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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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