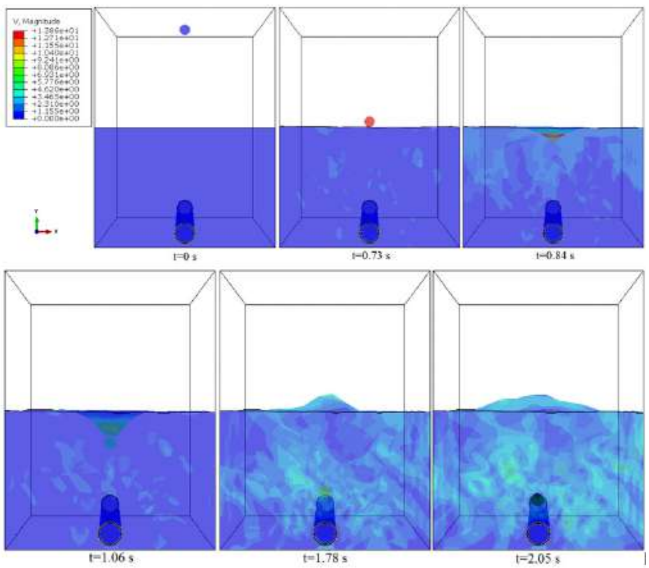
Surface movement of the water under falling object is seen in Fig. 9. ABAQUS post processing using Eulerian Volume Fraction (EVF) is used to visualize the position of the water during the analysis. If EVF is equal to 1, means that the elements are filled with Eulerian material (water). Isosurface option of contour plots is used to achieve the surface movement. Elements with no results are in black color.

Table 3: Velocity-displacement values of falling object for land and underwater models.

Displacement (m)		y=0	y=-0.5	y=-1.0	y=-1.5	y=-2.0	y=-2.5	y=-3.0	y=-3.5	y=-4.0	y=-4.5	y=-5.07
Velocity (m/s)	Land	0	-1.95	-3.96	-5.43	-6.31	-6.89	-7.73	-8.32	-8.91	-9.39	4.35
	Under water	0	-1.95	-3.96	-5.43	-6.31	-6.33	-3.55	-1.97	-1.66	-2.26	-0.12

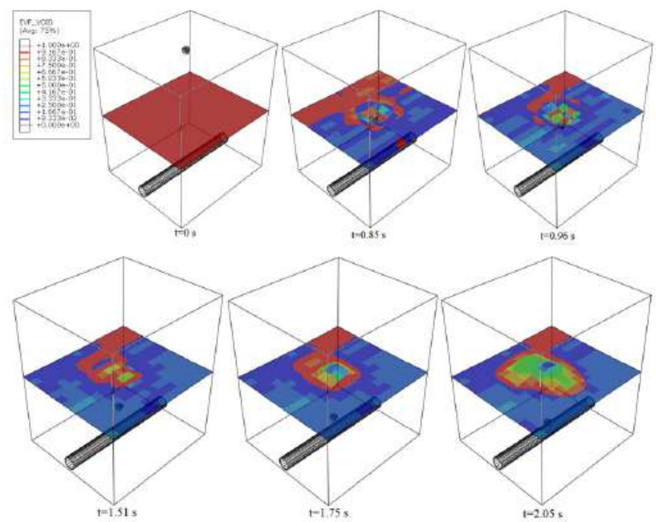
Source: Authors.

Figure 8: Velocity distribution of underwater pipe model.



Source: Authors.

Figure 9: Velocity distribution of underwater pipe model.



Source: Authors.

Conclusions.

Pipe systems are used for various purposes in practice. The most significant assignment of these systems is transferring the materials through different geographies. However, pipe systems may be subjected to impact loads that are not considered in design phase. So, investigating the pipes under sudden impact loading due to several reasons is an important issue. In this paper, non-linear dynamic analyses are performed to determine behaviour of both under water and land pipelines under falling object effects. For this purpose, the single 5 m long span of the pipeline is modelled for both above ground and underwater in Abaqus. The drop height and striker mass are adopted as constant values in the simulations. Impact parameters, such as acceleration, velocity, displacement, impact load and pipe pressure are obtained for both models with stress distributions after the analysis. Along with these, surface movement of water is visually presented for underwater pipe model.

When the analysis results are examined, it is seen that water is effective on the impact response of the pipe due to its damping effect. When the acceleration values are investigated, the biggest values are obtained from the land pipe model. The same situation is also observed for the values of displacement and impact load. According to the displacement time graph in Figure 3, it is seen that the pipe is displaced before the moment of impact. This is due to the fact that the pipe is underwater.

Contrary to the above outputs, when stress values are examined, it is seen that the stress values are higher in the underwater pipe model. While the stress distribution in the aboveground pipe model is symmetrical, the stress distribution behaves unsymmetrically in the underwater pipe model as seen in Fig. 5. According to Fig. 5, it is seen that maximum stress values are accumulated around impact point for land pipe model.

The effect of water on the pipe is also seen in the external pressure values. When the external pressure values changing over time in Fig. 6 are investigated, it is seen that there is a pressure fluctuation in the underwater pipe due to the effect of the falling object before the impact. Thus, it can be said that the effect of the turbulent movement of the water is taken into account in the outputs. On the other hand, there is no pressure in the pipe before the moment of impact in the above-ground pipe model.

In order to examine the effect of water on the falling object, the velocity-displacement graph of the falling object has been determined for both the underwater pipe and the aboveground pipe models. This effect is presented in Fig. 7. Therefore, it can be said that CEL supported fluid structure interaction works effectively. The velocity values of the falling object, which are given both graphically and as a table, are also obtained visually with Fig. 8. The values in the colour scale of Fig. 8 and the values given in Table 3 and Fig. 7 are compatible with each other. While the falling object in the pipe on land is rebounded, no rebound motion has been observed in the pipe in the water. The displacement behaviour is shown in the velocity graph. The movement of the falling object is limited only vertically. After the moment of impact, the falling object does not move in other directions and sets its velocity to zero.

The CEL technique allows modelling the free surface movement of water as well as the fluid structure interaction. Since the water surface is also activated by the effect of the sudden falling object, water surface movement is also obtained as seen in Figs 8 and 9. The effect of the changes in the water surface on the behaviour of the pipe can be seen both in the visual and the numerical outputs. The use of CEL technique in cases where fluid motion is examined as well as structural behaviour, interaction modelling is suggested due to its convenience and analysis period. If the underwater pipe model was modelled by a one-way fluid-structure interaction or a pure Lagrangian approximation, the water fluctuation effect would be ignored.

There are several difficulties in the experimental studies such as design of test setups, high costs of materials and calibration of test devices. Therefore, computer simulation has been a strong alternative way to investigate the behaviour of several test elements under various load conditions. This study exhibits that accurate finite element models could be utilized in impact behaviour of land and underwater pipelines. Finally, it is thought that this study will contribute to the literature in terms of proper analysis steps for pipe sections under impact loading.

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Review of the Nautical Sector in Andalusia

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ABSTRACT

Andalusia is a region in southern Spain with almost a thousand kilometers of coastline on the shores of the Atlantic Ocean and the Mediterranean Sea. Previous research has pointed out that it would be interesting to address the question of the sustainability of marinas and the drivers for sustainable growth of this market in Andalusia. In order to fill this gap, this paper aims to answers two important research questions: What is the current situation of the nautical sector in Andalusia? And what is the future of Andalusian marinas? Firstly, the paper will shed light on the main characteristics of the nautical sector in the region and the drivers of market growth. Secondly, a theoretical framework will be proposed to determine the future need for moorings in different scenarios.

1. Introduction.

Andalusia is a region in southern Spain with approximately 8.5 million inhabitants. The region is characterized by its diverse landscape, which includes mountains, plains, and coastline. Geographically, Andalusia has 910 km of coastline in a privileged location and Mediterranean climate (Junta de Andalucía, 2015). Its numerous beaches, nautical facilities and moorings enjoy a unique environment, which for decades have not only been an important focus of leisure, but also a relevant economic engine in the region, see Rojo (2009) and García Barroso (2010).

According to Martínez-Vázquez et al. (2022) it would be interesting to address the issue of sustainability of Andalusian marinas and the economic activities developed to achieve sustainable growth. In this sense, a first step is to find the answer to the following research question: What is the current situation of the sector in Andalusia? The first goal of the paper is, therefore, to carry out a detailed analysis of the current health of Andalusian marinas. This preliminary analysis will be the basis for answering a second question: what is the future of the ports in Andalusia? This is an extremely complex question, due to the number of parameters that influence on the supply and demand of moorings in the region. From a theoretic view point, the answer should be a methodological proposal to determine the demand, and this is the second goal of the paper.

The article is structured as follows. Section 1 is the introduction and presents the general objectives of the article. Section 2 makes a brief review of the literature that inspired the present research. Section 3 analyses the current situation in placeAndalusia, focusing on three fundamental aspects of the facilities: the occupation of moorings, the waiting lists and the type of user. This analysis is intended to answer the first basic research question. In Section 4, a methodological proposal is developed to define the determinants and future scenarios for the ports in placeAndalusia. The proposal is based on physical and socio-economic indicators and the definition of the theoretical scenarios are based on the growth expectations of the nautical market (pessimistic, optimistic and neutral). Finally, conclusions and future research are presented.

