JMR
JOURNAL OF MARITIME RESEARCH
Spanish Society of Maritime Research

VOL. X No3
DECEMBER 2013

JMR
JOURNAL OF MARITIME RESEARCH

UNIVERSITY OF CANTABRIA

Escuela Técnica Superior de Náutica
c/ Gamazo nº1, 39004 SANTANDER
Telfno (942) 201362; Fax (942) 201303
e-mail: info.jmr@unican.es
http://www.jmr.unican.es

Layout: JMR

Printed bay: Tratamiento Gráfico del Documento, S.L.

ISSN: 1697-4840

D. Legal: SA-368-2004

JMR

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 3 - 6

ISSN: 1697-4040, www.jmr.unican.es

Passenger Ships Inspection in Spanish Ports Navigation

M.J. Hermida-Castro[1,2], D. Hermida-Castro[1], J.A. Orosa[1,3,*] and M.M. Silva-Costas[1]

ARTICLE INFO

Article history:
Received 19 June 2013;
in revised form 26 June 2013;
accepted 02 September 2013

Keywords:
Inspection, ports, legislation, Maritime Safety.

ABSTRACT

The present work aims to unpack the standards and legislation on the inspection of passenger ships sailings between Spanish ports. The aim is to simplify, as much as possible, the proper inspection methodology, as well as the certificates and documents required to be considered by the ship. It will be necessary to consider the legislation, both national and international, that regulates the conditions of maritime safety and pollution for merchant vessels, highlighting the International Convention for the Safety of Human Life at Sea (SOLAS 74/78) and the Convention for the Prevention of Pollution from ships (MARPOL 73/78). Compliance with the provisions governing the procedure of civilian ships revisions will be justified by a number of certificates and documents as evidence that the inspected object or activity complies with national or international regulations previously discussed. There are a lot of certificates and documents relating to various activities and objects common to all ships and other specific documents and certificates for passenger ships. In particular, all those certificates and documents to ensure conditions for safe navigation will be cited, which will allow to check the state of its elements, both of the hull, machinery and safety devices.

1. Introduction

The present work aims to unpack the standards and legislation on the inspection of passenger ships sailings between national ports. The aim is to simplify, as much as possible, the proper inspection methodology, as well as the certificates and documents required to be considered by the ship.

It will be necessary to consider the legislation, both national and international, that regulates the conditions of maritime safety and pollution for merchant vessels, highlighting the International Convention for the Safety of Human Life at Sea (SOLAS 74/78) and the Convention for the Prevention of Pollution from ships (MARPOL 73/78).

Compliance with the provisions governing the procedure of civilian ships revisions will be justified by a number of certificates and documents as evidence that the inspected object or activity complies with national or international regulations previously discussed.

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In particular, all those certificates and documents to ensure conditions for safe navigation will be cited, which will allow to check the state of its elements, both of the hull, machinery and safety devices.

The objectives of this paper can be summarized as follows:

- Familiarization with the regulations governing maritime safety and ship pollution.
- Differentiate inspections in both shelf-life and reach, which are made throughout the life of a ship.
- Know the certificates from the various agreements and regulations for safe navigability of a passenger ship, in the safety of human life and the environment.
- List the different items that are inspected (check-list) when doing a general inspection of vessel conditions to determine in which state it is.

2. Material and methods

2.1. Standards

2.1.1. International legislation

- International Convention for the Safety of Life at Sea (SOLAS 74/78) (International Maritime Organization, 2009). Standards for design, instructions against fires, rescue elements, communications, propulsion and steering systems, fillers, etc.
- Convention for the Prevention of Pollution from Ships (MARPOL 73/78) (International Maritime Organization, 2006). Rules to prevent pollutant discharges, accidental operational, from ships.

[1] Department of Energy and M.P. University of A Coruña. E.T.S.N.y M. Paseo de Ronda 51. 15011. Coruña (Spain). Tel +34981167000, Fax +349811167107.
[2] Researcher, Email: mjhermida@gmail.com
[3] Associate Professor, Email: jaorosa@udc.es
[*] Corresponding author.

- Convention on the Regulation for Preventing Collisions (Colregs-72). Government rules, lights and shapes to be carried on s hips and other guidelines to avoid collisions at sea.
- International Dangerous Goods Code (IMDG Code). Regulations for the safe transport of packaged dangerous goods by sea.
- International Code of Safety Management (ISM)
- Resolution 481 of the XII Assembly of the International Maritime Organization (IMO Res 481 (XII). Recommendations for allocation of the minimum safety crew.
- Convention on Maritime Search and Rescue (SAR 79). Organization and procedures of search and rescue services.
- Maritime beacon system of the International Association of Lighthouse Authorities (IALA). Standards of channel markers and various obstacles which may represent a hazard to navigation.
- Directive 98/41/EC on the registration of persons sailing on board passenger ships.
- Directive 2009/45/EC on safety rules and standards applicable to passenger ships.
- ISPS Code, International Code for the Security of Ships and of Port Facilities.
- STCW 95 Convention on Standards of Training, Certification and Watchkeeping of seafarers.

2.1.2. Spanish legislation

- Spanish Order 06/10/83. Additional rules to SOLAS Convention 74/78.
- Spanish Order 14/07/64, which establishes the minimum crew for merchant and fishing vessels.
- R. D. 1253/97. Decree which incorporates national law Directives 93/75 and following, on ship reporting conditions with dangerous goods.
- R. D. 1952/95. Approval of the Commission for the coordination of transport of dangerous goods.
- R. D. 230/98. Containing Explosives Regulations.
- R. D. 1835/83. Beacon standards on the Spanish coast.
- Order 02/18/88. Regulates the conditions for a ship to enroll anyone other than the crew.
- Order 31.7.92. Establishes training requirements for maritime security which crews of merchant vessels and fishing must meet.
- R. D. 457/2011 on safety rules and standards applicable to passenger ships engaged in voyages between Spanish ports.
- R. D. 1861/2004 on specific stability requirements for passenger ships.
- R. D. 1837/2000 approving the regulations for inspection and certification of civilian vessels.

2.2. Inspections

All Spanish civilian vessel in order to verify compliance with the provisions of applicable national and international regulations and to ensure at all times a sufficient condition of maritime safety and marine environment protection, shall be subject, during its service at scheduled examinations and unscheduled reviews, according to the terms and provisions set forth in RD 1837/2000 (España. Real Decreto 1837/2000).

These inspections will be conducted by the maritime administration of the state, which in turn may delegate inspection responsibilities in organizations and ship classification societies, which will carry out on its behalf the functions of inspection, survey and certification of ships, in compliance with the international conventions and national regulations on safety at sea and prevention of marine pollution. The duties, responsibilities and limitations assumed by the organizations and authorized vessels classification societies are regulated by Royal Decree 877/2011 (España. Real Decreto 877/2011).

Scheduled examinations will be held at regular intervals, either to check the maintenance of the condition of the vessel after the last issuance of a certificate, in which case it will mean a referendum, or to verify whether the ship is entitled to the renewal of the license if its validity period has ended or is about to expire.

Within this type of recognition the following types of awards can be distinguished, in relation to a particular certificate:

— Periodical examinations.
— Renewal examinations.
— Intermediate examinations.
— Annual examinations.

3. Results and discussion

From previous standards and inspections, different results were obtained. A certificate is a document issued in accordance with the provisions governing the procedure of civilian ships reviews, certifying that the inspected object or activity complies with applicable national or international regulations.

The renewal of a certificate equivalent to the issuance of a new certificate, the period of validity indicated therein, once successfully completed the renewal survey for that certificate.

The endorsement of a certificate is the act of signing and sealing the box of a certificate by the authorized officer when one of the annual, intermediate or periodical prescribed during validity period has successfully been completed or an extension, a grace period, or any other foreseen circumstance, is authorized.

When inspection activities are successfully completed, they will result in either the issuance, endorsement, renewal or extension of a certificate or the issuance of other documents that clearly reflect compliance or adjustment of the inspected entity with the applicable regulations.

All certificates, unless they have the character of indefinite, will show their maximum period of validity, after which they must be renewed. This period will be established in accordance with the provisions of national or international law enforcement.

The Directorate General of Merchant Marine is authorized to normalize all models of certificates.

The General Deputy Director of Merchant Marine will be responsible for the issuance and renewal of certificates required by international regulations for vessels of 24 meters or longer.

The Head of the Marine Survey Department will be responsible for endorsing and extending the validity of the certificates required by national and international regulations for vessels of 24 meters or longer, having been the scheduled examinations carried out under his/her technical direction.

3.1. Certificates and documents required for all vessels.

- International Tonnage Certificate (1969).
- International Load Line Certificate.
- International Certificate of Load Line Exemption.
- Undamaged stability booklet.
- Damage control booklet.
- Document on the minimum safe manning.
- Titles of master, officer or seaman.
- International Certificate of prevention of oil pollution.
- Oil Record Book.
- Emergency onboard plan in case of oil pollution.
- International Certificate of prevention of pollution by sewage (Organización Marítima Internacional, 2006a).
- Garbage Management Plan.
- Garbage Record Book (Organización Marítima Internacional, 2006b).
- Data logger cruise system - Document of Compliance.
- Load Securing Manual (Organización Marítima Internacional, 2005).
- Certificate of safety management.
- Document of Compliance.
- International Certificate of Ship Security or Temporary International Certificate of Ship Security.
- Ship Security Plan and associated records.
- Continuous Synopsis Record.

3.2. Certificates and documents to be carried on passenger ships.

In addition to these certificates and documents listed above, passenger ships shall carry the following ones:

- Safety Certificate for Passenger Ships.
- Exemption certificate.
- Passenger Ship Safety Certificate for Special Traffic.
- SAR Collaboration Plan (Organización Marítima Internacional, 2006c).
- List of operational limitations.
- Support system for decision-making by the captain.

4. conclusions

- The rules concerning maritime safety and ship pollution is given by the SOLAS and MARPOL.
- As for the issue and renewal of different certificates it is the administration of each contracting government agency that is responsible for this procedure. The function of these documents is to certify compliance with the various agreements and regulations on inspections (inspection of the load lines, emergency planning, security management, etc..).
- The required certificates of various international conventions ensure safer navigation and better environmental protection.
- These certificates involve periodic inspections that make the ship safer and at the same time can lengthen its life.
- The mandatory inspection periods have a specific extension depending on the certificate to be renewed.
- Personnel performing inspections have to be able to interpret the rules and have their own assessment capacity of the condition of the vessel.
- Inspection for vessel evaluation must be made with a checklist in order not to forget to inspect any item.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 7 - 12

ISSN: 1697-4040, www.jmr.unican.es

Determining Flinders' Bar Correction by Heeling the Ship

I. Basterretxea[1,2,*], J. Vila[1,3] and I. Sotés[1,4]

ARTICLE INFO

Article history:
Received 24 June 2013;
in revised form 30 June 2013; accepted 17 September 2013

Keywords:
Coordinate reference systems, susceptibility tensor coefficient $\chi_{x,z}$, deviascope, Flinders' bar.

ABSTRACT

The aim of this article is to provide the compass adjuster with an innovative method of determining the length of Flinders' bar while the ship's latitude remains unaltered. In this way the definitive compass adjustment may be carried out in a single procedure. This would be valid for ships navigating in limited waters. The drawback lies in the need to heel the ship during the adjustment.

1. Introduction

When the ship remains in the same position and orientation for a long time, the steel structures rich in carbon, called hard irons, are magnetised under the induction of the earth's field and, consequently, they are turned on permanent magnets. On the other hand, the structures of soft iron poor in carbon are temporarily magnetised, turning on magnets whose polarity changes depending on their orientation with respect of the earth's field. The ship's irons create thus a disturbing magnetic field that separates the needle of the compass an angle from the magnetic meridian. The resulting angle is called deviation. This angle is reduced during the procedure called compass adjustment, during which the ship has to turn on herself 360º so that the deviation can be obtained every 10º or 15º by comparing the magnetic and compass bearings (Jenkins, 1869). The soft irons are magnetized a few minutes after the earth's field starts to affect them in the same direction and, consequently, the compass course is erratic during this interval. To avoid this error, called Gaussin error, the ship's heading must stand steady around five minutes before each bearing is read by the adjuster (Grant and Klinkert, 1970). The compass adjuster uses correctors such as horizontal or vertical permanent magnets, soft iron spheres and soft iron bars to carry out the reduction of the deviation. These correctors are set in the binnacle at a proper distant from the needle to create the necessary magnetic field to reduce the ship's magnetism. This article deals with the reduction of that part of deviation due to magnetic field caused by the disturbing vertical soft irons. The effect of these irons would be the same as a hypothetical vertical soft iron bar located at the centre line of ship.

2. Coordinate reference systems, definitions and symbols

The ship's total magnetic field is broken up into its components under different Cartesian coordinate systems. Thus it may be represented in three different coordinate systems by the vectors in (1), (2) and (3); where:

- B_h is the total field in the horizontal coordinate system where the axis x, y and z coincide respectively with the magnetic North-and-South, East-and-West lines and with the Zenit-and-Nadir line;
- B_r is the total field in the up righted ship coordinate system where the axis x, y and z coincide respectively with fore-and-aft line, the projection of atwarthship line over the horizontal plane, and Zenit-and-Nadir line;
- B_s is the total field in the heeled ship coordinate system where the axis x, y and z coincide with fore-and-aft, athwartship, and topmast-and-keel lines respectively.

[1] University of Basque Country. María Díaz de Haro, 68, 48920. Portugalete. Spain.
[2] Professor, Email: imanol.basterrechea@ehu.es, Tel +34946014792, Fax +34946017700.
[3] Professor, Email: jesusangel.vila@ehu.es, Tel +34946014848, Fax +349426017700.
[4] Professor, Email: iranzu.sotes@ehu.es, Tel +34946014848, Fax +34946017700.
[*] Corresponding author.

The subscripts h, r and s denote the coordinate system of the vector and the matrices $T(i)$ and $T(h)$ are used for the conversion of coordinates.

$$B_h^t = \begin{bmatrix} X_h & Y_h & Z_h \end{bmatrix} \tag{1}$$

$$B_r^t = \begin{bmatrix} X_r & Y_r & Z_r \end{bmatrix} \tag{2}$$

$$B_s^t = \begin{bmatrix} X_s & Y_s & Z_s \end{bmatrix} \tag{3}$$

The total magnetic field at compass position depends on the earth's field (B_E) as well as on the hard and soft irons of which the ship is built. Hard irons behave as permanent magnets; therefore their effect is called permanent magnetism (B_P). Soft irons, on the other hand, vary their induction with every change in the direction of the material with reference to the earth's field. This means that the direction of the induction will vary with every alteration in the direction of the ship's head. This requires that the ship, as a whole, be considered an anisotropic material. Consequently, the magnetism caused by soft irons, called induced magnetism (B_I), is measured by the coefficients of the magnetic susceptibility tensor and by the earth's field.

The vector B_{Eh} in (4) is the earth's field in the horizontal coordinate system, H and Z being the horizontal and vertical components respectively. The vector B_{Ps} in (5) is the permanent magnetism and the vector B_{Is} in (7) the induced magnetism, both of them in the heeled ship's coordinate system. Therefore, the subscripts E, P and I refer, respectively, to the earth's field, permanent magnetism and induced magnetism. The matrix χ in (6) refers to the susceptibility tensor of the induced magnetism.

$$B_{Eh}^t = \begin{bmatrix} H & 0 & Z \end{bmatrix} \tag{4}$$

$$B_{Ps}^t = \begin{bmatrix} P & Q & R \end{bmatrix} \tag{5}$$

$$\chi = \begin{pmatrix} \chi_{x,x} & \chi_{x,y} & \chi_{x,z} \\ \chi_{y,x} & \chi_{y,y} & \chi_{y,z} \\ \chi_{z,x} & \chi_{z,y} & \chi_{z,z} \end{pmatrix} \tag{6}$$

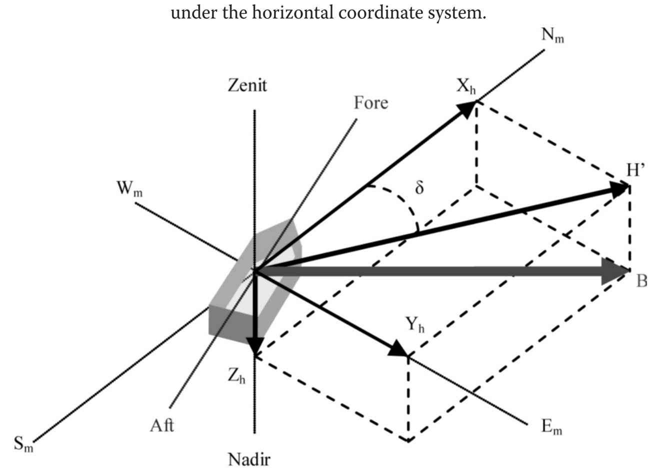
$$B_{Is} = \chi \cdot B_{Es} = \chi \cdot T^t(i) \cdot T^t(h) \cdot B_{Eh} \tag{7}$$

3. Deviation formulae when the ship is up right or heeled

In figure 1 the total magnetic field at compass position (B_h) is split in the three components under the horizontal coordinate system. The component X_h is the directive force to guide the needle towards the magnetic North. The component Y_h is the disturbing force pushing the needle away from the magnetic meridian. The resulting vector of these components (H') is the horizontal magnetic field. The deviation (δ) is the angle included between H' and X_h, the value of which is arctangent of the result of Y_h divided by X_h, as in (8). Hence, the conversion to the horizontal coordinate system is needed in order to calculate the deviation.

$$\tan\delta = Y_h / X_h \tag{8}$$

Fig. 1. Components of the total magnetic field at compass position under the horizontal coordinate system.



Source: Authors

The equation in (9) indicates the total magnetic field at compass position when the ship is heeled. It's refers to three coordinate reference systems. The matrix $T(i)$ converts the components of a vector from the heeled to up the righted ship's coordinate system. $T(\zeta)$ converts the components of a vector from the up righted ship to the horizontal coordinates. The respective transverse matrices will convert the components in the opposite direction. The equation in (10) indicates the total magnetic field at compass position when the ship is up right. In this case the matrices $T(i)$ and $T^t(i)$ are equal to the unity, since the heel is equal to zero ($i=0$).

$$\begin{aligned} B_{h_i} = B_{Eh} + B_{Ph_i} + B_{Ih_i} = B_{Eh} + T(\zeta)\cdot T(i)\cdot \\ B_{Ps} + T(\zeta)\cdot T(i)\cdot \chi \cdot T^t(i)\cdot T^t(\zeta)\cdot B_{Eh} \end{aligned} \tag{9}$$

$$\begin{aligned} B_h = B_{Eh} + B_{Ph} + B_{Ih} = B_{Eh} + T(\zeta)\cdot B_{Ps} + \\ T(\zeta)\cdot \chi \cdot T^t(\zeta)\cdot B_{Eh} \end{aligned} \tag{10}$$

In both cases, either up right or heeled, the ship may be considered symmetrical with reference to the centre line and thus the coefficients $\chi_{x,y}$, $\chi_{y,x}$, $\chi_{y,z}$ and $\chi_{z,y}$, representing the susceptibility of asymmetric soft irons, may be considered negligible. Given that the heel i is always a small angle, the value of its sine may be considered as the angle i in radians, its cosine as negligible, its square sine as negligible and its square cosine as the unity. The deviation for either an up righted ship or a heeled ship may be expressed respectively as in equations (11) and (12).

$$\tan\delta = \frac{Y_h}{X_h} = \frac{B\cdot\sin\zeta + C\cdot\cos\zeta + D\cdot\sin 2\zeta}{1 + B\cdot\cos\zeta - C\cdot\sin\zeta + D\cdot\cos 2\zeta + F} \quad (11)$$

$$\tan\delta_i = \frac{A_i + B\cdot\sin\zeta + C_i\cdot\cos\zeta + D\cdot\sin 2\zeta + E_i\cdot\cos 2\zeta}{1 + B\cdot\cos\zeta - C_i\cdot\sin\zeta + D\cdot\cos 2\zeta + E_i\cdot\sin 2\zeta + F} \quad (12)$$

In order to reduce the terms of both equations, similar mathematical expressions have been put into coefficients A_i, B, C, C_i, D, E_i and F, the value of which appears in table 1.

Table 1. Coefficients for equation of deviation

$A_i = \frac{\chi_{x,z} - \chi_{z,x}}{2}\cdot i$	$B = \frac{(P + \chi_{x,z}\cdot Z)}{H}$	$C = \frac{(Q + \chi_{y,z}\cdot Z)}{H}$	$D = \frac{\chi_{x,x} - \chi_{y,y}}{2}$
$E_i = \frac{\chi_{x,z} + \chi_{z,x}}{2}\cdot i$	$F = \frac{\chi_{x,x} + \chi_{y,y}}{2}$	$C_i = \frac{[Q - R\cdot i + (e-k)\cdot Z\cdot i]}{H}$	

Source: Authors

If we use different trigonometric identities and we put different terms into groups, the equations in (13) and (14) may be replaced by those in (11) and (12).

$$\sin\delta = B\cdot\sin(\zeta-\delta) + C\cdot\cos(\zeta-\delta) + D\cdot\sin(2\zeta-\delta) - F\cdot\sin\delta \quad (13)$$

$$\sin\delta_i = A_i\cdot\cos\delta_i + B\cdot\sin(\zeta-\delta_i) + C_i\cdot\cos(\zeta-\delta_i) + D\cdot\sin(2\zeta-\delta_i) - E_i\cdot\cos(2\zeta-\delta_i) - F\cdot\sin\delta_i \quad (14)$$

4. Determination of coefficient $\chi_{x,z}$ by heeling the ship

The Flinders' bar is a vertical case installed around the binnacle, where various soft iron fragments are set to reduce the coefficients $\chi_{x,z}$ and $\chi_{y,z}$. Depending on the amount and dimension of the fragments placed in the case, the length of the Flinders' bar may be altered. The traditional method to obtain the coefficients $\chi_{x,z}$ and $\chi_{y,z}$ from a ship is to navigate between two latitudes where the earth's field components are different enough, so as to obtain two different B and C coefficients in each position (Defense Mapping Agency and Hydrographic/Topographic Center, 2004). Thus, their components and coefficients belonging respectively to permanent and induced magnetism may be separated, which gives us the possibility to calculate their values by means of a system of two equations and two unknowns. Nevertheless, the coefficient $\chi_{y,z}$ refers to asymmetrical soft irons and, bearing in mind that they are not usually found on board, the Flinders' bar is permanently installed in the centre line without slewing it. On the other hand, the coefficient $\chi_{x,z}$ refers mainly to soft irons placed below and after the compass, which means that the Flinders bar case is fixed forward and below the binnacle so that both effects cancel each other out (Denne, 1979).

The main drawback of this method lies in the impossibility of obtaining the length of Flinders bar at single latitude. Therefore, it is not possible to know this length on ships navigating in limited waters as, for example, some tugs, dredgers, fishing vessels etcetera. The aim of this article is to provide compass adjusters with a method to obtain the coefficient $\chi_{x,z}$ without changes of latitude. In this sense, the adjuster can take advantage of the heeling trials carried out in some type of vessels, since the ship may be heeled up to 15 degrees (Rawson and Tupper, 2001).

The starting point to find out the value of $\chi_{x,z}$ is the replacement of the deviation in the equations in (13) and (14) by the difference between the magnetic and compass course ($\delta = \zeta - \zeta'$). Next the ship is steered to the East compass course, either up right or heeled, and thus various trigonometric identities may be taken to determine the equations in (15) and (16), assuming that ζ'=90º. The formula in (17) is obtained from the subtraction of both equations, taking the coefficient $\chi_{x,z}$ as common factor and considering the coefficient $\chi_{x,x}$ negligible, on the assumption that the spheres have just been installed properly after a previous compass adjustment.

$$-\cos\zeta = B + D\cdot\cos\zeta + F\cdot\cos\zeta = B + \chi_{x,x}\cdot\cos\zeta \quad (15)$$

$$-\cos\zeta_i = A_i\cdot\sin\zeta_i + B + D\cdot\cos\zeta_i + E_i\cdot\sin\zeta_i + F\cdot\cos\zeta_i = \chi_{x,z}\cdot i\cdot\sin\zeta_i + B + \chi_{x,x}\cdot\cos\zeta_i \quad (16)$$

$$\chi_{x,z} = (\cos\zeta - \cos\zeta_i)/i\cdot\sin\zeta_i \quad (17)$$

5. Experience with the deviascope

The deviascope will be used to confirm the theoretical calculations cited above since it seems more realistic than other VRML simulators to carry out the required test (Wu et al., 2010). This device simulates the magnetic forces to which a compass is subjected on board a steel ship and shows how to cancel them out. Basically, it is made up of a magnetic compass mounted on the centre line of a revolving plank representing the ship deck (henceforth 'deck') which can also be heeled. At both ends of the centre line the fore and aft part of the deck can be distinguished. There are likewise various apertures on the deck for the insertion of permanent magnets and soft irons (Brown, 1961). The desviascope is, therefore, a proper device to carry out a practical experiment to prove that the formula in (17) is correct.

First of all, it is necessary to find a demagnetized place to carry out the experiment with the deviascope, since the needle should not be disturbed by any external magnetic field in the surrounding area. In order to find such a place, the desviascope has to be up righted and released from all of its magnets and soft irons. Then it has to be moved to different locations until the deviation at the four cardinal courses is nil. The marks pointing out the true cardinal points may be obtained by means of nautical charts or maps on the internet (in this case the on-line Iberpix Visor was used) and have to be far enough from the desviascope as to allow us to move it slightly without affecting the bearings. Then, if the needle is oriented to the cardinal points (ζ'), the relative bearings (*RBRG*) to the true marks obtained by the pelorus should be equal to the magnetic declination (*DEC*). If they are not, it means that the place is magnetized and the experiment cannot be carried out there. The value of the magnetic declination, along with *H* and *Z*, may be collected from the IGRF (International Geomagnetic Reference Field) model using the on-line GEOMAG calculator (National Geophysical Data Center, 2011). Table 2 shows the value of these parameters for the date, altitude (*h*) and position in which the experiment was carried out.

Table 2. IGRF geomagnetic parameters at Bilbao on 18th April 2012.

Date	Latitude	Longitude	h	H	Z	D
18.4.1 2	*43-19.6 N*	*003-01.4 W*	10	*23,884.1*	*39,135.2*	*1.5º(-)*

Source: Authors

Once the demagnetized place is located, a vertical soft iron rod is set in the hole which is located at the aft part of the centre line of the deck, the top rod being at the same plane as the card. In this way, the compass course is altered only by a symmetrical soft iron representing the coefficient $\chi_{x,z}$ and thus the experiment can be carried out.

$$\delta = RBRG - DEC \qquad\qquad \zeta = \zeta' + \delta \tag{18}$$

The following step consists in revolving the deck until the East compass course (*ζ'=090º*) is reached; as can be seen in Figure 2. After that, the deviation is obtained by the application of the formulae in (18), obtaining thereafter the deviation and the magnetic course for zero, five, ten and fifteen degrees of deck inclination. This allows us to calculate the coefficient $\chi_{x,z}$ for the deck, either up righted or heeled, by the application of the formulae in (19) and (17). The formula in (19) is used for the up righted ship and emerges from the equation in (13), considering that all coefficients and components are negligible except $\chi_{x,z}$. On the other hand, the disturbing magnetic field created by the vertical rod (B_r) may also be calculated by the formula in (20), according to Figure 2.