2. Literature review.

Ten years ago Kizielewicz and Lukovic (2013) noted that the phenomenon of nautical tourism in Europe, and in particular the marine industry, was insufficiently explored. In recent years, the issue of sustainability and the sustainable management of cultural and nautical tourism has been addressed, at least, in the cases of Portugal, see e.g. (Lopes et al. 2022) and

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(Santos et al. 2022), and Croatia (Gracan et al. 2016). The great challenges for the nautical sector now and in the coming years are to implement circular approaches at all levels and to disengage from the traditional linear economic model in order to take advantage of the rise of the blue economy (Martínez-Vázquez et al. 2022). In this sense, the post-covid scenario, together with the war in Ukraine, has marked a before and after in the nautical sector.

The importance of nautical tourism and its role in the economic development of Europe has already been underlined by Luković (2012). But this issue is not homogeneous across countries and markets. Some regions are more relevant than others. In this respect, the Mediterranean market is perhaps the most relevant and attracts the most attention in Europe. But the nautical sector also enjoys good health in other regions and markets; see e.g. the analysis of nautical sector in the Atlantic area in Perez-Labajos et al. (2014). An interesting issue in the previous literature is the study of the factors that motivates the growth of nautical sector; see Jovanovic et al. (2013). In general, researchers use a number of common variables to describe the economy and socio-economic aspects of the regions, such as a monthly income, employment, age, population, etc. These parameters, together with the physical constraints of the coasts, are the basis of most analysis.

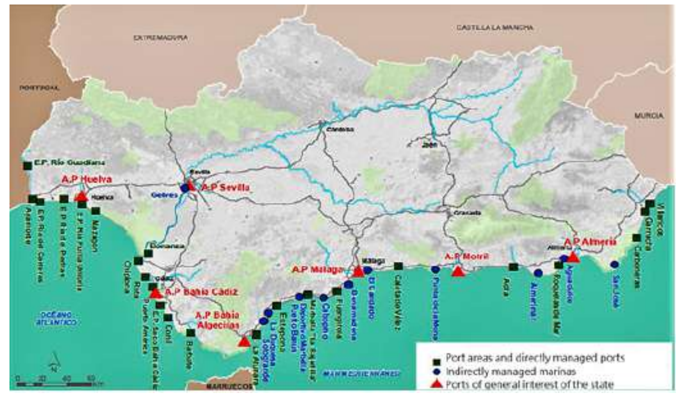
This dynamic and expanding sector, which connects economic activities (such as urban coastal recreational development, boat building, leisure, services and water sports) needs to be well planned. It can be concluded from the above literature that the bedrock of planning in a given area or region is a thorough knowledge of the main features that shape the demand for nautical services and infrastructures. From there, it is also necessary to establish some general indicators to characterize the current market and its future. Unfortunately, there are no studies that address methods to predict the future demand for nautical facilities. However this is an extremely important task for local economies in Europe. Therefore, in the following sections the necessary steps are taken to address this problem in order to create more sustainable strategies for the future.

3. Analysis of the current situation.

3.1. Context.

The Andalusian maritime space, its administration and management problems were first addressed in Suárez de Vivero (1983) and Muñoz (1993). Although the ports of Andalusia have evolved over the years towards a more optimized and practical management, there is still way to go. The activities carried out in the ports are of three types: commercial, fishing and recreational. According to (www.puertosdeandalucia.es), the autonomous community of placeAndalusia has 52 ports, 16 of which depend on the Organismo Público Puertos del Estado (OPPE) because they are ports of general interest of the state (or marinas managed indirectly by the state). The rest of the ports depend on the Junta de Andalucía organism, which is the local administration. In total, there are 45 ports with recreational activity, see Figure 1.

Figure 1: Port system in Andalusia 2022.



Source: Martínez-Vázquez et al. (2022).

Leaving aside the ports managed by OPPE and focusing on the management of the ports under the Junta de Andalucía, there are two types of management, direct and indirect. In the former, 24 ports are managed directly by the Junta de Andalucía through the Agencia Pública de Puertos de Andalucía (APPA) organism. In most cases, these are ports of mixed fishing and recreational use that make up a network of great functional heterogeneity that extends along the entire Andalusian coastline. This group of ports is a heritage of great value for the autonomous community; see Anguís Climent (2008).

On the other hand, the operation of the remaining port facilities is granted under concession to operators who undertook the construction of the infrastructures for their subsequent operation by means of an administrative concession. In total there are twelve marinas which constituted the initial nucleus of the Andalusian nautical-recreational offer, and which are managed indirectly by the autonomous administration. Insights for the management of these facilities are presented in Fernández Méndez (2015), Martín and Piqueras (2017) and Aragón Sánchez (2020).

Having presented the main types of ports, the following sections will describe some of their operating characteristics (focusing, as mentioned above, on ports under the regional administration), specifically: berth occupancy, waiting lists of berths under concession and percentage of yachts in transit.

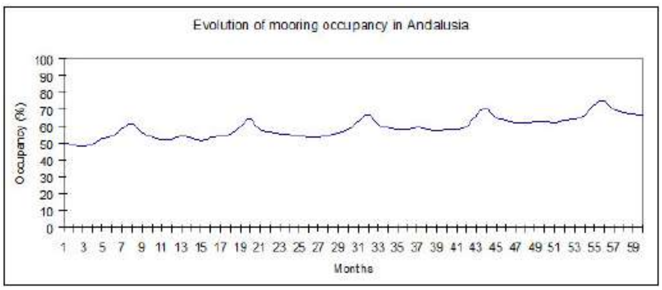
3.2. Occupancy of ports.

This section is focused on the ports under direct management of the APPA where monthly public information is available (15 out of 24). Here, the monthly occupation of moorings for the last 5 years prior to the war in Ukraine (60 months from January 2017 to December 2021) is analyzed. In general, a port can be in one of three states:

- Under-utilized or under-occupied port (below 60% occupancy).
- Port in the process of problematic exploitation when occupancy exceeds 60%.
- Port in the process of saturation when the 80% occupancy threshold is exceeded.

Figure 2 shows the monthly evolution of the occupancy for the total number of ports for which data are available. Firstly, it is interesting to note that there is a moderate upward trend. Secondly, there is a certain seasonality of demand which is reflected in the existence of occupancy peaks corresponding to the summer periods. Finally, it is also interesting to note that occupancy begins to move towards the problematic zone (60-80%) from the summer of 2020 onwards, not only on an occasional basis but throughout the year.

Figure 2: Evolution of mooring occupancy in Andalusia.

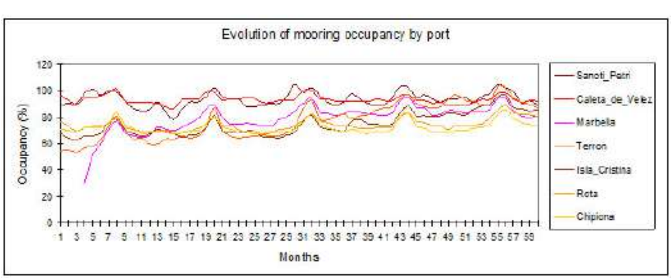


Source: Own elaboration. Data from APPA.

The above Figure 2 corresponds to the ports as a whole. What happens if we analyze each port separately? The answer is that occupancy is quite heterogeneous. On the one hand, there are some ports with very high occupancy, which can be considered saturated (e.g. Sancti Petri and Caleta de Velez ports). On the other hand, there are others with problematic or conflictive operation during peak periods (e.g. Marbella, Terrón, Isla Cristina, Rota and Chipiona) and other ports without problems due to low utilization (e.g. Garrucha and Adra for example). A common feature is that, in almost all ports, peaks of occupancy are observed in the summer months coinciding with the high season.

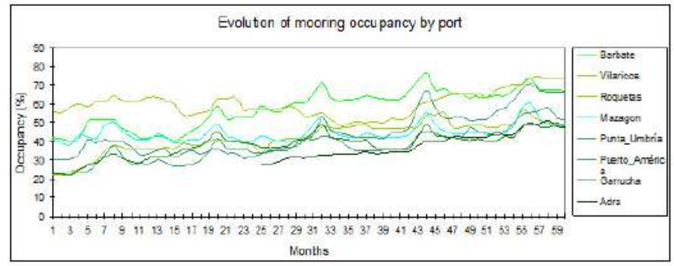
The following figures show the evolution of occupancy in ports with problematic management (see Figure 3) and in ports without problems (see Figure 4). In both cases, the ports are ordered from most to least problematic on the right hand side of the figures. It should also be noted that a port with low occupancy, e.g. Adra (most underutilized port), could also be considered to be in a problematic situation as its infrastructures are being wasted (underutilized).

Figure 3: Evolution of occupancy in ports with problematic management.



Source: Own elaboration. Data from APPA.

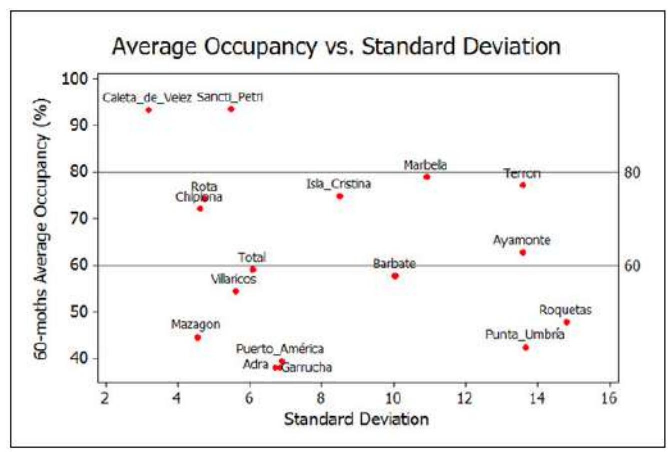
Figure 4: Evolution of occupancy in ports without problems.