Additionally, should the up righted deck with the vertical rod be again revolved at the four cardinal compass courses, the vector of the horizontal magnetic field affecting the rose at every course (*H'*) can be obtained by the application of the formula in (21), the module being as in (22).

$$\chi_{x,z} = H/Z \cdot \sin\delta \tag{19}$$

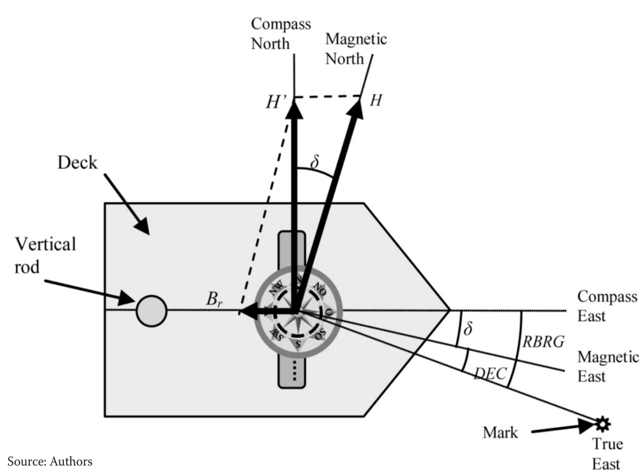
$$B_r = H \cdot \sin\delta \tag{20}$$

$$\overrightarrow{H'} = \overrightarrow{H} + \overrightarrow{B_r} \tag{21}$$

$$H' = H \cdot \cos\delta - B_r \cdot \cos\zeta' \tag{22}$$

The experimental results obtained from the desviascope are given in Table 3 and have been rounded off to the tenth for higher precision. To do this, it is preferable to obtain the data by means of a fluxgate, provided that this electrical device does not disturb the total magnetic field at compass position. On the other hand, the values of *Br* and *H'* are shown in table 4, together with the coefficient $\chi_{x,z}$ for different inclinations.

Fig. 2. Desviascope at North hemisphere with the vertical rod inserted through the deck.



Source: Authors

Table 3. Results obtained from the desviascope during the experiment.

Up right deck				Heeled deck		
i=0º	*i=0º*	*i=0º*	*i=0º*	*i=5º*	*i=10º*	*i=15º*
ζ'=000	*ζ'=090*	*ζ'=180*	*ζ'=270*	*ζ'=090*	*ζ'=090*	*ζ'=090*
ζ=000	*ζ=080.5*	*ζ=180*	*ζ=279.5*	*ζ=080*	*ζ=079.5*	*ζ=079*
δ=0	*δ=−9.5*	*δ=0*	*δ=+9.5*	*δ=−10*	*δ=−10.5*	*δ=−11*

Source: Authors

Table 4. Calculation of $\chi_{x,z}$ and the total and disturbing magnetic fields (h' and br) in the experiment.

	Up righted deck				Heeled deck		
i	0º	0º	0º	0º	5º	10º	15º
ζ'	000	090	180	270	090	090	090
ζ	000	080.5	180	279.5	080	079.5	079
B_r	*	3,942	*	*	*	*	*
H'	19,942	23,557	27,826	23,557	*	*	*
$\chi_{x,z}$ (-)	*	0.100038	*	*	0.100076	0.100157	0.100243

Source: Authors

Taking into account the asymmetrical irons are negligible and the coefficient $\chi_{x,z}$ has been already calculated, the length of the Flinders' bar is obtained as follows:

1. There must not be fore-and-aft B magnets set in the binnacle.
2. The spheres must be installed properly in the binnacle to reduce $\chi_{x,x}$ and $\chi_{x,z}$.
3. The compass heading must be 090º at the time the ship is heeled.
4. The part of the deviation caused by the symmetrical soft irons ($d\delta$) is equivalent to the deviation in (22). In other words, this part of deviation may be obtained by the formula in (23).

$$\sin d\delta = Z/H \cdot \chi_{x,z} \tag{23}$$

5. The following step consists in adjusting the length of the Flinders' bar until the course is altered $d\delta$ degrees.

Once the Flinders' bar is adjusted, the adjustment proceeding should be carried out installing the other correctors in the following order: spheres, heeling magnet and horizontal magnets.

6. Conclusions

The method hereby explained shows the adjusters to know the amount of the Flinders' bar set in the binnacle without having to navigate to a distant position. It is thus suitable for small vessel and crafts the use of which is reduced to limited waters. The problem lies in the heel that the vessel is capable to reach so that the resulting mass of vertical soft iron representing $\chi_{x,z}$ can be calculated accordingly. In addition to the possible difficulties found by the Master to heel deliberately the ship by reason of stability conditions, it should be noted that the measurement of the heel has to be precise enough so as not to affect the final results. For instance, an error of one degree for a heel of 15º would result in a variation of 0.15 thousandths in $\chi_{x,z}$. In the same sense, it is very important the courses at the East are obtained with great precision, whether the vessel either up righted or heeled. In the experiment a precision of one tenth is taken in obtaining the courses. Bearing this course precision in mind, the differences of $\chi_{x,z}$ with respect to the inclinations of the deck are around only 0.2 thousandths and, on the other hand, the error in $d\delta$ would be a little less than 0.2º at the time of adjusting the Flinders' bar on board a real ship. Therefore, it would be advisable to use a fluxgate sensor and a precise inclinometer to carry out the adjustment by this method.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 13 - 22

ISSN: 1697-4040, www.jmr.unican.es

Taxation and Privateering in the Medieval Mediterranean: The Conformation of Privateering Regulations and its Application on the Island of Mallorca

M.D. López[1,2,*] and K. Alvaro[1,3]

ARTICLE INFO

Article history:
Received 27 June 2013;
in revised form 07 July 2013;
accepted 23 September 2013

Keywords:
privateering, piracy, Mallorca, Medieval Mediterranean, taxation.

ABSTRACT

In 1229 the island of Mallorca, then in Muslim hands, was conquered by troops of the Catalan-Aragonese monarch Jaime I. From that very moment a group of investors formed which would combine commercial business with that of privateering-pirates – to the point that privateering became one of the most important resources of the Mallorcan economy. However the Mallorcan privateering phenomenon didn't acquire an international dimension until the 14th century when it became necessary to adopt a regulation – common to all the territories of the Crown of Aragon – capable of regulating and controlling the activities of the corsairs which frequently resulted in piratic operations. In this work we will analyse that process of shaping the corsair policy and its application in the particular Mediterranean space of Mallorca, and especially the emergence of a tax, the "quint" (the fifth), used by the monarchy to control and exploit the lucrative privateer enterprises.

1. A concretion of the issues

On the 31st of December 1229 the troops of Jaime I entered the besieged Madina Mayurqa. After long months of siege the Muslim city was conquered by blood and fire and its population killed or enslaved. Only a few managed to escape and take refuge in the central mountains of the island where they were protagonists in a fierce resistance that lasted 2 long years. 100 years previously, in 1114-1115, Pisans and Catalans had already tried to jointly take possession of the Island. The motives given for this conquering enterprise, eloquently exposed by the Pisan author of 'Liber Maiolichinus de gestis pisanorum illustribus', never fail to be revealing: to put an end to Majorcan piracy. Armed Muslim vessels from the shipyards of the island were terrorizing the Christian coasts of the Western Mediterranean and were hindering the thriving commercial Pisan republic. However, Piracy wasn't the primary activity of the Island but rather complimentary to the flourishing agriculture and an active trade. Nevertheless, this first Christian attempt didn't come off. Almoravid pressure on the Catalan borders forced the count Ramon Berenguer III, head of the military expedition, to retreat hastily and leave the island, after having plundered the territory.

In the 13th Century the Piratic problem had undoubtedly worsened and was threatening the already thriving commercial activities of Barcelona whose ships crossed Mallorcan waters en route towards the Maghreb or Italy. Bernat Desclot testifies to this. The chronicler tells us how the Mallorca governor, Abu Yahya al-Tinmalli, had captured two boats, one coming from Bugia and another that was headed toward Ceuta. This happened in 1227 and gave rise to a serious diplomatic conflict (Desclot, 1982, pp.72-73).

The version offered by the Muslim historiography differs in regard to those motives that provoked the Christian incursion and instead trace the origin of these events back to 1226. Ibn Amira al-Mahzumi recounts how that year Abu Yahya al-Tinamlli sent a transport *tarida*, accompanied by a warship, to the island of Ibiza in search of the necessary wood for the armament of new ships. The news reached the authorities of Tortosa who were poised to send out an expedition with the aim of capturing the coveted cargo. The chronicler's appreciation of the transmission of information is interesting. He says that various Christian merchants (perhaps Genoese, Pisan if we consider the indications of Desclot) observed the arma-

[1] University of Barcelona. C/Montalegre, 6-8, 08001, Barcelona, Spain.
[2] Senior Lecturer, Email: mdlopez@ub.edu, Tel +34937037949, Fax +34934037932.
[3] Adjunct Professor, Email: kalvaro@ub.edu, Tel +34934037950, Fax +34934037932.
[*] Corresponding author.

ments from a boat off the island of Mallorca. The response from Abu Yahya was swift. He ordered a naval campaign against the Catalan coast which ended with the capture of several vessels and that of a major trader, whose name is not specified. In the midst of this climate of impending war a ship from Barcelona, associated with Tortosa, appeared of the coast of Ibiza which led to a rapid response from the Mallorcan Valí. The Mallorcan squadron sent to protect the island managed to appropriate a Genoese ship and confiscate the cargo from the ship of Tortosa. Al-Mahzumi tells us that four rich and powerful Genoese potentates were captured. However, the ship from Barcelona managed to escape but, according to Al-Mahzumi, the gravity of these events and the advice from those closest to him made Jaime I decide to invade Mallorca (Ibn Amira al-Mahzumi, 2008, pp. 73-80).

Both chroniclers argue different reasons to explain the assault of Madina Mayurqa, although, ultimately the underlying cause in both reasoning is identical: the need to end Muslim maritime activities. As an essential knot in the commercial circuits, the conquest of Mallorca became essential to satisfy the ambitions of the Catalan merchants for whom Muslim possession of the island was hampering the potential expansion of commercial influence.

With the conquest of 1229, Mallorca went from being a Muslim “piratic” society to a society of Christian “pirates”. From that first moment, on the island settled a group of investors who knew how they were going to reconcile the perfection of the commercial trade with that of the privateer-pirates. They would have to wait, however, until the 14th Century for the privateer investments to acquire official recognition within the Mallorcan economy. It’s in that moment - the 1300’s - that the Privateering phenomenon took on an international dimension and the adoption of common rules across the whole Mediterranean area became necessary.

The objective of this work will be centred on an analysis – to the extent permitted by the documentation - of the exercised control over privateering activities by the State. To do this it will be necessary to evaluate the process of shaping the privateering regulations and their application in a Mediterranean space – the island of Mallorca – and especially the emergence of a tax, ‘el quinto’, used by the monarchy in order to control and profit from the increasingly lucrative privateering enterprises. Privateering would become one of the most important economic resources for Mallorca – an ‘alternative commerce’. We must remember that as there existed a great permissiveness, the Mediterranean islands were the safest refuge for both privateers and pirates. Their vulnerability due to the extensive coastline, the scarcity of population and the difficulties in relying on immediate help in the case of an attack explain why the authorities adopted measures hardly orthodox and made themselves a welcome land for renowned pirates by allowing the ‘illegal’ unloading and sale of their captives. And one of these refuges would be Mallorca.

On the other hand the conquest of the island took place at the moment in which Christian Naval eminence was consolidated in the Western Mediterranean, whilst at the same time a gradual decrease was seen in the corsair activities carried out by Muslims. Control of the island undoubtedly helped to tip the balance of maritime power toward the Christian side. The hitherto powerful Islamic squadrons saw their capacity for intervention limited in a process that would go on until the beginning of the 14th century (Díaz Borrás 1993). The last decades of the 13th Century and the first years of the 14th Century witnessed considerable wear to the coasts and Maghreb marine centres because of the countless captures by Corsairs coming from the major port centres of the Crown of Aragon. Catalan-Aragon hegemony in the area of the western Mediterranean was becoming apparent. The area of greatest activity seems to have been Tunisia, as a result of military activity in waters near Sicily between the Catalan-Aragonese and the Angevins with the objective of dominating the island (Ferrer, 2008, p. 838). Nevertheless, from that moment there was a turning point in the trend. Since the first decades of the 1300’s armed Marinid galleys, especially in the city of Ceuta, began a gradual methodical persecution of Christian vessels – particularly Catalan-Aragonese. This slow increase in tension in the Mediterranean culminated in the second half of that century with the emergence of Hafsid piracy. The actions of armed vessels in enclaves like Bona or Bejaia, quiet in the first half of the 14th century, came alive from 1360 turning the western Mediterranean area into the stage of a confrontation between two privateer powers, Tunisia and the crown of Aragon.

2. Towards a slow shaping of the regulation: the definition of a general frame

The first regulations concerning the control of the Corsair activities date back to the 12th century. A few years after the fleeting Catalan-Pisan occupation of the island the Catalan counts enacted some privileges whose objective was to regulate certain aspects of privateering. The provisions made in this respect are significant and demonstrate what the primary concerns of the authorities actually were. The first thing of importance is that they established a theoretical distinction between piratic and Corsair activities, but especially to regulate the division of benefits and to establish the part corresponding to the authorities as guarantors of legality. The monarchy sensed the huge source of resources that could be drawn from the actions carried out by privateers and tried from the beginning to keep some for itself. And that is what is transparent in those initial privileges, in so much that the part of the loot for the King is the first aspect of the privateering to be regulated.

The first precept documented on these issues is an ordination of 1118 by which the count of Barcelona, Ramon Berenguer III, granted the natives of Barcelona immunity from the *quintam* that the galleys that arrived at the city were paying. The count affirms that this was a new usagium that he had planted himself, and he did it to reward the men of Barcelona for their rendered services (Ferrer, 2006, p. 310).

Some dispositions from 1129 have been attributed to the same count, but ones which must have originated earlier. These dealt with regulating the payments that the corsairs had to make to the participants in the expedition and to the local lord of whichever place they landed with the booty. However, in the document are notable figures of Tortosa - a city that would not be conquered by the Muslims until to 1148. M. T. Ferrer explains this by alleging the widespread custom of subsequently redoing the provisions by adding new personages. This clarifies the presence of notable people of Tortosa next to the count.

The right to *ribatge* is detailed between the clauses of this precept – the quantity that the corsairs would have to defray to the lord of wherever they disembarked as compensation for the public auction of the booty. To this they had to add the delivery of a Muslim slave, the distribution of the amount obtained between the crew members and the compensatory amount that the boatswain would receive for ensuring the maintenance of the ship, as well as the rights of the latter to the seamen fugitives - a real proclamation of intentions. These precepts were repeated in the thirteenth century in a privilege granted in 1243 by Jaime I to the city of Valencia. However, M.T. Ferrer points out a substantial difference: the authorization of 1243 does not refer to a payment on the Corsair loot but only to payment for the right to auction the loot, an issue which appears confirmed by making explicit that it will only affect the ships and corsair vessels that make *encantum* - that's to say an auction in whichever part of the Valencian Kingdom. Therefore this arrangement affected the tax regulation on trade as it only applied in the case of goods obtained as loot. The tax on privateering was always proportional to the booty obtained; in this case however it was a question of a few fixed payments according to the draught of the vessel, differentiating between ships, galleys, vessels, boats with 16 to 30 oars and boats with less than 16 oars. The only common point was an obligation to hand over a Muslim slave (Ferrer, 2006, pp. 310-311).

Subsequently, these precepts went on to the Valencian *Furs* in 1261, and from here to the *Costum* of Tortosa drafted in about 1272. García Sanz stresses that in this way these precepts were responding to legal customs followed by the Corsairs in the 12th and 13th centuries in Catalonia and Valencia (1991, p. 98). As this same author points out, a tendency to restrict Corsair activity started from the middle of the 13th Century. This crystallized in the establishment of patent or actual licenses which imposed the provision of a bond as a condition for allowing armaments. Various actual interventions could be cited - generated in reaction to Corsair armaments done in Valencian territory.

An early provision of Jaime I, granted in 1250, has generated a lively discussion among historians, summarized by Diaz Borrás (1993, pp. 21-22). The terms included in this provision seemed to prohibit any type of armament - as Dufourcq concluded when considering that the document facilitated the opening of a favourable period for trade characterized by non-violence (Dufourcq, 1969, pp. 60). However the consequences are much more complex, as has been shown by R.I. Burns. The intention of Jaime I was not to prohibit privateering but to centralize the powers into the hands of the Bailiff of Valencia thus preventing other authorities of lesser rank from being able to grant armaments to Corsairs (Burns, 1987, pp. 175-179). This latest interpretation, probably the closest to the reality, is consistent with the attitudes displayed by the successor of Jaime I three decades later, Pedro el Grande. On December 1st 1283 the monarch was promulgating the *Privilegium Magnum* in Valencia where the granting of a license by the general bailiff was envisaged as an indispensable condition in the consideration of legal Corsair weaponry (García Sanz, 1991, p. 98).

Ultimately both Pedro el Grande and Jaime I would attempt to avoid, through the promulgation of these decrees, the undue granting of licenses by local bailiffs more easily influenced through being authorities of lower rank. So they opted for centralization by establishing the general bailiff in Valencia as the only competent authority. So by the end of the 13th century the king was clearly attempting to control some activities that could be extremely lucrative and at the same time could serve as complementary defence forces at the service of the monarchy in times of war. Its repetition would surely reflect the routine character of the infractions and the need to "remember" the regulations.

Nevertheless, in this privilege of 1283 there is still no mention of the demand of some bonds and the provision of guarantors - essential to ensure the fulfilment of the agreed arrangements. How does Díaz Borrás explain this? According to this author, the target first and foremost was to prevent the uncontrolled proliferation of pirate activity and at the same time promote it moderately without imposing obstacles too onerous (Díaz Borrás, 1987, p. 51).

It would be necessary to wait until 1288 for the appearance of the imposition of providing guarantees as an indispensable condition for the legalization of Corsair armaments. In that year Alfonso el Franco decreed the need for a license from the corresponding Royal authority in addition to the obligation to return to the place of armament before starting any other privateer expedition. And it is significant that the monarch also prohibited the royal officials from taking part in the armaments and imposed the detention of Corsairs arriving on the coasts of the crown with captives until the legitimacy of these had been declared (García Sanz, 1991, pp. 98-99).

So the 13th century appears to be a decisive period in the shaping of privateering rules. Through their decrees and enactments, Jaime I, Pedro el Grande and Alfonso el Franco drew-up a framework aimed at the control of certain Corsair activities which easily drifted into piracy. At the end of the century then we already have the legislative theory. But what happened in practice? The answer is more complex, in the hope that a meticulous study of the preserved documents for these crucial decades of the 13th century throws some light on these questions. The doubt lies in the compliance or not of the implicated model with the imposed conditions and, ultimately, in the degree of ability that the authorities had in their control.

In the 1300's the doubts begin to fade as the documentation studied starts to reflect the everyday life and the inherent fraud of the controls. M. Sánchez revealed this in a study some years ago about the control of Valencian Corsair Activities in the temporary space created by the ending of hostilities between the Crown of Aragon and the Marini and Nazari Sultanates in 1334. Alfonso el Benigno, in this *impasse* of the so called War of the Strait, issued an order banning any kind of aggression towards the subjects of both sultanates in order to preserve a peace that would materialize in the following year. The demand of a guarantee was an indispensable condition to getting a license for the armament of privateer vessels. Sanchez also documents that included in the clauses of the licence was the amount of the fine that would have to paid in the case of breaking the actual provisions and a relation of the guarantor or guarantors that ensured the effectiveness of the payment. Guarantees and penalties were already present by the 1330s. This comprehensive control was ordered not only for the Valencian port, but also for the other ports where Corsair enterprises were organized, including the Mallorcan harbour. The question that remains to be answered is whether this control is an isolated case, motivated by a certain situation in which it was of interest to guarantee a few favourable conditions for the political negotiations, or evidence of an effective and consistent pattern of regulation on the part of the Valencian authorities.

An analysis of the documentation generated by the Royal Chancellery gives a provisional answer to these questions. Through the content of these documents, it is noted that the practical application of the regulations is not widely observed in all the ports of the Crown, at least not until the second half of the 14th century. An extremely clear example constitutes some provisions decreed by Pedro el Ceremonioso in July 1343 which make reference to the armaments in the Mallorcan port. The king prohibited the arming of corsair ships in the kingdom of Mallorca without prior obtaining a licence granted by the monarch or governor. It is clear that this ban reveals that the armaments carried out outside of state control on the islands constituted a common practice (Cateura, 1982, p. 270). Moreover, in 1353 it was required that the corsairs should promise to the governor that they would not attack anybody who was at peace with the monarch. To ensure that they would comply with this the provision of guarantors was demanded for the lump sum of 3000 Libras.

The problem, however, is much more complex and makes it impossible to draw general conclusions about all of the territories of the Crown due to a lack of contemporary information on other ports like Barcelona or Valencia. The kingdom of Mallorca had just reinstated the crown of Aragon after a long period of *independence* known as the *privateer kingdom*[1]. Was the Mallorcan King allowing the *free* exercise of privateering without exercising any type of control? Or was it that following reinstatement the change of powers favoured an illicit activity? It is assumed that the temporary parenthesis marked by the reintegration of the Balearic Islands to the domain of the Catalan-Aragonese monarch defined a favourable period for this type of action. Judging by certain concessions of the monarch to the subjects of the islands, it seems likely that the norms that regulated privateering during the independent Kingdom were either extremely flexible or were simply no longer effective.

To learn about the organization of privateering on the island during the years immediately following the reinstatement reveals extremely interesting information provided by some claims raised in 1349 by the Majorcan Governor, Gilabert de Centelles, in the presence of Pedro el Ceremonioso. The monarch had previously enacted a decree compelling the Mallorcan merchants to remove their goods from the Maghrebi markets. The reason for this was to avoid possible reprisals caused by the Monarch granting a corsair license to the inhabitants of Ibiza. The arguments of Centelles[2] have a twofold perspective: on the one hand, he tries to convince the monarch of the harm caused by the free authorization of privateering to the natives of Ibiza – the most palpable being the Royal order of the abandonment of the Maghreb markets - and on the other hand he alludes to the benefits that an identical concession would bring to the inhabitants of Mallorca.

Centelles presents economic justification to defend his petitions. He says the monarch could only obtain minimal economic benefit from the concessions made to the Corsairs of Ibiza since it only possessed a quarter part of the jurisdictional rights over the island; the rest belonged to the archbishop of Tarragona, consequently the highest percentage of the tax on the captures would not be deposited in the royal treasury. Centelles also objects to the repeated failure on the part of Ibizan Corsairs of the clauses prohibiting the arrest of Muslims with whom there existed a signed truce and even Catalan-Aragonese subjects.

Why were the natives of Ibiza acting like this against the *laws* of diplomacy? Centelles also provides a logical explanation for these attitudes. Ibiza did not maintain commercial contacts with the North African markets and consequently its inhabitants would not suffer material damages arising from reprisals taken by the Maghreb rulers in the face of uncontrolled pirate actions.

These factors were used by Gilabert de Centelles to wield his own petitions aimed at achieving the free grant of Corsair arms to Mallorca. He claimed the island brought together the best conditions to proceed with a legal and productive application of regulations that govern the Corsair attitudes. The previous year in 1348 the plague had caused, as in the rest of the territories of the Crown, major havoc among the population of the Island - both free and enslaved - in a way that affected the royal finances through a drastic decrease in the

[1] The privateer kingdom of Mallorca had its origins in 1276 as the result of the testamentary dispositions of Jaume I. As a consequence of the monarchs' will, the Crown of Aragon split into two independent states - the Crown of Aragon, integrated by kingdoms of Aragon and Valencia and the principality of Catalonia, and the Balearic Islands which formed part of the Kingdom of Mallorca, the counties of Rosellon and Cerdenya, the manor of Montpellier and the viscounty of Carlades - whose government was inherited by Pedro el Grande, the primogenitor and Jaime II. This judicial situation was modified some time later, in 1279, when the Mallorcan monarch was forced to become a recognized "feudatario" of the crown of Aragon: of an independent kingdom, this way Mallorca became a vassal kingdom. The Franc-angevine invasion of Catalonia, in 1285, justified with the exclusion of Pedro el Grande, put to the test the faithfulness of the Mallorcan vassal. Jaime II, instead of helping his master entered into a coalition with the invaders - an alliance that justified, once the angevine offensive was rejected, the intervention of the Catalan-Aragon monarch and the reinstatement of the Balearic archipelago to the Crown in 1286. In 1298, in the face of great pressure both from the Holy See and France, the successor of Pedro el Grande, Jaime II, was forced to return the archipelago to Jaime II of Mallorca. From that moment, the successive Mallorcan monarchs ruled until 1343, when the islands were reinstated to the Crown of Aragon forever.

[2] Gathered in a memorial that had to be submitted to the monarch by a Valencian, Guillem de Majencosa [Archivo del Reino de Mallorca (Archive of the Kingdom of Mallorca), ARM, Governació, 4380, ff.24 r.-25 r. (Mallorca. 10, abril, 1349)].

revenue. Centelles claimed that this decrease could be remedied via privateering: *"per la mortaldat la terra és fort despoblada e per lo cors se poblarà, e.s millorarà".* That would result positively in an increase in the income from crops and most importantly it would constitute a way of waging war free of expenditure against Muslims with whom an agreement did not exist.

The conditions considered by the governor as indispensable for assuring an optimal operation of the privateering enterprises consisted of the adequate provision of guarantees. This would ensure, under a fine of 900 Mallorcan *sueldos*, the safety of subjects not considered as just targets and the payment of a tax of 10% on seizures. Therefore the key to ensuring the perfect operation of privateering enterprise, according to Centelles, rests on the guarantees and the payment of taxes. We will analyse this issue in more detail later. Undoubtedly the inclusion of tax was actually an economic tactic directed at obtaining the concession of the monarch.

We know nothing about the final granting of this prerogative but nothing could justify a refusal on the part of the king if it is considered that previously it had been granted to the natives of Ibiza. From subsequent information one can deduce that there was transgression of those rules (Capmany, 1963, p. 244).

What conclusions can be drawn from the reasoning of Centelles? Hypotheses might be established on the importance granted to the privateer activities as an alternative economic system in periods of difficulties, as a method of attracting and, if we consider the capture of slaves, bringing settlers to the island. What is undeniable is that privateering, throughout the 14th century, would go on to form an indisputable economic element as a parallel activity to legal commercial operations.

3. The war with genoa and the ordinations of 1356

The determining factor in the regulation of all aspects related to the privateering war would be the war against Genoa that exploded in the decade of 1350. The roots of this conflict, however, are found in the Catalan conquest of Sardinia initiated in 1323. The conflict of interest between Genoese and Catalans in Sardinian territory led to the outbreak of periodic hostilities throughout the 14th century; from 1325 to 1327, between 1331 to 1336 and a longer period between 1351 to 1360 – the year in which the hostilities stopped, although peace was not established until 1378 (Ferrer, 2006). During the last of these period, in the 1350s, some ordinations were drawn up that would have a general application in all of the territories of the confederation and that would serve to regulate 'the market of the war'. These were the *Ordinacions sobre certas reglas que.s deuen tenir en los armaments de corsaris particulars (Ordinations on certain rules that must be taken into the arms of individual corsairs* (Capmany, 1963, pp. 254-257), published in 1356 and they justified the urgent need of being able to rely on an important reinforcement of the royal fleet in the face of the continuing Genoese push. There is no doubt that the Corsair war was a mechanism used by both powers, giving rise to illegalities and associated claims after peace had been signed (Ferrer, 1993; 2006).

Some conditions inherent to the armament itself were imposed by these ordinations, among them the obligation to pay the royal authorities a certain percentage of the profits; disarming the galleys in the port of departure or the provision of due guarantees, although the quantity is not clear. But a series of privileges were also granted, such as making prepared and equipped galleys available to interested ship-owners in order to set sail for Sardinia, along with sufficient provisions for four months and enough wages to pay for 1 month or for the provision of guides and special moratoriums to the crew members of the privateer vessels with the aim of facilitating the always difficult enrolment. Likewise, they attempted to suppress possible violations through the appointment of inspectors for each one of the territories of the crown. These inspectors had a wide authority which included the power to review records of income made from royal tax (Díaz Borrás, 1987, pp. 53-56; Ferrer, 2006, p. 280).

The main feature that emerges from these ordinations is the high degree of State participation in privateer activities in regards to level of salaries and food supply. The loaning of boats and the partial funding to which the monarch committed himself seems to be based on prior experiences of negotiations with individual privateers which must have obtained satisfactory results for the two parties involved. What was the monarch receiving? By delegating an important part of the maritime defence in particular, a greater defensive and offensive range was achieved. And the ship-owners? The economic benefits would have been undoubtedly considerable by not having to get capital up front to cover expense items associated with the Corsair armaments, and at the same time, obtain identical prerogatives at jurisdictional level as those of the captains of the royal galleys.