Source: Own elaboration. Data from APPA.

An interesting aspect to be studied further is the variability of occupancy. As already mentioned, a larger deviation from the average occupancy in a port implies more pronounced peaks, i.e. a greater seasonality effect of demand. Figure 5 shows the average occupancy and the standard deviation observed in each port. It clearly distinguishes the 3 zones in which the ports are located according to the degree of occupancy.

Figure 5: Average occupancy (%) vs. standard deviation (h).



Source: Own elaboration. Data from APPA.

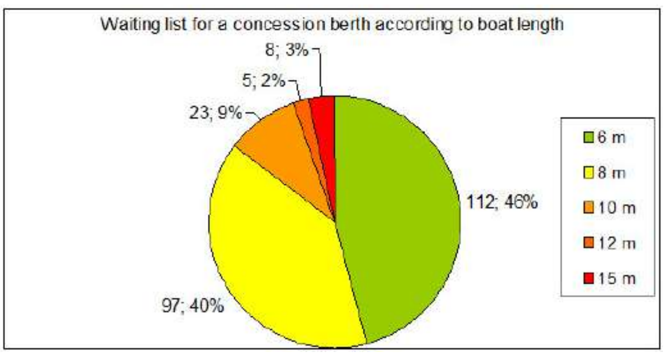
Ports on the left side of the above figure have a low deviation from the monthly occupancy measures, i.e. they are ports with less peak or seasonality of demand. This may suggest that they do not have as much capacity to capture transiting vessels during the summer and are consequently eminently used by yachts based in the port in question (all year round). The ports on the right side are more seasonal ports, suggesting that they still have some capacity to handle transient yachts during the summer. The data collected also suggest that ports in the province of Málaga (e.g. Caleta de Vélez and Bajadilla Marina) are in a situation of high occupancy, especially in the high season since the year 2017.

3.3. Waiting lists.

The occupancy of the ports gives an idea of the utilization of moorings, but to fully understand the latent demand it is necessary to know the register of mooring applicants. Unfortunately, this information is again very difficult to obtain, as the ports not directly managed by APPA prefer not to share this information. In contrast, the ports directly managed by APPA share the waiting lists at https://oficina.puertosdeandalucia.es/lista-de-espera/

It is important to note that according to APPA records there are 10 ports with latent demand out of a total of 17 ports with no demand (for the rest there is no information). In total, in February 2022 (the month prior to the start of the war in Ukraine) there were 240 applicants for moorings and approximately 10% of these requests corresponded to individuals or legal entities (companies) with 2 or more applications. The moorings with the highest demand are those corresponding to small boat lengths (6 and 8 metres), which account for 86% of the mooring requests, see Figure 6.

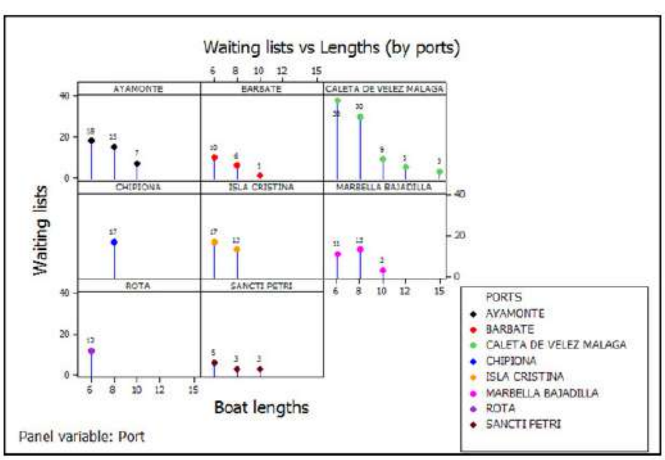
Figure 6: Mooring requests by length (m).



Source: Own elaboration. Data from APPA.

In the next step, the waiting lists have been cross-referenced with the length information to identify the exact demand in each selected port, see Figure 7. It is important to remark here that these figures show only a part of the Andalusian ports (i.e. those where waiting lists were publicly available).

Figure 7: Waiting lists for access to a concession berth.



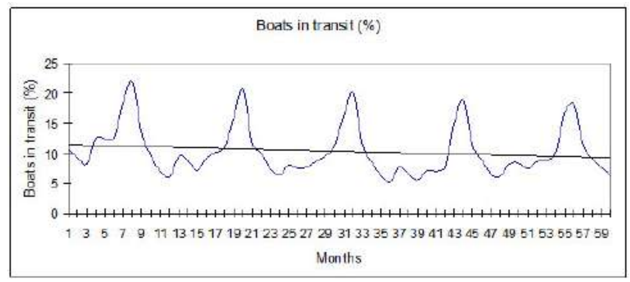
Source: Own elaboration. Data from APPA.

Once a general notion of the occupancy rates and waiting lists in a significant number of Andalusian ports has been presented, the next step of the analysis will be the characterization of the type of user in each facility.

3.4. Yachts in transit.

In order to characterize the users, we will now focus on the origin of the yachts. In this respect, the vast majority of leisure boats in the region are moored in their ”home” port and have a basic contract with the APPA, either ordinary (signed for a period of one year), special (for a renewable period of two years) or long-term (for a longer period). However, there is a percentage of yachts that are in transit, i.e. using the facilities temporarily. Figure 8 shows the monthly evolution of yachts in transit in the ports of the region over the last 5 years.

Figure 8: Boats in transit at marinas (total).



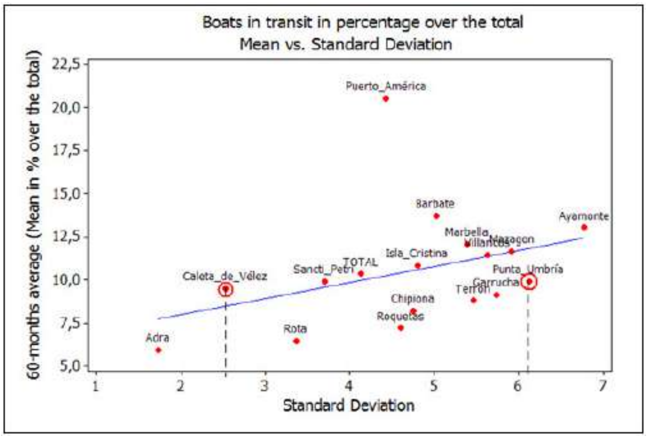
Source: Own elaboration. Data from APPA.

As with mooring occupancy, peaks are observed, in this case of transiting vessels, during the peak seasons. However, a different trend is observed. While the occupation in the ports as a whole was increasing, in the case of boats in transit it is decreasing, i.e. the % of boats in transit over the total is lower every year. Although the data may seem contradictory, in reality, what it is doing is to endorse the fact that the high occupancy of some ports makes it difficult to visit them, either in coastal navigation (from other ports in the region or other Spanish regions), or in foreign navigation (from Morocco or other areas of the Mediterranean). In short, if we assume that the Andalusian coastline remains attractive, this is just another sign that the current nautical-sports offer could begin to be insufficient.

On the other hand, if we represent the mean and standard deviation in Cartesian axes, as we did with the occupation but with the yachts in transit, we obtain an approximate representation of the activity of each port, see Figure 9. First of all, we observe a certain correlation in the port measures (mean and standard deviation). Only Port America, with approximately 20% of the yachts in transit, escapes this correlation. Overall, the percentage of vessels in transit during the last 5 years (60 months) has moved between 5% and 15% of the total.

To analyze the effect of the standard deviation it is sufficient to take a sample of two ports (Caleta de Vélez Málaga and Punta Umbría for example) and observe the evolution of the yachts in transit during those 60 months, see Figure 10. As with occupancy, the port with the highest standard deviation (Punta Umbria) presents more pronounced peaks in the summers. This can be interpreted as a greater capacity to receive short stays of yachts in high season. In contrast, the port with the lowest standard deviation (Caleta de Vélez-Málaga) lacks this capacity, either due to lack of attractiveness or lack of moorings to

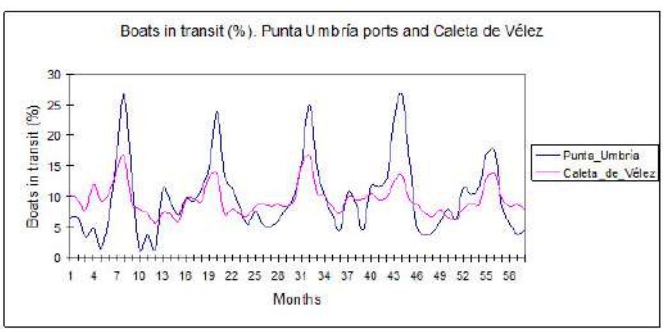
Figure 9: Boats in transit at selected marinas.



Source: Own elaboration. Data from APPA.

cover this demand for short stays. In general, each case can be analysed according to its particular characteristics.

Figure 10: Boats in transit at two selected ports.



Source: Own elaboration. Data from APPA.