Nevertheless, it is supposed that the concession of these generous privileges to individuals should have been reduced to a temporary restricted space – of extreme maritime danger - given their high cost and the financial difficulties that the crown would have to confront due to armed clashes, not just against Genoa but also against Castille while subject to certain requirements of reliability on part of the beneficiaries. As shown in the subsequent negotiations with corsairs that were made due to the conflicts with Castille, it seems likely that the most usual practice consisted of a mixed system in which the monarch simply granted himself full jurisdiction over crew members and, on occasions, a certain amount of supplies, while the individual or individuals provided the prepared vessel.

There exist, however, notable differences between the terms included in the general ordinations of 1356 and the particular examples that have been preserved and which denote a practical adaptation of the rules. The theoretical terms established in the ordinations presupposed important disbursements difficult to meet by the crown in exchange for the uncertainty of effective results. On the contrary, in the chapters negotiated with individuals the adoption of intermediate solutions can be observed: the corsairs provided the boat, dealt with the equipment, and went to the service of the king if it was requested. The contract of agreements allowed, therefore, the availability of an additional fleet - free from expenses and available when needed. In exchange, the Corsairs obtained a series of privileges at jurisdictional level and partial exemption from taxes and a facility in the always difficult process of enrolling the crews.

Although nothing more than hypothesis, it's probable that from the ordinations of 1356 onwards there was a widening in the obtaining of certain royal permits which didn't exclude the beneficiary from the obligation to obtain a license and provide bonds to the bailiff or governor, but did allow the easier armament of a galley. This can be deduced by the fact that a guide was made extensible to crew members, about the crimes and excesses committed up until the very day of the enrolment with the exception of heresy, sodomy, and the counterfeiting of currency,… as well as debts, except for those contracted by the dead, violators and commanders. At the same time the same prerogatives were granted to the skipper as to the captains of the royal armadas in terms of high and low and civil and criminal jurisdiction over the crew members. These guides were not new, but they seem to constitute an already common practice by the 2nd half of the 14th century.

The war against Genoa led to new regulations against the indiscriminate practice of Corsairs. After the peace treaties of 1386 and 1390 a limitation was imposed on the ports where Corsair boats had been able to arm. That was due to the numerous abuses carried out by many privateers who were attacking people with whom a peace treaty existed. The objective of this limitation was twofold, on the one hand it was an attempt to carefully check the Corsairs who had licences, and on the other it imposed a reduction in the number of ports authorized to maximize control. Mallorca and Ibiza were two of those ports. Barcelona, Valencia, Caller and l'Alguer completed the set of legalized ports. Genoa, however, could arm in its own city, as well as in Savona, Albenga, Ventimiglia, Portovenere, Vera, Caffa, Famagusta and Quios (Ferrer, 2006, p. 266).

4. The indispensable requirements: privateering licenses and the taxes on seizures

Together with guides and permissions, the armament of a boat required a license that would legalize the privateer activity. The legality of the companies was already being sanctioned with the reimbursement to the royal authorities of a proportionate part of the loot on returning to port. From a theoretical perspective, therefore, licenses and taxes would constitute the elemental differentiators between pirates and corsairs. The last element that gave an institutional character to privateering navigation was the obligation to return to the port of departure in order to sell the prey –a condition not always fulfilled since the corsairs preferred to sell apprehension in enclaves characterized by a lack of control (López Nadal, 1993).

With regard to the licenses, their sale suggested a direct implication of the state. According to D. Valérian, on the Muslim side there had to exist some kind of control of Corsair activity comparable to that which we are analysing developed by the Christian Corsairs. The problem lies in the lack of documented evidence (2013, p. 41). In Barcelona and Valencia, the concession was a prerogative of the general bailiff and from 1386 also of the jurors, as long as there was a prior provision of bonds in front of the bailiff, while in Majorca this power rested with the Governor of the island.

Let's look at the Majorcan case. In Mallorca these licences - once granted by the governor - were registered in the books of *Guiatges* and in the corresponding *Lletres Comunes*, both types of records preserved in the Archive of the Kingodom of Mallorca. So far the oldest localized corsair licenses correspond to 1375. However that is not proof of its prior inexistence. But what does turn out to be significant is the typology of these. First of all the names were specified of the beneficiary, the corsair and the type of vessel that would be used in the enterprise. Next, a clause was pointed out by which the subjects of the crown of Aragon were excluded as possible targets of prey along with those with whom a truce existed depending on the political situation – good for the non-declaration of war, good for the signing of a treaty of peace, as is the case of the Maghreb states. Also excluded were Jews and Muslims who were moved to the Catalan-Aroganese economic centres with the object of doing trade. Compliance with this arrangement sought to be guaranteed through the fixing of bail and the appointment of guarantors.

In regards as to the finances, there were some fixed amounts published by the royal authorities. However it seems that in practice the rate depended not so much on the existence of some previously established fixed rules but probably on the specific negotiating that went on between the corsair and the public authorities. This negotiation was undoubtedly influenced by the degree of credit that the endorsed subject offered. Perhaps the regular settlement of corsair contracts and the fulfilment of the various different provisions offered a certain security and contributed to the establishment of guarantees for amounts below the generally agreed scale. Likewise the existence of guarantors of recognized solvency would have slightly altered the required amounts. There was rarely just one grantor; the responsibility was often distributed between various. Almost all of them participated in the armament of the vessel or, to a lesser extent, of the family of the boss. Each one of them was responsible for a certain amount and some also had a shared responsibility for which the group of guarantors were committed by the total of the deposit.

The physiognomy of the endorser group was made up of shipmasters, sailors, fishermen, notaries, *mestres d'aixa* – in short trades related to the ocean – but also notaries, money changers, silversmiths, clogg vendors, shoemakers, plasterers, butchers, weavers, apothecaries, tailors, wool-carders, and above all Merchants. Alongside them were the wives of the shipmasters that were acting as guarantors for their husbands, and even women with no apparent relation to the corsairs - something which indicates a certain active participation and feminine integration into the world of trade.

In respect to the taxes on privateering, at least in Mallorca starting from the last quarter of the 1300s, from the information we have we know it had to be paid to the same authorities that had issued the licenses, given that in these the obligation to sell the loot at public auction and in the same place of departure was pointed out. On one hand the sale in the Mallorcan market itself resulted in revenues that, in favourable circumstances and depending on the stipulated rate, could become extremely high. On the other hand, through the inspection of the composition of the seizures, it allowed an enforcement of the clauses relating to the exclusion of detainees not considered just targets – especially Muslims whose states or sovereign were observing a truce. Sometimes it could be that a vessel involved in commercial purposes and not Corsair would seize an enemy ship without being in possession of a license. This didn't mean it was except for the royal tax that had to be paid on arrival at port and after the sale of the booty.

In the case of Mallorca, which is the focus of our attention, the profit under this concept was registered in the books of *Rebudes*. Those corresponding to the period 1330 – 1410 have been cleared and that allows us to confirm that entries under the concept of corsair taxes didn't exist until 1375 – the same year from which the first licences were available. Despite having conserved virtually all of the records, it is risky to presume the absolute inexistence of entries. Although it is likely that during the private realm, and in the first years after the return of the crown, there didn't exist such an exhaustive control of licensing and enforcement of clauses as that which was seen starting in the last quarter of the 14th century.

In spite of gaps resulting from the loss of some records, an analysis of the entries corresponding to the period between 1375 and 1408 allows you to document that the royal treasury doesn't have income proceeding from privateer activities every tax year. Furthermore, the amount of entries is extremely irregular – something which agrees with the variable nature of the tax. Therefore what is really interesting from our perspective is the royal part which was almost always stipulated on the licenses. According to negotiations carried out between the ship master and the governor himself, the amount that was going to end up in the royal coffers ranged between 1/10 and 1/40, although the most common was that which reserved 1/20 or 1/30 of the profit from the sale of loot. Figures show that the speculatively fixed rate set at 1/5 was negotiable - both on the Muslim side as well as Christian - and was closely related to the varying situation of greater or lesser endangerment in the Mediterranean. It's interesting to see how legislation developed throughout the 12th and 13th centuries and clearly demanding the surrender of one-fifth of the booty to the monarchy, was losing force while adapting itself to the Mediterranean situation. As the monarch required private naval cooperation to deal with the many open fronts in the western Mediterranean, the expectations of income from privateering were lowered. On occasion the corsair was even exempt from paying any tax.

The documents show that such percentage was applied on net benefits, after deducting the expenses incurred by the supply of provisions for the boat and the salaries of the crew, as well as any other disbursement derived from the company. However, exemptions of general character were possible for all of these. These exemptions were determined by privileges granted by various monarchs to concrete populations. An example of this would be Tortosa, whose pirates enjoyed exemption from the *quinto* in 1378, and for the natives of Ibiza who in 1406 obtained an exemption from the *quinto* of the booty for a period of 2 years – thus matching the corsairs of Mallorca and Menorca (Ferrer, 2006, pp. 312-313).

A correlation between dates and percentages reveals a progressive decrease in the percentage reserved for the royal treasury. In fact through specific news, extracted from documents from the chancellery, it is clear that by the middle of the century the tax that the monarchy was trying to charge was still the Royal *quinto* - 1/5 of the profits. The Mallorcan data doesn't reflect at any moment the already extremely high percentage, furthermore at the beginning of the 15th century the recorded amounts were 1/30 or 1/40 of the total, figures which are indicative of the clear intentions of the authorities - at least the Mallorcan authorities - to encourage privateer activity.

5. Privateering as a defensive element against muslim piracy

The attitudes of the Mallorcan authorities, aimed explicitly at promoting the privateer armaments through a decrease in taxation, are related to the progressive increase of Muslim piracy evident from the last decades of the 14th century and which took the Balearics as the preferred area of the action (Díaz Borrás, 1993, p. 58-59). A known fragment of Ibn Jaldun indicates the beginning of that boom, led by the Hafsid navy in the decade of the 1360s (1969, p. 117) - a phenomenon which, on the other hand, has been documented by several historians such as Bresc (1980, pp. 751-757).

Ibn Jaldún goes further and specifies the geographical privateering area on the Ifriqiya coast and considers Bugia as the main conciliatory focus of this boom. Catalan-Aragonese documentation confirms these appreciations and shows that from around 1370 the Hafsid pirate actions cannot be regarded as sporadic, without discrediting the Nasrid or Marinid raids. The difference is that the latter show a consistency throughout the 14th century, whereas Hafsid activity increased dramatically in the last decades of the century. Initially in a timid way, the Tunisian Corsairs were progressively increasing their areas of intervention and, from Mallorcan waters, would go into action on the coasts of Cataluña and Valencia.

The question that emerges from these findings is whether the Hafsid actions in that period were individual initiatives aimed only at achieving immediate benefits or, on the contrary, a policy of the State with some economic objectives but with destabilizing implications. We could find the answer in the same internal politics of the Hafsid Sultanate. The political conjuncture is diametrically opposite to the one that was developing at that time in the rest of Maghreb. While the Marinid sultanate was being subjected to a genuine policy of external interference – Nasrid and Castillian – and the kingdom of Tremecén was torn between the alternative Marinid and Hafsid protection, the latter witnessed, in the last quarter of the 14th century, a remarkable recovery and a restoration of the unity of the territory, up till then divided and controlled under Marinid protection.

1360 was the starting date of this recuperation. In that year Abu-l-Abbas, former Sultan of Constantine, peacefully regained his city and Marinid intervention in the Tunisian area ended. From Constantine, Abu-Abbas would initiate the task of reuniting the territory. This task materialized in the progressive occupation of Bona, Bugia, Tedelis and the capital Tunis and continued with the reconquest of Sahel, Susa, Mahdia, Djerba and Tripoli - a work consolidated by his son and successor, Abu Faris, by removing the local dynasties of Tripoli, Gafsa, Tozeur and Biskra (Brunschwig, 1982, pp. 210-216).

The question facing us is why, at a particular time and a specific juncture, this recently restored power started a policy of encouraging privateer activities. M. Fontenay, referring to Berber piracy in the 17th century, points out that this had earlier roots that revealed an early peripheralization of the Western Muslim area. This peripheralization would be reflected later in the modern era by an increased intensity of the Berber Corsair phenomenon in relation to piracy exercised by other Mediterranean areas such as Malta, Sicily, Tuscany and Monaco – clear evidence of the inequality of development that existed between the north and the south. On the other hand, in a general way privateering would be a response to specific difficulties, since that ensured the inflow of cash and animated the economic life thanks to the market of arms and seizures. Moreover, Fontenay has the impression that privateering, far from being harmful to the European economy, was an element of enrichment, a sort of accelerator of the movement of goods and, for the same reason, a means of responding to the depressive tendencies of the market in the 17th century (1986, pp. 116-121).

From this perspective, if we go back to the 14th century we can see that the Muslim corsair boom took place at the time of the reunification of the Hafsid state under the direction of Abu-l-Abbas - reunification that could not be carried out without an important source of cash that would help to defray all the expenses inherent to such an action of this nature. The economic structure of the North African sultanates conditioned that the greater part of government revenue came from direct and indirect taxes on trade with European powers, not so much from the activities of the country itself whether agricultural, pastoral or handicraft. The benefits from the pirate activities promoted by the sovereign implied a substantial injection of cash garnered from the direct sale of the booty or from taxes on the sale of the seizures. These earnings helped to defray the expenses incurred by the recruitment of mercenaries and equipment etc. in the successive military campaigns promoted by Abu-l-Abbas aimed at the reunification the country. Therefore the first goal of this piratic boom, rather than a destabilizing one, would be as a provider of monetary funds at a time when some extraordinarily high expenses were exceeded the flow of income.

In this sense Brunschwig (1982) points out the apparent constant attempts of the Hafsid sovereign to prohibit piracy and only promote privateering against potent vessels not protected by a peace treaty. This signified a clear attempt for control of power. Ultimately piracy always involved a considerable dose of autonomy; corsairs, on the other hand, were controllable and could be manipulated. Taxation therefore, whether Christian or Muslim, was inherent in the pirate activity and its degree of permissiveness would be in close relationship to some provisional needs of the State.

Regardless of the causes, what is clear is the relationship between the progressive increase of the Muslim presence in the waters of the Crown of Aragon, especially on the islands, and the progressive decrease in rates of tax on apprehensions required by the Mallorcan corsairs.

The difficulties in proceeding with an effective defence subsidized by royal representatives would encourage the provision of services for Corsair enterprises as a substitute defensive system. That would also explain the absence of fiscal revenues in Mallorca in specific years, as has been revealed earlier. It also seems to confirm that the lowering of costs of maritime defence was the main purpose of the legalization and promotion of Corsair activities by the public authorities - a goal that was already being observed due to the serious armed conflicts in the middle of the 1300s with Genoa and Castile.

Did this decline continue through the 15th century? It's not possible to answer this question yet. It will be necessary to wait for the possible responses that Mallorcan archives might provide in the future.

6. Some provisional conclusions

The 13th century was an essential period in the shaping of the regulations that governed privateer activities in the crown of Aragon. Once the legislative body was established it would take somewhat longer for the practice to be implemented. In Mallorca, the case chosen as example, privateering was established as a complimentary industry of the commerce probably just shortly after the Christian conquest of the island. The creation of an 'independent' Kingdom from 1276 no doubt offered a framework for particular development to the corsair enterprises. That year followed the death of Jaime I when the archipelago was left to his second son, Jaime II of Mallorca in accordance with the will. The fiscal reforms undertaken by the monarch at the beginning of the 14th century that intended to increase the royal income don't seem to have been reflected in the Corsair tax. It is true that it is a period that we still do not know much about, but instead asks us to wait for the second half of the century when the islands were reincorporated under the Crown of Aragon before a true and effective control of the corsairs was imposed.

That is a control of the legality of the activities and not so much a fiscal control. Obtaining a licence and the provision of guarantees would be essential in order to be able to practise as a Corsair, but there were never any definitive reasons to exclude the existence of transgressions. Undoubtedly they existed. The barrier between privateering and piracy is, in far too many cases, very fragile and the lust for profit made corsairs frequently forget the provisions laid down in the permits and they would find themselves acting as real pirates. The authorities tried to control these infringements, always with the goal of defending diplomacy and the interests of the merchants - the main 'receivers' of the repressive measures of the sultans (Ferrer, 2005, pp. 119-126). It was an attempt to eradicate uncontrolled piracy, not the legal corsair. The interest of the monarchy changes according to the conjunctures: strictly economic, through taxes, in times of 'peace' and as a defensive substitute or complementary method in times of open military conflicts or increased Muslim raids. In the latter case, the defensive function of privateering starts to play an important role from the outbreak of one the numerous wars of the 14th century – that between the crown of Aragon and Genoa in the 1350s – and was consolidated during the War of the Two Pedros. But it would be the increase in Hafsid piracy, in the last thirty years of the century, that would explain the enormous importance played by the Mallorcan corsairs to the essential defence of the island, and that would explain the waiving of part of the revenue from taxes by the monarchy.

Acknowledgements

This text is the result of the researches done within the framework of the Medieval and Post medieval Archaeological Research Group. [Grupo de Investigación en Arqueología Medieval y Postmedieval GRAMP-UB (2009SGR-00469)], subsidized by La Generalitat de Catalunya.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 23 - 28

ISSN: 1697-4040, www.jmr.unican.es

Technical Management of Guarantee as Part of Quality Control in Construction of a Ship

A. Dionis[1,2,*], S.L. León[1,3], F. Padrón[1,4] and M.C. Adrián[1,5]

ARTICLE INFO

Article history:
Received 30 June 2013;
in revised form 15 July 2013;
accepted 30 September 2013

Keywords:
Ship building, Management, guarantee.

ABSTRACT

Nowadays, the buying and selling of manufactured goods and associated services are sufficiently regulated so that the buyer (a private, commercial or industrial customer) is protected from the quality and performance of the goods or services purchased or hired. This coverage, generally called "Guarantee", is fixed by national laws and regulations of international application.

In the naval industrial sector, the implementation of the "Technical Guarantees" are those that the builder gives about the features, benefits and condition of the ship and all the equipment, responding to manufacturing defects and compromising the replacement of parts and equipment damaged during a period of time. These guarantees should be clearly stipulated in the contract.

Just keep in mind that the great majority of products and equipment are manufactured and massively distributed to the market. However, for Shipbuilding Industry, many of the materials supply and service are unique and are tailor-made. The construction and delivery of a ship is a special case and complex of industrial supply. Therefore, the management of the technical guarantees after the construction and delivery of a ship owner provides clear advantages that have to be object of special study.

1. Introduction

Management of Technical Warranty inside the naval industry is done on equipment, parts and services related to those goods. Manufacturers and sellers of goods and services are responsible for translating legal guidelines to safeguard quality (assurance) in its general conditions of sale and service, but add other particular conditions agreed between seller and buyer, reflected in four main sections.

— The agreement for the construction of a ship is formalized through the Construction Contract. It is a commercial document which specifies the terms and conditions of the purchase and sale of the ship, between the ship-owner and the shipyard.

— The second part to consider is the Quality Approach in the Project, where the owner, in defense of their interests, should do a quality approach adapted to the project.

— In the third paragraph, must take into consideration the General Aspects of the Warranty. In any contract for construction of a vessel a section on techniques is associated guarantees the fulfillment of customer expectations has to appear.

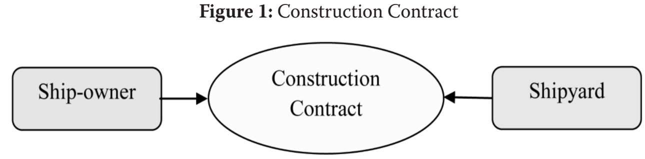
Finally, it is required to have a formal procedure and document database to collect the entire procedure Management of the Technical Guarantees.

2. Development

2.1. Construction contract

As mentioned above, the construction of a ship is formalized through the construction contract, which specifies the terms and conditions of the transaction for the sale of an asset, in this case of a ship between the ship-owner and the shipyard that builds.

Figure 1: Construction Contract



Source: Authors

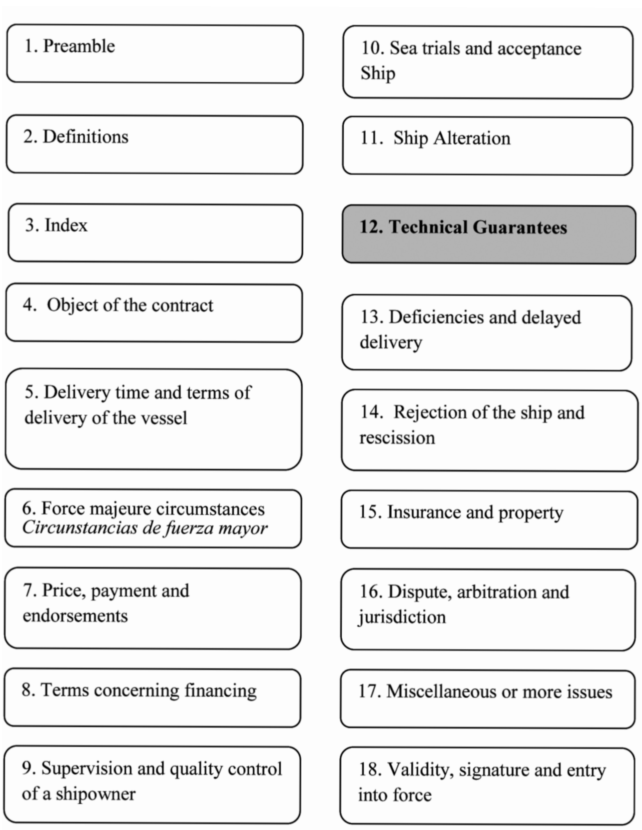
[1] Dpto. Ingeniería Marítima, Univerisity of La Laguna. Avenida Fco. La Roche, s/n, 38001, S.C. de Tenerife, Spain. Tel +34922319831, Fax +34922319830.
[2] Researcher, Email: adionis@ull.edu.es, Tel +34626444030.
[3] Researcher, Email: luis@opdr-canarias.com,
[4] Researcher, Email: fpadron@ull.edu.es.
[5] Researcher, Email: madriang@ull.es.
[*] Corresponding author.

It is obvious that the construction of a ship starts with the signing of the contract. However, before the firm has taken a more or less long technical definition, preliminary and pre-negotiation process, which typically involved the owner, shipyard, engineering, suppliers, consultants, management flag, classification society, etc. The contractual relationship is terminated when all the issues related to it are resolved and well accepted by both parties.

The contract can be public or private, although the first mode given the high turnover figures and advised risks involved.

A standard shipbuilding contract usually consists on the following sections:

Figure 2: Sections of a Construction Contract



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We can shortly describe each of the sections of the Construction Contract the following way:

1. **Preamble:** Confirm the identity of the parties and the attorneys appointed to execute the document is signed.
2. **Definition**: Set of key words and terms that appears in the text.
3. **Index**: List of contents of the contract document.
4. ***Object of the contract:*** The scope of supply is defined corresponding to the price paid. Basically, the ship building, main technical features and benefits are defined. Mention is also made to the *"Detailed Technical Specification"* included in an annex that part of the contract.
5. ***Delivery time and terms of delivery of the ship:*** Includes the timing of production milestones (entry into force of the contract, the first steel cutting, keel laying, launching and delivery), the supply conditions of the ship and the port of delivery ship-owner.
6. ***Circumstances of force majeure:*** Circumstances are mentioned, under which the seller can extend the delivery within agreed upon notice and justification of such circumstances and with a ceiling agreed by both parties.
7. ***Price, payments and guarantees:*** First, the contract price is set, if fixed or variable (usually motivated by unfavorable commodity market, equipment or wages) and default interest. Moreover, the plan rhythmic partial payment to production milestones mentioned above is detailed. Finally, it specifies how they are to be generated and exchange guarantees mutual guarantee both parties, in anticipation of the damages that may be caused to a party for breach of the other.
8. ***Funding conditions:*** If it were the case that the shipyard act as an intermediary or facilitator credit from external financial institutions should reflect the terms agreed in the contract.
9. ***Supervision and control their own quality of owner:*** In this section the right of the owner to locate formalized at the shipyard throughout the construction and a team of technicians who will exercise control and approval of the construction as it progresses. Moreover, the law also provides for moving the shipyard before the vessel is a crew or any part thereof for the purpose of familiarization.
10. ***Sea trials and acceptance Boat:*** Sea trials are fixed once the ship has adequate seaworthy. These tests must attend shipyard representatives, shipowners, classification society and independent experts involved in the project. The media and risk tests run by the shipyard. If the tests are successful, a protocol signed by authorized parties and forcing the acceptance of the shipowner shall be developed. If during testing a compromising fault occurs, the test shall be suspended and shall be repeated once repaired the malfunction or mishap.
11. ***Ship Alterations:*** Modifications of the project under contract proposed by the builder or owner, and agreed to be agreed conditions and impact on contract commitments before being made. Basically delivery, characteristics and finals technical performance.
12. ***Technical guarantees:*** Those giving the builder about the features, performance and condition of the ship and all its equipment, responding to manufacturing defects and compromising replacement parts and faulty equipment for a period of time.
13. ***Deficiencies and delays in delivery:*** The delivery delay and the appearance of certain deficiencies linked to production and design, tends to go hand penalties, awards, rejection or renegotiation of the ship. Some typical aspects penalize-reward, are the delivery, the vessel's speed, the specific fuel consumption and capacity.
14. ***Rejection ship contractual termination:*** In this section is mentioned the lives of both parties (rights and

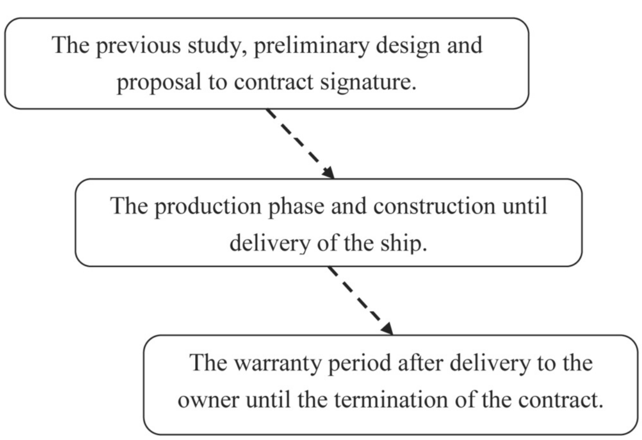
obligations) in the event that the owner rejected the supply boat under the application of any contractual clause.

15. ***Insurance and property:*** It will document that the ship will be property of the ship yard until the delivery date, in which the buyer will become the owner. Until then, all the responsibility on the ship it will be of the shipyard. In this section, must be realized actions to take by both parties in case of partial or total loss of the vessel prior to delivery.
16. ***Dispute, arbitration and jurisdiction:*** It is contemplated in this section how to be resolved disputes among the parties, as a result of the different interpretations of the contract.
17. ***Miscellaneous or more issues.*** In this section it will be included those minor issues, scattered, previously untreated, but which affect the contract will be included. For example, the endorsement of the contract to another shipyard, patents and intellectual property rights.
18. ***Validity, signature and entry into force:*** This is the page that shows the agreement, goodwill and date of entry into force of the contract, by the signatures of the parents.
19. ***List of contents of annexes which form part of contract:*** Detail Specification of the ship. It is the block, most voluminous of the contract, includes lists of suppliers agreed and documents delivery; acceptance certificate for the owner, list of supplies that directly provides the owner, etc.

2.2. Quality approach in the project

The shipowner, in defense of their interests, should do a quality approach adapted to the project. This scheme must consider three stages:

Figure 3: Quality approach in the project



Source: Authors

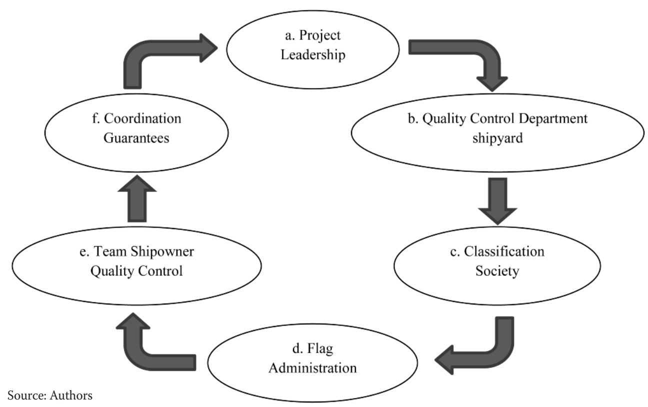
The initial stage of **study and preliminary,** usually a period fraught with many technical and commercial discussions, not without formalism and rigorous technical protocol, with a view to achieving a final project proposal.