Several conclusions can be drawn from the analysis of the current situation. Firstly, there is a reasonable amount of data to make projections and predict the future demand of nautical services in Andalusia. However, this demand is highly dependent on the location of the marina. Secondly, there are ports with high occupancy rates, while others have a medium or low occupancy rate. Thirdly, occupancy is not homogeneous throughout the year. Some ports have important peaks of high occupancy during the high season between October and March. A simple solution to cope with this problem is to increase the number of dry marinas and to convert spaces close to ports into storage spaces for small boats. This is already being carried out in some ports (e.g., Almerimar) with success (Martínez-Vázquez et al. 2022). All these aspects together with the uncertain international derived from the COVID pandemic and the war in Ukraine make complex to predict the future demand for nautical facilities in Andalusia. Although time series can be used to extrapolate current figures into the future, this method excludes other parameters that have an important influence on demand. Consequently, it is necessary to develop a more robust method that includes more related variables to predict demand. Having justified the need for a new method, the next section develops the proposal.

4. Methodological proposal for demand valuation.

4.1. General characteristics of demand.

Nautical facilities, and especially marinas, have very complex demand parameters. Some of the factors that directly affect the market for nautical facilities are physical (length and type of coastline, maritime climate, bathymetry), others are socio-economic (population, tourism, income level and economic activity) and, finally, there are other non-quantifiable elements that also influence the market, such as maritime tradition, culture, nautical sports enthusiasts, etc. All these elements directly condition the demand for nautical leisure facilities in a given area.

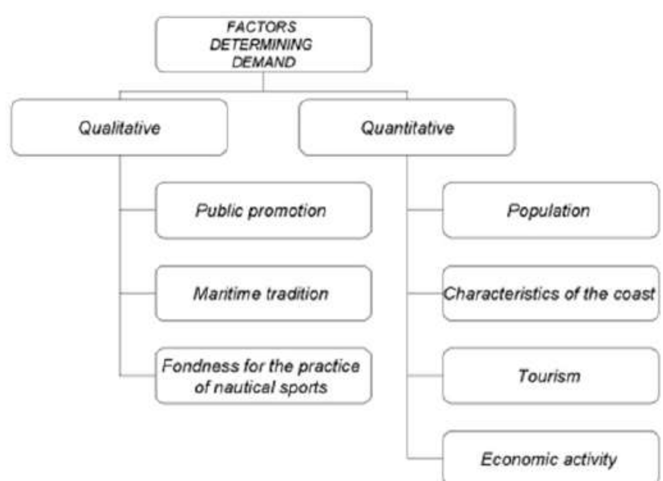
It is very unusual that a wide, permanent and diversified supply of facilities exists to cover the demand in all its importance and complexity. The real demand only becomes clear when there is an oversupply and especially when there is an oversupply of the main variable used to quantify the market, which is the number of moorings. This variable is the most common to calculate the capacity of marinas.

In short, the most complete models and techniques to study the market for nautical-recreational facilities in a given coast are based on considering the elements that condition the demand for moorings. Therefore, the demand for this variable is always analyzed indirectly in all studies and port plans, through the main elements and factors that condition it.

4.2. Factors determining demand.

As mentioned above, the factors that directly affect the demand for moorings can be quantitative or qualitative, see Figure 11.

Figure 11: Factors determining demand.



Source: Own elaboration.

The former are based on representative magnitudes of the element conditioning demand, while the latter, which are impossible to quantify, are of great importance in determining how demand will manifest itself in the future. The latter explain why coastal areas with similar levels of population wealth and income have very different demands for nautical facilities, or why even regions with harsh climatic conditions have a higher number of boats in relation to the population than other areas with climates more favorable to water sports. The most representative qualitative factors that are usually highlighted in all demand studies are basically the following three: public promotion, maritime tradition and fondness for the practice of water sports.

- Public promotion. Despite the fact that boats of all types are becoming more and more affordable for a wider public, public promotion is a determining factor in the development of this industry. In this sense, public subsidies for sailing and the construction of ports and marinas have traditionally been incentives to encourage the demand for boats, moorings and all related elements, including nautical tourism.

- Maritime tradition. Geographical and historical factors are two driving forces behind the increase in the supply of moorings. Some municipalities have a long and deep-rooted tradition linked to the practice of fishing which is the basis of their local economy. Today, this tradition is manifested through a gastronomic culture linked to the sea. The importance of this ancient industry in Andalusia has already been discussed in Vázquez (2003) and Paz Martí (2018).

- Fondness for the practice of nautical sports and recreational boating. Last but not least, there is a double phenomenon inextricably linked to the sea: the practice of nautical sports (often encouraged from childhood through sailing schools) and nautical leisure in general, see Rivera Mateos (2010). These aspects affect not only the demand for new boats, but also the equipment associated with them, the first of which is mooring. At the same time, the practice of some nautical sports can be a potentially source of conflict on the coast (González Ramallal et al. 2010).

On the other hand, the quantitative factors that affect the demand for moorings and that are usually highlighted in all studies on nautical facilities are the resident population, the characteristics of the coast, tourism and economic activity.

- Population. The amount of resident people near the sea is the first element that conditions the practice of water sports and recreational boating throughout the year and, therefore, is the first significant element of demand.

- Characteristics of the coastline. Perhaps the most important parameter to take into consideration when evaluating the global nautical demand in coastal municipalities is the length of the coastline measured in kilometers. Other parameters and conditioning factors are the specific bathymetry of the port and the wind, waves and currents of the coastal area where the port is located.

- Tourism. The demand for boats and nautical facilities grows with non-residents. This parameter can be analyzed through the number of overnight stays in hotels, the number of foreign passengers at the airports, etc. Tourism Indices can be used to reflect the importance of the activity or its relative weight in a region with respect to others or to the Spanish total.

- Economic activity. Logically, the demand for boats and nautical facilities grows with the income level of the population. Likewise, nautical activity generates employment, and has an added value for the economy. With all other variables constant, demand is an increasing and proportional function of the variables representing the wealth of the resident population. These variables can be per capita income, employment generation, value added, or any other index of economic activity.

4.3. Selected indicators and projected scenarios.

It is considered that the above factors, measurable through different magnitudes are adequate and sufficient indicators to explain nautical demand in Andalusia. The method for making demand projections consists of applying the ratios observed in Spain to Andalusia. The quantitative indicators that most directly affect the demand for moorings and for which precise information is available in Andalusia (and for the Spanish coastline as a whole) are: distribution of marinas and moorings, population and length of the coastline, tourist activity (described by the Monitur tourist index and the nautical tourism index) and economic activity (described by the generation of employment and the Added Value of the nautical sector). The sources of these indicators are diverse:

- For the population projections, the best resource is the official census, available on the website of the National Institute of Statistics (2023). Projections can be made at regional or local level by municipality, depending on the needs of the study. The population projection can be expressed as population per existing mooring in the region.

- To assess the characteristics of the coast, the best indicator is the length of the coastline measured in kilometers. These and other data can be obtained from the website of the Ministry for Ecological Transition and the Demographic Challenge (2023) which is a reliable source of information. As mentioned above, some parameters and constraints (such as bathymetry, average wind, waves and currents) are difficult to include in a regional-level perspective. In contrast, the length of the coastline can be easily combined with other parameters, e.g. the number of moorings per kilometer of coastline.

- To assess tourism potential in general and nautical tourism specifically, the selected source is the MoniTUR Report (2018). This report is published annually by Exceltur (an association made up of 34 of the most relevant companies in the entire Spanish tourism value chain). These companies provide the MoniTUR Tourism Index (TI) that comprehensively quantifies the relative competitive position of the tourism offer of the 17 Autonomous Communities in Spain. Specifically, MoniTUR evaluates the capacity of each Autonomous Region through 82 objective indicators. Among the 82 objective indicators used to construct the MoniTUR index, there is a specific index on the value of Nautical Tourism (NT). As a result, two indicators can be used, the number of moorings per unit of the Tourism Index (Moorings/TI) and the number of moorings per unit of the Nautical Tourism Index (Moorings/NT).

- Finally, to assess the importance of the nautical-sports sector in the economy, it is proposed to use two indicators measured by the National Association of Nautical Companies (ANEN 2021), which are the employment generated and the value added to the economy. As a result, two indicators can be obtained, the number of moorings per unit of the Employment Index (Moorings/Employment) and the number of moorings per unit of the Added Value Index (Moorings/Value Added).

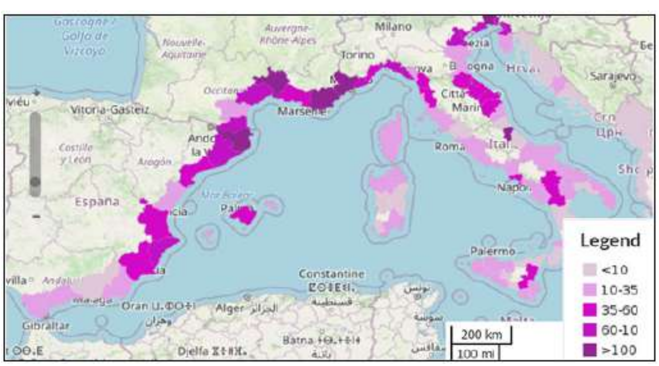
With the above mentioned ratios or representative standards of nautical facilities we have a clear picture of the sector itself (in relation to the length of coastline, population, tourism indices and economic activity). Consequently, a composite function can be drawn up for each of the Autonomous Communities of the Spanish coastline and specifically for Andalusia. The following hypotheses on the potential demand for moorings are proposed:

- In the neutral hypothesis the expected demand is the average of the minimum and maximum scenarios.

- In the minimum scenario (or pessimistic hypothesis) there is no change in demand. The number of moorings for the future population is obtained as an extrapolation of the current indicators in Andalusia.