The phase of, manufacturing and delivery is it consumes more time and resources, while requiring multiple and rigorous monitoring tools to try to ensure project quality.

It should be remembered that the contract usually not resolved with the delivery of the vessel to the shipowner. After this milestone, must be dealt the final stage of "guarantee" for which the means is advisable also arbitrate.

To carry out these three stages, the approach of quality should have different control mechanisms based on the following elements:

Figure 4: Control Mechanisms.



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These control mechanisms must begin with th*e leadership of the project from the ori*gin of the idea and throughout the preliminary stage. It must have a project leader able to combine proposals to meet the expectations of the shipowner.

The Quality Control Department shipyard, acts as entity's internal control over activity by the production department and ensure technical purity in the implementation of the project with the technical specification.

The Classification Society is chosen by the shipowner and its main role is focuses on advising, control, monitor and implement appropriate corrective actions for the project to comply with the rules of its own classification in order to get rated and certified class.

Administration flag, depending on the legal powers conferred and under the international commitments made by the state that it represents, must monitor compliance with national and international standards as far as safety and navigability concerns.

When a ship is built in a foreign country, the flag Administration itself usually refers to a recognized organization (Classification Society) as an entity authorized to act on behalf of the same and issue provisional statutory certificates.

Team quality control shipowner is formed by a group of technical specialists (Team Leader and supervisors hull and structure, mechanical assemblies, electrical assemblies and supervisor of paintings) moved permanently to the yard during the time of manufacture, exercise direct control of compliance of the project, on the fly, defending the general interests of the owner and, in particular, the standard of care is respected project.

Finally, there must be Coordination of Guarantees which will manage the final contractual phase. To do this, you must involve office staff of the shipping and the crew itself.

2.3. General aspects of the guarantee

In any contract for construction of a vessel a section devoted to the technical guarantees appears. In drafting the whole contract the text and in particular with regard to the guarantee should participate Management, Risk departments and Technicians plus an external consultant to review contrast.

By the supplier or manufacturer, technical guarantee is associated with the fulfillment of customer expectations. In this sense, the guarantee is offered to purchasers of equipment and property as an added value to their products.

If that occurs the delivery (the good, ie the ship) with outstanding deficiencies, their resolution will not be against the amount allocated to guarantees, unless timely agreement.

It is common practice to set a total economic amount, which constructor takes a maximum guarantee value. That amount can be given direct monetary value or percentage of contract value.

The warranty period starts from the date of delivery and acceptance of the vessel.

The seller must ensure that the ship and all its systems and equipment will operate without failure for a specified time that is generally 12 months from the date of delivery and acceptance. During that time is required to repair faults and correct defects not known by the shipowner at the time of delivery, as are design defects, incomplete work or improperly made, poor quality, faulty materials, etc. Generally not liable for failures resulting from misuse, negligence, accident or lack of maintenance. The responsibility is usually limited to repairing or replacing parts or pieces of the hull structure, machinery and equipment of the ship.

For guarantee repair work performed by the shipyard or authorized agent is used to give an additional guarantee of 6 months, but with a maximum of 18 months from the delivery and acceptance of the vessel.

If to consider a warranty repair that requires input in shipyard causes great inconvenience to the buyer (eg by remoteness), by agreement or judgment of the owner, a shipyard will be selected in the normal work area to make the ship repair. After repair, the original invoice by warranty refers.

Any guarantee claims must be communicated to the shipyard and delivered a copy to the engineer onboard warranty, if any. Usually prescribed that since the problem is detected until it is communicated to the yard, must not spend more than 14 days.

After a warranty claim, as required, by agreement, may be resorted to the services of an independent surveyor in order to check the problem. Based on its report, the shipyard may accept or reject the claim. If yes, proceed to the repair.

To a fault arising under warranty, usually stated in the contract that the seller is not responsible for lost profits, detention of the ship, crew costs or other consequential damages.

At the request of the buyer, the shipyard reports the warranty conditions given by the various subcontractors. Moreover, these conditions usually endorse the shipowner but always under the minimum requirement of 12 months from the delivery of the boat.

It is normal for the buyer and subcontractors can resolve the guarantees arising directly, always informing the shipyard and understanding that this does not relieve the seller of its ultimate responsibility for technical guarantee. This possibility of resolution is an advantage for the owner as all claims resolved directly by the manufacturer of the equipment does not reduce the amount of collateral agreed with the shipyard. If a manufacturer rejects a claim despite the opinion of the owner, finally, could claim the shipyard.

If the ship was paralyzed on his holding to repair a under warranty problem, the shutdown period would not count for the purposes of the same for all the equipment and be added to the initial guarantee period.

The shipyard may designate and maintain on board an engineer qualified warranty for some time, but now is not a common practice and often contemplate how discretionary but not mandatory shipyard for cases of ships with special features or complex projects.

Typically require that parts or components defective, which would have been replaced under warranty, must be kept on board during the warranty period in order to subject them to study if necessary to resolve the claim.

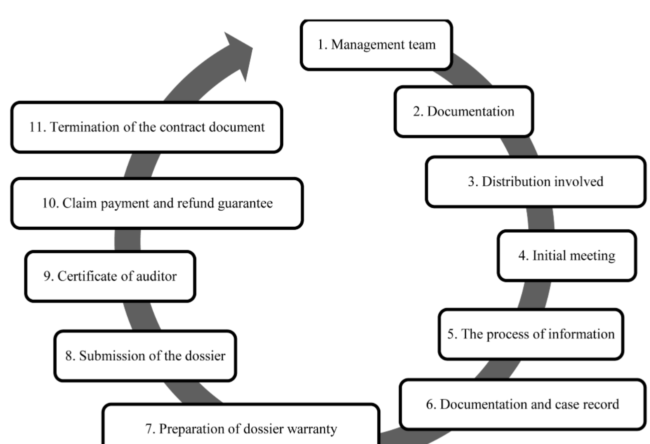
All costs of providing warranty parts (transport, forwarding, taxes...) borne by the shipyard, manufacturer or subcontractor.

After all the warranty period (standard is 12 months), you must specify the documents needed to settle the set of all warranties (guarantee by the dossier) time limit to complete the dossier, if intervention is necessary an independent auditor to evaluate and settle the acceptance or rejection (service paid by the yard).

2.4. Management procedure technical guarantees

A successful "management of guarantees" bring benefits to the ship and the company. To achieve this purpose, required to have a formal procedure and document database. This proce-

Figure 5. Method of managing technical guarantees.



Source: Authors

dure assumes all contractual provisions devoted to technical guarantee.

Additionally, the guidelines that staff must follow the shipping for the proper management of the guarantees will be incorporated.

We then propose the main components and basic lines of this management model:

1. ***Management team.*** It is usually formed by a coordinator based in the office of the shipping and communications manager with the shipyard, and Captain, responsible for the ship
2. ***Documentation match.*** Must have at least an updated construction contract, the Act of delivery and acceptance of the ship and the list of deficiencies, if any.
3. ***Writing and distributing the text of the written procedure.*** This procedure should be developed at the time the construction contract. It should be a permanent and improved standard within the company.
4. ***Initial meeting*** between the coordinator and commanders ship after delivery of the vessel, to instruct the crew answer questions of procedure and set management objectives, which are:
   – Resolution of all problems classified as claimable under warranty.
   – Document all actions to develop the dossier warranty.
   – Resolution of the list of outstanding deficiencies, if any.
5. ***The process of information.*** In the process, they have vital information flows. In this regard, we distinguish the following:
   – Communication of the ship. Essentials ship building number, delivery date, description, date of detection of the problem, date of submission, etc: before a warranty issue, a format designed to incorporate be completed.
   – Communication to the yard and / or subcontractor. It will confirm whether the present case is appealable to the warranty or not.
   – Response shipyard-subcontractor: Additional information, further clarification, support, spare parts.
   – Performance and problem resolution. Archive of all related records: working parts, supply slips, photos, reports, etc.
6. ***Documentation and record of the case.*** While each claim is closed, all related documents are saved as part of the final record of warranty claim.
7. ***Preparation of record of warranty.*** The final and complete record of the shipyard guarantee claims must contain at least the following: cover letter, complaint and request for acceptance led to the independent auditor. A summary of all cases that claim table. Copies of the Act or Protocol delivery and acceptance of the ship, the endorsement of guarantee provided by the shipyard, construction contract, the signature and entry into force of the contract, the contract section on technical guarantees, and for each case, communication complaint to the yard and all documents that support it, including original invoices generated.
8. ***Transfer of the case to an auditor at the end of the warranty period.*** After all the warranty period, should be designated an independent auditing company by mutual agreement by both parties, to rule on cases claimed warranty.
9. ***Auditor's certificate.*** The auditing company (chosen with mutual acceptance of shipowner and shipyard) must evaluate the dossier, request clarification or additional documents and finally issue a certificate related cases and those not accepted..
10. ***Claim for payment to the shipyard and refund guarantee.*** From here, the shipyard must pay the owner the amount claimed warranties accepted..
11. ***Termination of the contract document.*** Once the owner has received payment, was the last formal act referred to in the contract: the return of a guarantee to the shipyard and the signing of the termination of the contract document.

3. Case study

Actual experience indicates that the adoption of a formal, systematic, documented process for managing the technical guarantee after the construction and delivery of a ship owner provides numerous advantages. Without going into a detailed analysis of different cases and different factors, we can say that the inclusion of warranty management within the approaches of project quality and, moreover, the accommodation of this management to a rigorous procedure, make a difference between a system of quality management and casual. As an example, below a case control deficiencies and resolved guarantees:

Table 1: Case Study.

CONTROL DEFICIENCIES RECEIVED and GUARANTEE SOLVED Ship 1 and 2 Guarantee management procedure implemented Ship X without guarantee management process implemented				
DEFICIENCIAS	**Equipment**	Ship 1	Ship 2	Ship X
	Hull	20	2	1
	Machinery	15	0	1
	Electrical	16	0	1
	Painting	1	1	0
	Total	**52**	**3**	**3**
	Resolved by:			
	Subcontractor	46	0	3
	Shipyard	6	3	0
	Total	**52**	**3**	**3**
GARANTIAS	**Equipment**	Buque 1	Buque 2	Buque X
	Hull	15	8	3
	Machinery	63	64	15
	Electrical	54	53	11
	Painting	2	0	0
	Total	**134**	**125**	**29**
	Resolved by:			
	Subcontractor	93	85	3
	Shipyard	41	40	0
	Total	**134**	**125**	**3**

Source: Authors

4. Conclusions

- The owner is always in control of the management of guarantees against the shipyard or subcontractors.
- Reset faults are rectified and the condition of the ship according to the initial expectations of the owner.
- Replacement costs are recovered optimally, without formal fissures and making the most of the item or contractual warranty clauses.
- It helps to correct faults in other sister ships in quasi - simultaneous construction and before delivery to the owner.
- You can help improve the text of the contract for future projects.
- The crew awareness in detecting and reporting failures and shortcomings.
- During the warranty period , in principle , every problem is treated as claimable , however insignificant.
- Knowledge about the process is sped up the ship by the crew.
- The ship is refined and, in turn, reveals weaknesses to consider in the future exploitation.
- Assumes a plus for insurers and P&I Club.
- Starts and establishes contact with equipment manufacturers , facilitating future relationship.
- Help to make an initial assessment of equipment manufacturers as usual suppliers.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 29 - 36

ISSN: 1697-4040, www.jmr.unican.es

Parameter Estimation and Control of an Unmanned Underwater Vehicle

F. J. Velasco[1,3,*], E. Revestido[1,4], F.J. Lastra[1,5], J.M. Riola[2,6] and J. J. Díaz[2,7]

ARTICLE INFO

Article history:
Received 03 July 2013;
in revised form 18 July 2013;
accepted 04 October 2013

Keywords:
Parameter estimation, manoeuvring model, heading control, line of sight.

ABSTRACT

In the present article, based on a specific set of trials carried out in the CEHIPAR model basin, a parameter estimation of a torpedo-shaped underwater vehicle is performed. A complete modelling of the underwater vehicle is performed considering the dynamics of the vehicle and its actuators with data acquired in the model basin. Thanks to the obtained model, a heading controller is designed and tested in a guidance system for a manoeuvre defined by way points.

1. Introduction

The use of unmanned vehicles, in the naval field, is widely known in the scientific world, but it is the military and security, sectors that are moving this technology forward in recent years. Fleet formation constitutes one of the basic requirements for the design of a new generation of ships that will be employed in various missions such as mine clearance (Riola and Diaz, 2009) pathways, anti-submarine warfare, perimeter defense, surface warfare, support for special operations forces, etc.

The incorporation of unmanned vehicles to the Defence sector have contributed to the state of the art of unmanned systems (Riola, 2011) for hazardous or high-risk missions, such as tracking, detection and neutralization of mines. Today, the AUV-UUV are of paramount importance, for both defence and civilian applications and procedures for underwater exploration.

It is of great importance in naval construction to obtain as accurate as possible a mathematical manoeuvring model. This requirement is also of paramount importance in motion control applications in which, if the mathematical model used for the control design is not accurate when considering the operational conditions of the vehicle, or if external disturbances exist, it is difficult to tune the controller for a good behaviour of the vehicle.

The aim of this paper is to obtain a mathematical model based on the trials developed in the CEHIPAR installations for the design of a heading controller. The controller is tested in a guidance system for a manoeuvre defined by a sequence of way points.

2. Dynamic behavior of a vehicle

One of the challenges of this paper is the modelling of the dynamic behaviour of an underwater vehicle. To do this, we use a commercial torpedo-shaped vehicle, property of the University of Cantabria (UC), to carry out trials in the ("Canal de Experiencias Hidrodinámicas de El Pardo", CEHIPAR) model basin to determine the parameters of the mathematical model that describes the dynamic behaviour. This section describes the most important elements of the underwater vehicle hardware, and the tests/trials that have been conducted. It also outlines the sea trials performed that verify the dynamic behaviour characteristics of the vehicle obtained in the model basin.