- In the maximum scenario (or optimistic hypothesis) there is an important change in demand that is driven by the Administrations. The supply of moorings tends to be equal to that existing in the Spanish Mediterranean and to obtain it, the average indicators of the Mediterranean Autonomous Regions (Andalusia, Murcia, Valencia and Catalonia) are extrapolated. This scenario is inspired by the observed fact that in the western and central Mediterranean, adjacent stretches of coastline, even in different countries, tend to equalize their nautical offer. This is the case between the Costa Brava and the Côte d'Azur or between the Côte d'Azur and the Italian Riviera Ligure, see Figure 12.

Figure 12: Marina port capacity by number of moorings / km of coastline.



Source: http://data.tools4msp.eu/maps/.

The use of these indicators together with the scenarios expected by the Government of Andalusia can be used to easily determine the number of moorings need per 1000 inhabitants, the moorings / km of coastline, etc. in the short term, medium term or even in the long term. The determination of the number of moorings needed in each stretch of coastline is beyond the scope of this paper.

Conclusions and future research.

Marinas are an important and dynamic element for the economy in Andalusia. This paper analyses the nautical sector and proposes a theoretical methodology to determine the future demand for moorings in Andalusia. The supply of moorings can be expressed as a composite function of the physical conditions of the coastline (length of coast), the existing population (inhabitants), the general tourist potential and the particular potential of nautical tourism (both in terms of Exceltur indicators), and the economic potential of the region expressed as the employment generated and the added value in the economy by the nautical sector.

The composite function can be constructed and then extrapolated into the future to make predictions for Andalusia and other regions. With the selected indicators, decision makers can consider three scenarios (optimistic, pessimistic and neutral). Although the method is a simplified theoretical approach, it can be used to roughly estimate the future demand of moorings in Andalusia. As mentioned above, the determination of the number of moorings needed on each stretch of coastline, as well as the selection of the most appropriate scenario, is beyond the aim of the present paper.

In sum, the two main goals of the study have been achieved. The data analysis has shed light on the use of nautical facilities, and the theoretical proposal has opened a window to predict demand avoiding the use of more traditional methods such as time series based on a single variable. In the future, it could be an interesting line of research to include more indicators with the same general methodology. In particular, indicators related to air pollution (e.g., CO2 eq pollution units) and indicators related to ecological impact at sea (e.g., number of spills detected per 1,000 yachts).

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Using the Closed Loop Communication System to Prevent Accidents Caused by Human Errors

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ABSTRACT

This paper focuses on the implementation of the Closed Loop Communication System to minimize misunderstandings on board ship, which could be main causes of incidents/accidents at sea.
The Closed Loop Communication System is a communication system used specifically to avoid misunderstandings, in which the interaction between the sender and the receiver does not end until the message has been issued, received and, finally, verified and closed by the sender.
The only problem with this system is that its effectiveness is not generally known to seafarers and proper attention is not given to the communication problem as one of the main causes of accidents caused by Human Error.
This work is divided into 3 parts, the first, which talks about the main causes of communication failures, such as sociological, technological or linguistic factors. A second part in which the Closed Loop system is explained and examples of use to prevent communication failures and incidents related to human error. Finally, a third, more practical part, which has some empirical studies based on the results obtained in a survey of seafarers on the use of the system, implementation and its effectiveness. The results of the study can show that the mandatory implementation of this communication system on ships would improve onboard communication and will provoke the reduction or elimination of misunderstandings during critical operations, positively affecting the safety of the ship in general.
The Closed Loop communication system is the future of onboard communications, this may be the determining factor in minimizing something that has haunted seafarers over time: human error.

1. Introduction.

Statistics indicate that 75% of all maritime accidents are caused by human error (Allianz Global Corporate, 2023). Communication is the third most common human error, affected by differences in nationalities, mother tongues, body languages and language skills (Bocanegra Valle, A., 2011). Implementing an effective communication system can prevent many accidents attributable to 'human error'. In practice, even the captain can make mistakes in courses or orders. To prevent accidents, it is crucial to focus on improving systems rather than looking for culprits. With a proper system, for example, the third pilot can and should question the captain to avoid misunderstandings.

It is common that during radio communication (fixed or portable station) messages are not heard or understood correctly, and many seafarers do not ask for them to be repeated for fear of the reactions of the captain or officers. This lack of clarity can result in errors that lead to accidents. In critical operations such as anchoring or manoeuvring in rivers and canals, it is vital to execute all orders correctly, which is facilitated by a good on-board communication system. This system also promotes constant and effective communication between teams, which is crucial for safety on board.

There is a universal system known in the maritime industry as 'double check', which involves repeating the information re-

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ceived. However, this system is not always effective enough to prevent serious errors or misunderstandings. The 'closed loop' technique in communication during critical operations could significantly improve this situation, although its effectiveness is not widely recognised among seafarers, contributing to the problem of human error accidents. This work seeks to address and mitigate this lack of information.

In the maritime working environment it is of vital importance to ensure good communication, as in the course of day-to-day tasks it is easy for misunderstandings to occur, leading to possible accidents. This is what inspires this work: the recurring lack of success in communications on board ships even though there are international standardised tools to avoid misunderstandings (IMO, 2002), as evidenced by Porathe, Eklund and Goransson in their research studies published in 2014 and which form the theoretical basis of this work.

It is important that those who work on merchant vessels or are linked to them have all the information and manage the variables, which in this case would be the existing communication systems, and thus can make an intelligent decision that results in fewer accidents.

2. Literature Review.

2.1. Background to Closed Loop communication.

The origin of the closed loop communication system is not entirely clear, although it is suggested that its use began with early radio communications in the military. In this context, the need to confirm receipt of messages was crucial, especially as radio allowed messages to be sent beyond visual range. This led to the use of specific terms to close the communication loop: 'Roger', 'Over' and 'Out', meaning respectively 'message received', 'I'm done talking, your turn' and 'end of communication'. This system was designed to ensure that each message was not only sent, but also received and understood correctly in often confusing situations and under pressure.

Closed-loop communication involves a clear and concise exchange of information, confirmation of its receipt and verification of its correct understanding and, where possible, its proper execution. This method reflects a verification strategy that confirms that messages sent are received and interpreted as intended, promoting explicit and effective communication within teams. This communication pattern ensures that all team members share the same objectives, plans and understanding of the situation.

Given its high effectiveness, the closed-loop communication system has been implemented in multiple high-responsibility sectors such as healthcare, where it is used by operating surgeons; in the nuclear power generation industry; in aviation; and in the maritime domain, including merchant ships, icebreakers and cruise ships. In the latter, its use is vital due to the high economic and human value of the operations involved.

2.2. Closed Loop communication system.

Closed Loop communication is a technique of communication used to avoid misunderstandings. When the sender gives a message, the receiver repeats it. The sender then confirms the message using the word 'YES'. When the receiver repeats the message incorrectly, the sender will say 'NO' (or something similar) and then repeat the correct message. If the sender, i.e. the person sending the message, does not receive a response, he/she must repeat the message until the receiver begins to close the loop. To address the receiver, the sender can use his or her name or functional position. This system forces the sender to follow up on his request and close the request.

Closed-loop communications are essential in times of stress and tension, where it is important that the message is transmitted effectively. In the case of merchant vessels, almost all operations and manoeuvres include critical moments where safety is compromised, including the integrity of the ship and cargo, the environment and human life.

Below is the report (The Australian Transport Safety Bureau 2013) of the accident of the ship 'Bosphorus' caused by human error (Failure of communication system during critical operation).

On 29 October 2013, the general cargo ship 'Bosphorus' with the pilot on board ran aground at Lytton Rocks in Australia due to Human Error. There was a simple failure of the communication system on the bridge. No injuries, damage or pollution were reported as a result of the accident.

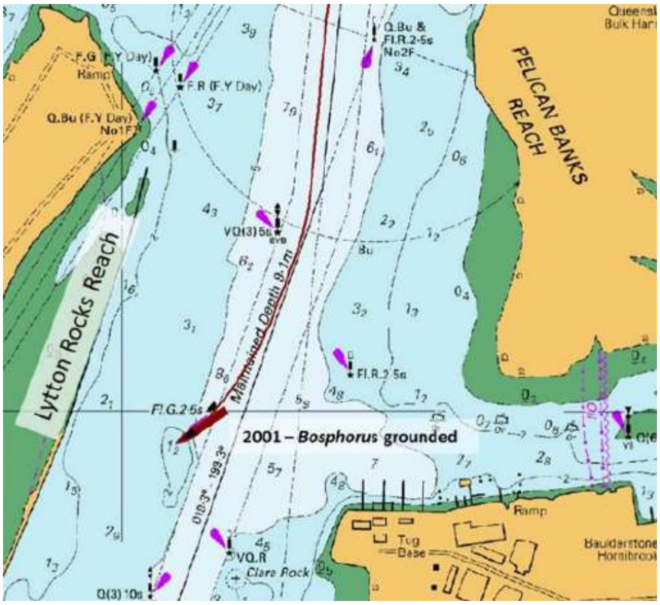
At approximately 20.00 hours, upon entering the very narrow part of the Brisbane River in Australia the pilot observed that the ship was not stable, but continued to swing to starboard towards shallow water. He ordered 'MIDSHIPS' followed immediately by 'PORT 10'. The helmsman responded verbally with 'PORT 10', but instead applied 10º of rudder to starboard. The pilot then ordered 'PORT 20' and then 'HARD A PORT'. Each time the helmsman repeated the command, but applied rudder to starboard. Within 9 seconds, the pilot noticed that the rudder was still to starboard and then shouted 'you go to starboard'. The third officer then intervened and turned the rudder hard to port. The pilot then ordered 'ALL BACK', and then a tug to 'come to help'.

At the critical stage of navigation, effective monitoring of the implementation of the rudder orders by the bridge team could have allowed early intervention to prevent the ship from running aground. However, the helm orders and their application by the helmsman were not being effectively monitored by the bridge team. However, by the time the helm was all the way to starboard and the pilot shouted 'you're going the wrong way', it was too late to prevent the ship from running aground.

This accident is an obvious example of Human Error caused by not having an effective communication system in place.

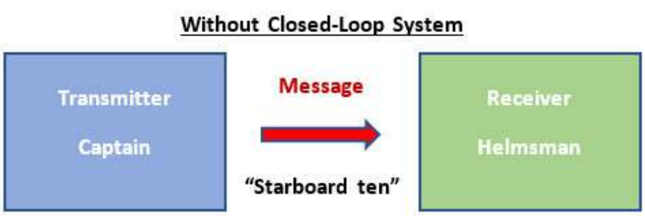
The fact that someone is asked to do something does not mean and is not a guarantee that they actually heard it properly and understood it correctly. And this demonstrates the importance of a communication system that allows the sender and receiver to be sure that the message has been sent and received successfully and its correct execution.

Figure 1: Nautical chart of the accident.



Source: Australian Hydrographic Office.

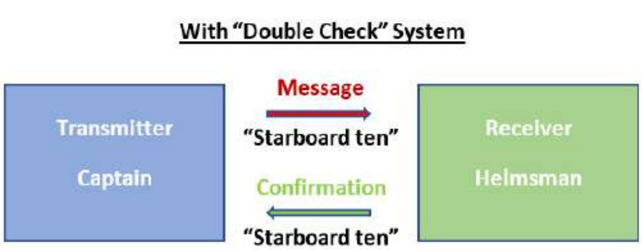
Figure 2: Closed Loop Communication System Process. Order / Execution (Simple message).



Source: Authors.

In this case, the order is executed without receiving any type of confirmation from the receiver, so in the case of erroneous or deficient communications, we have no way of confirming that the order received was the correct one and it is 'up to the receiver's interpretation'.

Figure 3: Closed Loop Communication System Process. Order / Execution (Double Check system).

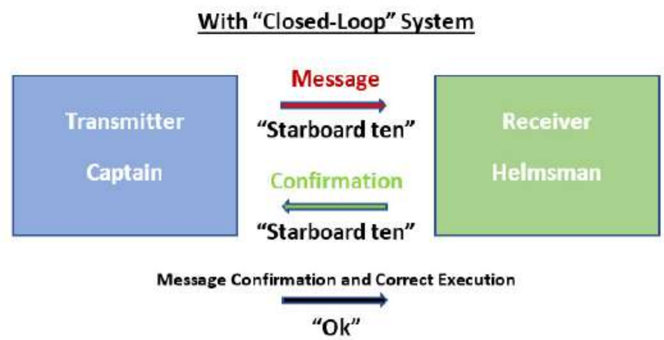


Source: Authors.

The "Double Check" system refers to a method often used in various fields to ensure accuracy and safety by having two individuals independently verify the correctness of a task or process.

This system is designed to prevent errors and enhance safety by ensuring that at least two people have independently confirmed that all parameters are correct before proceeding with a critical task. It's a simple yet effective way to reduce the likelihood of mistakes due to oversight or miscommunication.

Figure 4: Closed Loop Communication System Process. Order / Execution (Closed-Loop system).



Source: Authors.

The "Closed-Loop" system operates by continuously monitoring the output of a process and adjusting the input accordingly to maintain the desired output.

The defining characteristic of a closed loop system is the use of feedback. The system compares the desired output or indicated command (set point) with the actual output measured by the sensors or, where appropriate, the decision made by the receiver or operator. Any discrepancy between these two signals or what is the command and the application of the command (the error signal) is used to make corrections on a continuous basis, exercising the appropriate corrections.

Depending on the type of vessel such activities and processes vary according to the purpose of each vessel, but in general, a list of common activities on board merchant vessels that merit the use of the Closed Loop system would be as follows:

- Any order or directive given by a superior.
- Changes of watch.
- Helm orders.
- Orders/requests to the engine room.
- Orders during docking, undocking and anchoring operations.
- Changes to bridge equipment parameter settings (Critical and non-critical).
- Orders during ballasting and loading operations.
- Changes in the bridge command line.

2.3. Use of the Closed Loop System on board: example on an ice-breaking vessel.

Icebreaker operations are highly hazardous due to the harsh environmental conditions, the high risk of collision and the complexity of the procedures. In the following, a summary of the study conducted by Boström (2020) will be presented, which aimed to investigate the extent to which the Closed Loop communication system is used during icebreaker operations, to describe verbal maritime communication in the context of icebreaker operations and whether this practice deviates from the stipulated communication protocols. The data for this study consisted of verbal radio communications between an icebreaker and icebreaker-assisted ships over 40 days. The data were then compared with the stipulated communication protocol described in the Standard Marine Communication Phrases (SMCP) (IMO, 2002).

The results showed that closed-loop communication is not used to its full extent. Some types of messages are completely repeated, mainly instructions and questions, while other types of messages, such as information and intent, often receive a yes or no response. Closed-loop communications, i.e. a given message, completely repeated and followed by an acknowledgement, was only observed in 16.4% of the messages initiated by an icebreaker vessel and in 14.0% of the other vessels. Therefore, this study clearly shows that there is a gap between the actual use of language and the stipulated communication protocol.

The SMCP require that when an instruction or recommendation is given, the response must be a complete answer with the same meaning as the message. The same applies to yes or no questions. Given that research suggests that Closed Loop communication has positive benefits both in the maritime context and in other professional contexts (e.g. medical), Boström (2020) suggests that it would be prudent to use such a system even when it is not regulated.

Botröm's (2020) study provides a comprehensive description of the communications of an icebreaking vessel with the ships it attended, but the findings are not limited to those operations alone. Instead, they extend to other domains within the maritime business, as well as beyond the maritime area. The scope of interest could extend to any situation where interpersonal interaction is required and there is limited scope for operations that can be seriously affected by misunderstandings in verbal communications. Such as, for example, other areas within the transport sector, control rooms, manufacturing processes, military personnel and medical personnel.

2.4. Importance of oral communication for effective navigation.

Bringing a ship into port and berthing it safely is a difficult task that requires the combined efforts of the entire bridge team and other seafarers involved in this major task. Just one small mistake by any individual could result in a large-scale accident. There are endless scenarios that can occur on board where the ship can be operating with minimal safety margins and where there is definitely no room for communication errors. The entire team both on the bridge and the parties involved (VTS, Pilots, tugs, among others) have to work together to safely navigate the vessel. Add to this the fact that there may be a combination of nationalities and languages, and the situation becomes more complicated. The pilot, tugs and dock handlers may come from different countries, as may the port control personnel and the VTS operator. Each of these individuals may have different accents, even if they speak a common language. To deal with this successfully, the aim is for all these professionals to have good verbal communication skills to ensure the safety of the ship.

2.5. Effective communication on the bridge.

The main purpose of communication is to convey thoughts or ideas to another person and to get them to carry out the actions that need to be taken. Always encouraging the receiver to express what he/she thinks in order to be sure that the message has been clearly understood. If the communication fails to get the receiver to perform the desired action correctly, it could lead to an accident. Given the multinational and multilingual nature of the on-board environment, it is essential that when you speak, you speak clearly, slowly, precisely and explicitly, using simple words and short sentences. In addition, make sure it is loud enough to be heard above the general sound level of the surroundings, as English may not be the first, second or even third language of the recipient. On this basis, many authors argue that the use of the IMO Standard Phrases for Maritime Communications (SMCP) is a good resource, as seafarers in all countries are familiar with them and applying them is good practice, even if English is the first language.

On board it is operated in such a way that the sender, after having issued a communication, waits to see if the receiver understood it; it is shipboard policy, as a general rule, that the receiver repeats the given communication and, in the case of the use of the Closed Loop system, the sender must acknowledge that what the receiver repeated and executed is correct, thus closing the loop. Another key to successful communication is to know what information is needed, how best to ask for it and for whom the information is requested.

3. Methodology.

For this work we have used a questionnaire as the data collection technique for this research, which was constructed in Jotform (https://form.jotform.com/233073351964053) for easy distribution. The seafarers selected as a sample population were sent a link to a blank questionnaire ready to be filled in. In total, 44 seafarers were sent the link and 42 of them answered the questionnaire.

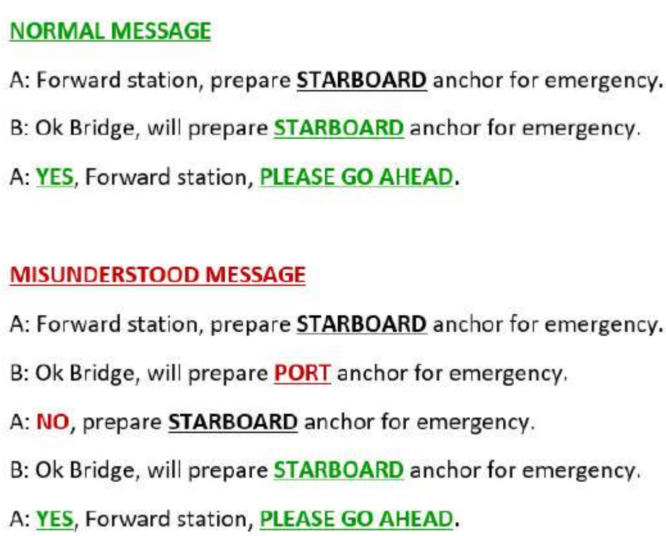
This questionnaire is broken down into nine questions, based on the research questions and objectives, as well as the information from the Closed Loop used in this study. The first two questions of the survey refer to specific information about the person who is carrying out the survey, i.e. the respondent, revealing the type of vessel he/she sails on and the rank he/she holds there.

Following these, questions 3 and 4 are related to the Closed Loop System, in order to find out if they are aware of it and how they learned about it, respectively. The next question refers to the company, whether it requires its use or not. Questions 6 and 7 refer to the effectiveness of the Closed Loop System and the respondent's opinion on the mandatory implementation of the Closed Loop System on board. Finally, question 8 reflects whether the respondent has experienced any communication problems using the Closed Loop system and finally, question 9 determines whether the respondent believes that there is any other method of communication more effective than the Closed Loop system. The Jotform tool was efficient in the completion of the questionnaire and in reviewing the responses, as it provides graphs showing the results of the questionnaires.

The 21% of the respondents who answered that they were not familiar with the Closed Loop Communication System were explained what it was and given a short example of a simple order to answer the entire survey.

They were additionally provided with a definition of the Closed Loop system and a short example so that those who were not familiar with it would have a reference and be able to answer the survey questions in full.

Figure 5: Example of the use of Closed Loop during anchoring operation.



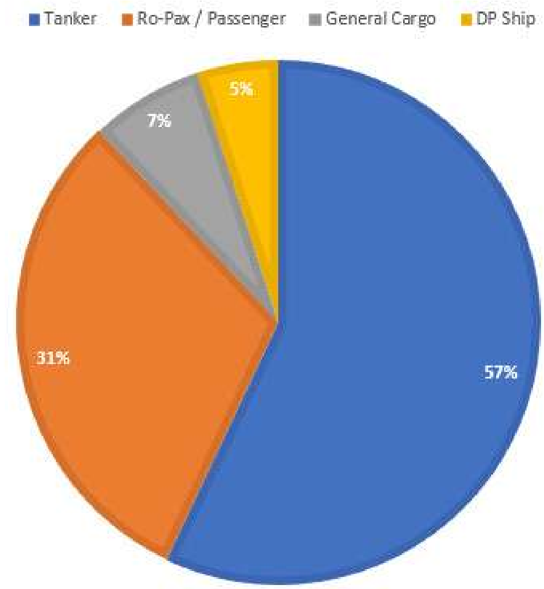
Source: Authors.

4. Results.

We wanted to find out how the Closed-Loop system is or is not currently in use in the sector.

Active merchant seafarers from different companies and in different roles were selected for the survey instrument. The survey consisted of nine questions, the results of which are presented below.

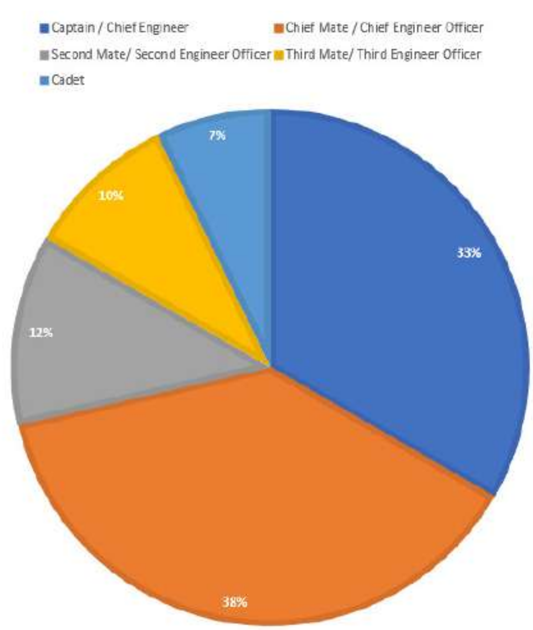
Figure 6: Ship Type.



Source: Authors.

As can be seen, most of the officers interviewed belonged to tankers and ro-ro/passenger ships, although we have also counted officers on other types of ships, which tend to be in the minority.

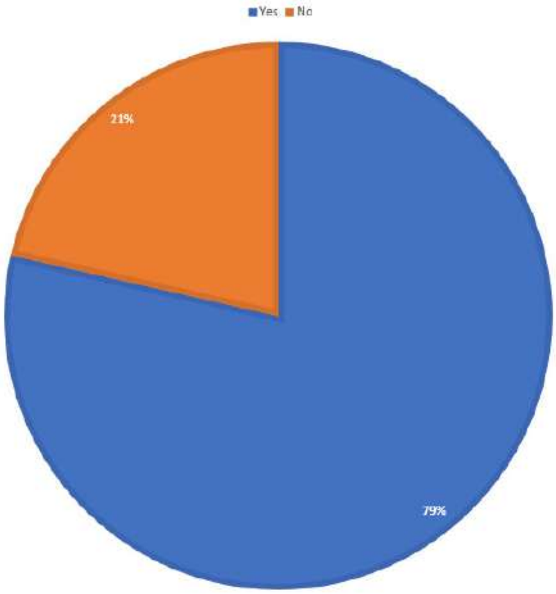
Figure 7: Position on board.



Source: Authors.

More than 70% of the answers correspond to Captains/Chief Engineers and Chief Navigation and Engineer Officers, precisely those who could benefit the most from the application of a communication system such as the one described to lessen the errors that could occur and therefore the consequences that could derive from such actions.

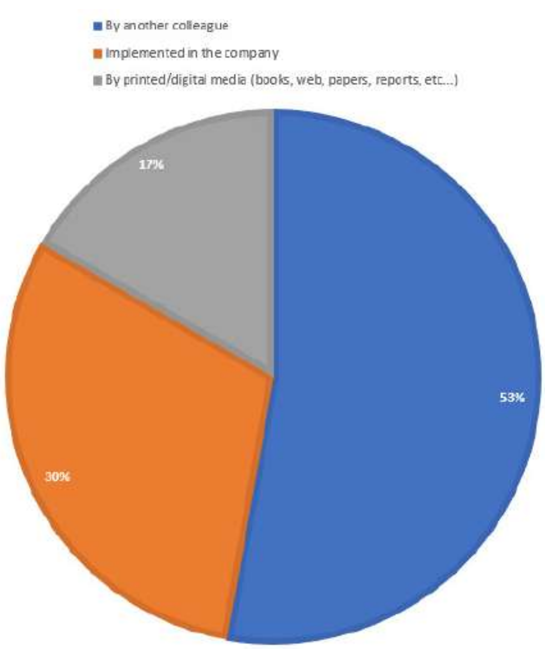
Figure 8: Do you know the Closed-Loop system?.



Source: Authors.

In the answers obtained, it stands out that 79% of the officers know it and, taking into account question number two, we could say that the Masters/Chief Engineers and Chief Officers are the ones who know the system the most, being the persons with the highest authority on board and the chief officer the head of the operations of loading, unloading, ship stability, maintenance, etc. and the one who manages the largest number of personnel on board, the officer who must ensure that the instructions and orders are carried out or executed correctly.

Figure 9: How did you hear about the Closed-Loop system?.



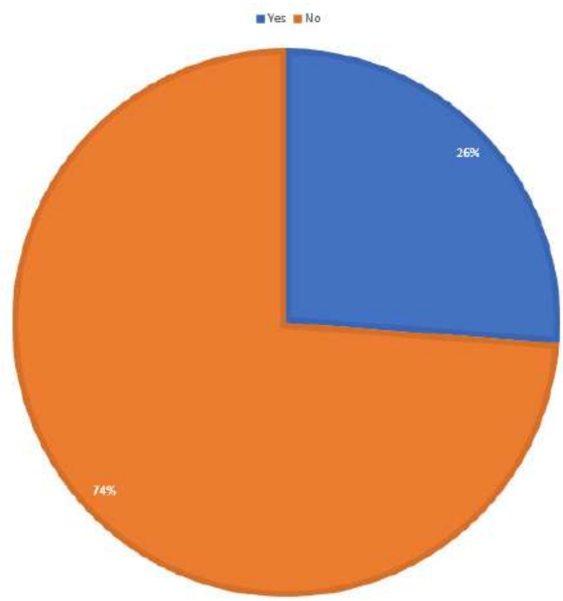
Source: Authors.

Most of the officers know about the system through a professional colleague, i.e. someone has told them or commented on this communication system; however, 53% of the officers are only aware of its existence but do not use it on a regular basis.

The opposite is the case for 31% of the officers surveyed, who are required to have this type of communication and its implementation on board from the company's own management system, which is good news but clearly insufficient.

And only 6% stated that they have learned about the system through print or digital media.

Figure 10: Is it required by the company as a tool for your job?.

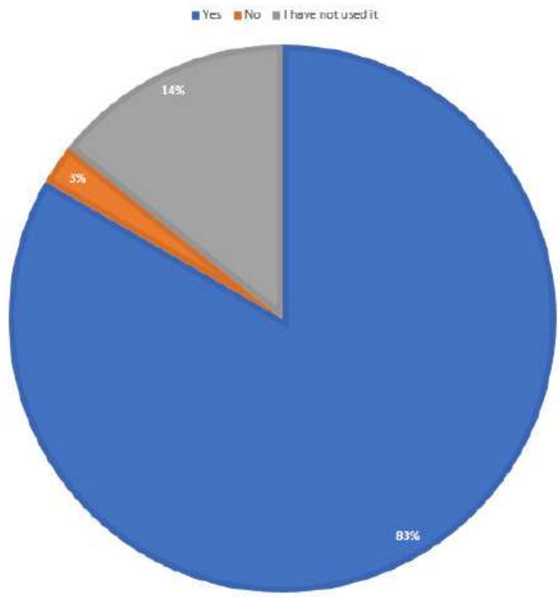


Source: Authors.

It is clear that the system under study is not used by the majority of merchant seafarers, unless the company makes it a requirement. It also coincides with the fact that 26% of the officers who answered yes to the question are precisely those who work on board cruise ships and passenger vessels, precisely because of the importance in these cases of avoiding errors due to misunderstood orders.

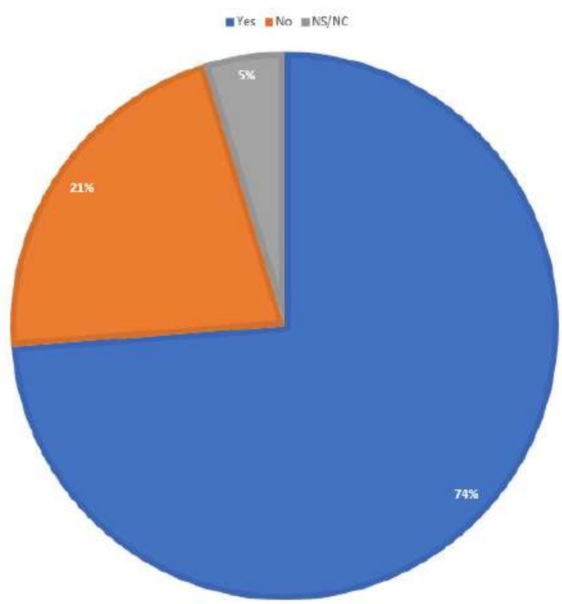
In the next graph (Figure 11), the majority of respondents agreeing that the Closed Loop Communication System is an effective system for avoiding misunderstandings, and assessing the numbers of officers and cadets who are aware of the system, those who have used it and those who have not, it can be concluded that by simply knowing how the system works and projecting it in day-to-day life on board merchant ships, maritime professionals can give an informed opinion on its effectiveness.

Figure 11: Do you find this system effective in avoiding misunderstandings?.



Source: Authors.

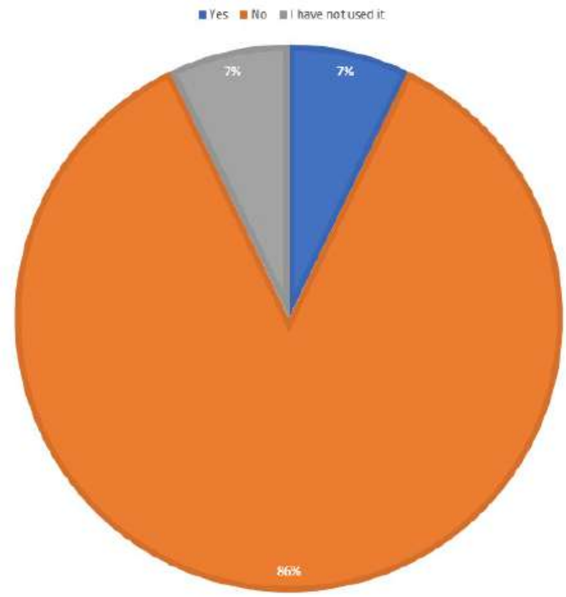
Figure 12: Do you think the Closed Loop system should be mandatory in the maritime domain?.



Source: Authors.

Although the majority of the respondents answered that they do consider that the Closed Loop Communication System should be made mandatory in the maritime world, there is a fifth of the respondents who either do not consider it necessary or are hesitant. This is not a negligible number, and highlights the difficulty of implementing new procedures and measures, as well as the fact that such changes often take a long time to implement and adapt. In addition, specific training and education campaigns are needed to raise awareness of the system and its benefits.

Figure 13: Have you experienced any inconvenience/misunderstanding using this system on board?.



Source: Authors.

This question, like the others, is key to highlighting the importance of good communication on board merchant ships to avoid or reduce misunderstandings. Of all subjects who use or have used the Closed Loop system, more than 85% have not experienced any inconvenience or misunderstanding on board. The low possibility of making mistakes or causing accidents due to misunderstandings in communications using this system is fully evident.

But accidents on ships due to communication errors are unfortunately common and can have devastating consequences. Communication errors can arise due to a variety of factors including unclear instructions, linguistic misunderstandings, technical problems with communication equipment, and the lack of standardized protocols. For example, we can cite the following cases:

- Costa Concordia (2012): Although the sinking of the Costa Concordia was primarily due to a poor decision by the captain, subsequent investigations also revealed significant communication failures between the crew and rescue teams, complicating evacuation operations and increasing the severity of the accident.
- Exxon Valdez (1989): This environmental disaster, one of the largest oil spills in history, was partially attributed to communication errors. Failures in communication between onboard personnel and shore-based radar operators contributed to the tanker veering off course and grounding.
- Queen Elizabeth 2 (1992): The ocean liner struck a submerged object while navigating off the coast of Massachu-

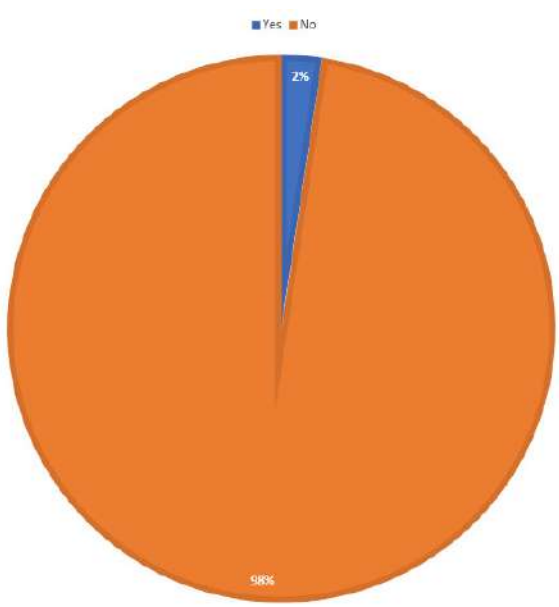
setts. Subsequent investigations suggested that poor communication between the control bridges and the engine room during navigation in shallow waters was a contributing factor.

- The Herald of Free Enterprise (1987): Shortly after leaving the port of Zeebrugge, Belgium, this ferry capsized, resulting in the deaths of 193 people. The main cause was that the ship's sea doors were left open by mistake. A failure in communications among the crew who were responsible for ensuring these doors were closed was one of the key factors in the accident.

- MSC Napoli (2007): This cargo ship suffered structural failure and was abandoned in the English Channel. Investigations indicated that there were communication confusions during storm conditions, which led to erroneous decisions exacerbating the critical situation of the ship.

To conclude the survey and to affirm the importance of the Closed Loop Communication System as the most suitable communication system to be implemented on board merchant ships, respondents were asked if they knew of any other systems that could be more effective or at least similar to the Closed Loop, and virtually all of the respondents answered negatively, as can be seen in the following chart (Figure 14). This clearly demonstrates that the Closed Loop Communication System is undoubtedly the best communication option on board.

Figure 14: Are you already aware of a more effective system than the Closed Loop?.



Source: Authors.

Conclusions.

On the basis of the results obtained in this study, we will make a series of considerations:

1. Onboard communication already has an established universal language, it already has the necessary guidelines to be carried out, the only thing missing is to establish an effective communication system that complements the previously mentioned factors, here enters the Closed Loop, which makes sure to reduce the probability of a misunderstanding onboard. The Closed Loop Communication System allows that once an order or request has been given to a designated person to perform a procedure, the giver of the order explicitly acknowledges the request. Additionally, the sender knows with certainty that his requests have been heard and understood.
2. The results reflect the need to optimise communication systems in the maritime world with the intention of minimising the possibility of error in orders flowing through the chain of command.
3. There is evidence of acceptance of the Closed Loop system and recognition that it is effective in its purpose.
4. Communication based on this system has been shown to reduce the rate of error by removing ambiguity from instructions, allowing questions to be asked if the instruction/request is not made clearly and allowing others present to be aware of what is happening and what is going to happen.
5. Any working team, in our case, the bridge team on board merchant ships, needs to be efficient if all team members are aware of their role, communicate correctly and are able to operate in an atmosphere of trust and respect.
6. Good communication is essential for operating ships, especially in times of stress. It is important to maintain a common vocabulary, to create a kind of shared mental model of the situation they are in, to avoid assumptions and misunderstandings leading to accidents.

In terms of future perspectives and as a result of this research, the importance of the contribution of maritime professionals to assist in research to improve on-board communications is evident, due to the technical complexity of the language used on board and the difficulty of accessing the data, examples and scenarios necessary for researchers in the area of communication (Bocanegra-Valle, A., 2011). The Closed Loop communication system is the future of shipboard communications, which may be the determining factor in minimising something that has haunted seafarers throughout time: human error.

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