[1] Dept. Electronic Technology & Systems Engineering a nd Automatic Control, Univ. Cantabria. E.T.S. de Náutica, C/ Gamazo 1- 39004 Santander (Cantabria) Spain.
[2] Under-Directorate for Technology and Innovation (SDGTECIN-DGAM);
[3] Email: velascof@unican.es.
[4] Email: revestidoe@unican.es.
[5] Email: fjlastra@tesia.unican.es
[6] Email: jriorod@fn.mde.es.
[7] Email: jdiaher@ext.mde.es.
[*] Corresponding author.

2.1. Unmanned underwater vehicle

The torpedo-shaped vehicle property of the University of Cantabria is shown in Figure 1, it has a maximum length of 1.65 m and a radius of 0.17 m. It weighs 35 kg and has a maximum speed of 6 knots. The bow shape is a hemisphere and has an aft cone with four flat stabilization surfaces. The thrusters have two longitudinal axes that are spaced from the axis of the cylinder 0.36 m. In the central area, it has a vertical propeller and a security mass. The vehicle is autonomous and the power generation system is based on a set of Li-poly (lithium polymer batteries) batteries that provides a range of approximately 1 hour at a speed of 3 knots or 2 hours at a speed of 2 knots.

Figure 1. Torpedo-shaped vehicle (C´Inspector, Kongsberg).

Source: Authors

Propellers commanded by electric motors make up the propulsion system. Two propellers are located in the centre of the vehicle at both sides, for surge and yaw motion. These propellers are mounted within fixed nozzles. The yaw motion is performed by acting on the port or starboard propeller with different numbers of RPM or an inverse number of RPM. A third propeller is also located in the centre of the vehicle perpendicular to the other two horizontal propellers for the depth control. The pitch movement of the vehicle is achieved by displacement of an internal mass in the rear half of the vehicle.

A summary of the variables that define the motion of the vehicle and the sensors used in the measurement is shown in Table 1.

Table 1. Variables and sensors.

Symbol	**Measurement**	**Sensor**
Ψ	Heading	Accelerometer
θ	Pitch	Accelerometer
Φ	Roll	Accelerometer
z	Depth	Pressure sensor
N port	RPM port propeller	Tachometer
N starboard	RPM starboard propeller	Tachometer
Vert. Prop.	Vertical propeller	Tachometer
Pos. Mass	Mass position	Potentiometer

Source: Authors

Furthermore, the vehicle provides a side scan sonar (single beam), which is used to perform seabed inspection functions.

The communication with the vehicle is performed through a fibre optic cable that carries data bidirectional. Thus, the operator is able to remotely control the vehicle through the "Human Machine Interface" (HMI), either by commands from the keyboard or using a joystick control unit. For the position of the vehicle, the vehicle provides a "Wideband Acoustic Positioning" (WAP) system that includes a GPS antenna with three hydrophones, which must be submerged at least a meter deep.

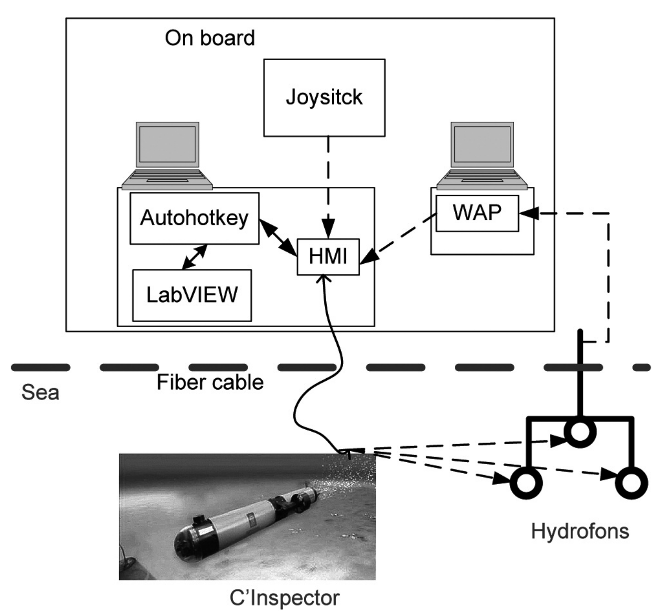
2.2. Sea trials

The construction of a marine vehicle involves the performance of different standard manoeuvres or sea trials (Lewis, 1998). Through them, in addition to evaluating their robustness, it highlights the potential limitations of the control system and the behaviour of the vehicle in emergency situations.

Data from sea trials can also be used for identifying a mathematical model of a vehicle dynamics (Perez et al, 2007; Perez and Revestido, 2010). That is why software has been developed in this work to capture data from the various instruments of the vehicle and to carry out standard manoeuvres automatically acting on the propulsion. In this particular case, Autohotkey free software (Mallet, 2013), which allows the emulation of the data entered via the keyboard, was used. In this way, it is possible to enter commands using the software provided by the Kongsberg company through another software implemented using Autohotkey to act on the propulsion.

The main purpose of the Autohotkey application is to act on the propulsion and capture data from the instruments on board the vehicle. In this way, this application can be used in control loops for motion control. Moreover, the application developed in Autohotkey can be integrated into other programming environments such as LabVIEW (Bishop, 2004).

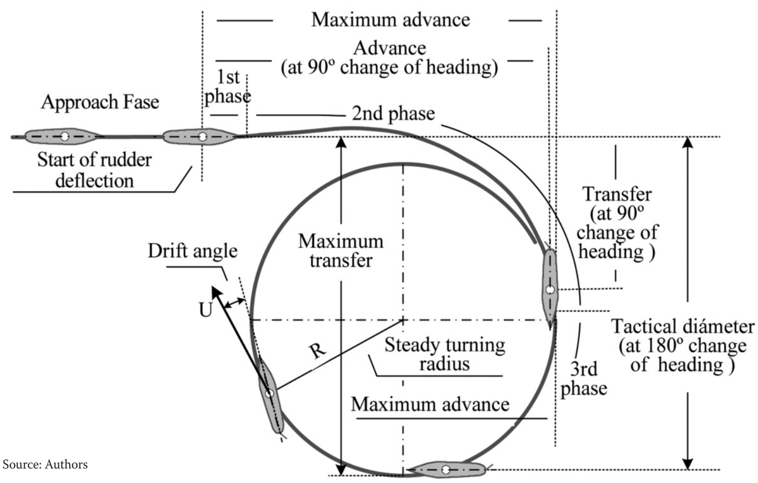
Figure 2. Software integration with the underwater vehicle.



Source: Authors

The sea trials proposed by the International Towing Tank Conference ITTC (2004) and summarized in the article Lopez et al. (2004) include, among others, the turning circle manoeuvre, which is used to calculate the radius of curvature of the vehicle and also to check the behaviour of the propulsion system in change of course manoeuvres. Figure 3 shows the various stages of this manoeuvre, which, due to its simplicity, can be done manually using the joystick unit control.

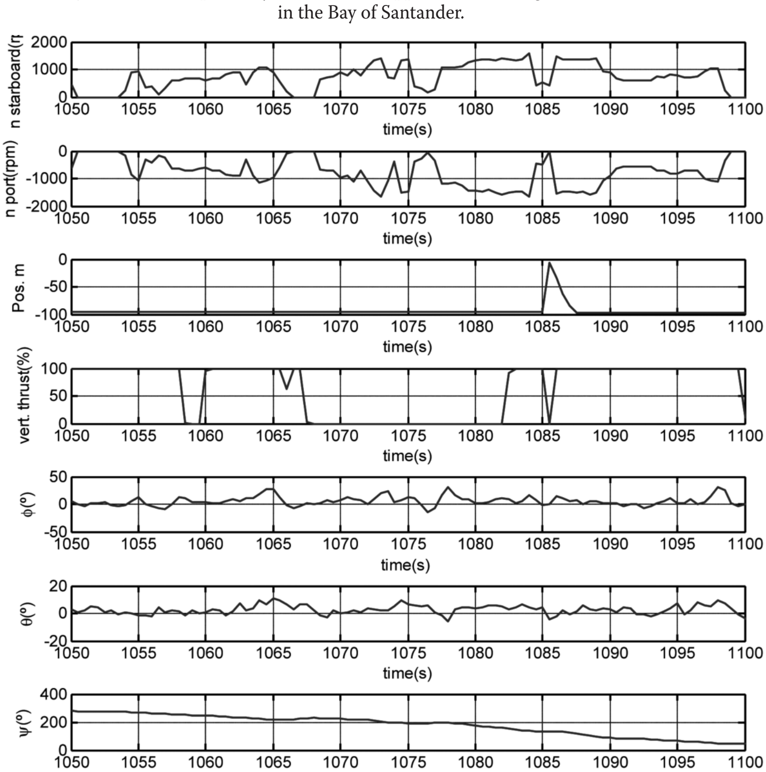
Figure 3. Turning circle manoeuvre.



Source: Authors

From the above, thanks to the tool developed, the results are given in Figure 4.

Figure 4. Data acquired by the software support for a turning circle manoeuvre in the Bay of Santander.



Source: Authors

2.3. Mathematical model

Underwater vehicles move in six degrees of freedom (DOF). In order to describe the vehicle motion, three translational coordinates are needed and another three to define the orientation. Two coordinate systems are used to study the vehicle movement: one coordinate is fixed to the vehicle and is used to define its translational and rotational movements and another one is located on Earth (inertial) to describe its position and orientation.

The 6 DOF nonlinear manoeuvring model can be expressed in the following form (Fossen, 1994, 2002):

$$M\dot{\upsilon}+C(\upsilon)\upsilon+D(\upsilon)\upsilon+g(\eta)=\tau$$
$$y=\eta+w,\ \dot{\eta}=R(\eta)\upsilon, \tag{1}$$

where $\eta=[x,y,z,\phi,\theta,\psi]^T$ is the position and Euler angles vector, $\upsilon=[u,v,w,p,q,r]^T$ is the linear and angular speeds vector, $\upsilon=[X,Y,Z,K,M,N]^T$are the forces and moments and w is the measurement noise. M is the added mass matrix, $C(\upsilon)\upsilon$ is the Coriolis term, $g(\eta)$ is the restore matrix and $R(\eta)$is the rotation matrix.

The hydrodynamic damping forces are a combination of lineal and nonlinear damping:

$$D(\upsilon)\upsilon=D_l\upsilon+D_{nl}(\upsilon)\upsilon \tag{2}$$

In the present work, an unmanned vehicle (C'Inspector) is used, in which three engines are mounted: two horizontal ones located at the centre of the vehicle for the surge and yaw motion and a vertical one for depth control. The movement of an internal mass achieves the pitch motion. Thus, the thrust can be expressed as:

$$T=\rho D_h^4 K_T(j_0)n|n|(1-t) \tag{3}$$

where ρ is the water density (1000), D_h is propeller diameter, n are the propeller revolutions per second, t is the thrust deduction factor (typical values of 0.05 to 0.2) and K_T is the dimensionless coefficient (Fossen, 1994). Based on the thrust equation (3) and yaw moment, the following expression is obtained:

$$\begin{bmatrix}\tau_{x,th}\\ \tau_{N,th}\end{bmatrix}=\begin{bmatrix}1 & 1\\ d_p & -d_p\end{bmatrix}\begin{bmatrix}T_p\\ T_s\end{bmatrix} \tag{4}$$

where $\tau_{x,th}$ is the surge force, $\tau_{N,th}$ is the yaw moment, d_p the distance from the centre of the vehicle to the propeller, T_p is the starboard thrust and T_s is the port thrust. Furthermore, if the roll angle $\Phi\neq 0$, the following equation must be taken into account:

$$\tau_{M,th}=-\left(T_p-T_s\right)d_p\sin(\phi) \tag{5}$$

As a result, the forces generated by the thrusters and the pitch actuator are $\tau = [\tau_X, 0, \tau_Z, 0, \tau_M, \tau_N]^T$.

2.4. Parameter estimation

This section summarizes the tests that were performed in the CEHIPAR for the parameter estimation of the mathematical model defined above. Figure 5 illustrates the assembly of the C'Inspector vehicle in the CEHIPAR installations.

This assembly has a measuring table, on which two cylinders that hold the vehicle is mounted. These cylinders are commanded by electric motors. The cylinders are of the screw type, to provide high precision in the movement. The measuring table is mounted in a system that moves along the CEHIPAR flat-water basin. Before all these basin trials, it was necessary to determine the moments of inertia, the centre of gravity and centre of buoyancy of the vehicle. The values obtained can be found in Table 2, including the weight values with and without security weight.

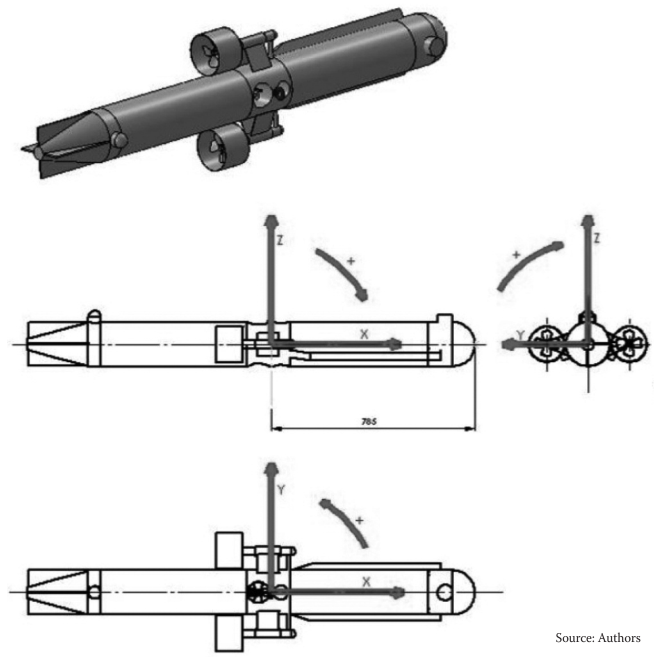
Table 2. Weight distribution.

	Security weight	
	with	without
Weight (Kg)	33	34,34
x_g (m)	0,184	0,167
z_g (m)	-0,012	-0,012
I_{xx} (kg m^2)	0,287	0,29
I_{yy} (kg m^2)	7,105	6,945
I_{zz} (kg m^2)	7,233	7,073

Source: Authors

All the estimated parameters are referred to a given orthogonal coordinate system clockwise centered on the axis of the cylinder at a distance of 785 mm from the bow end of the vehicle (at the height of the eye bolt fastening hole located between the vertical thruster and the equalizing orifice). The X-

Figure 6. Coordinate system.

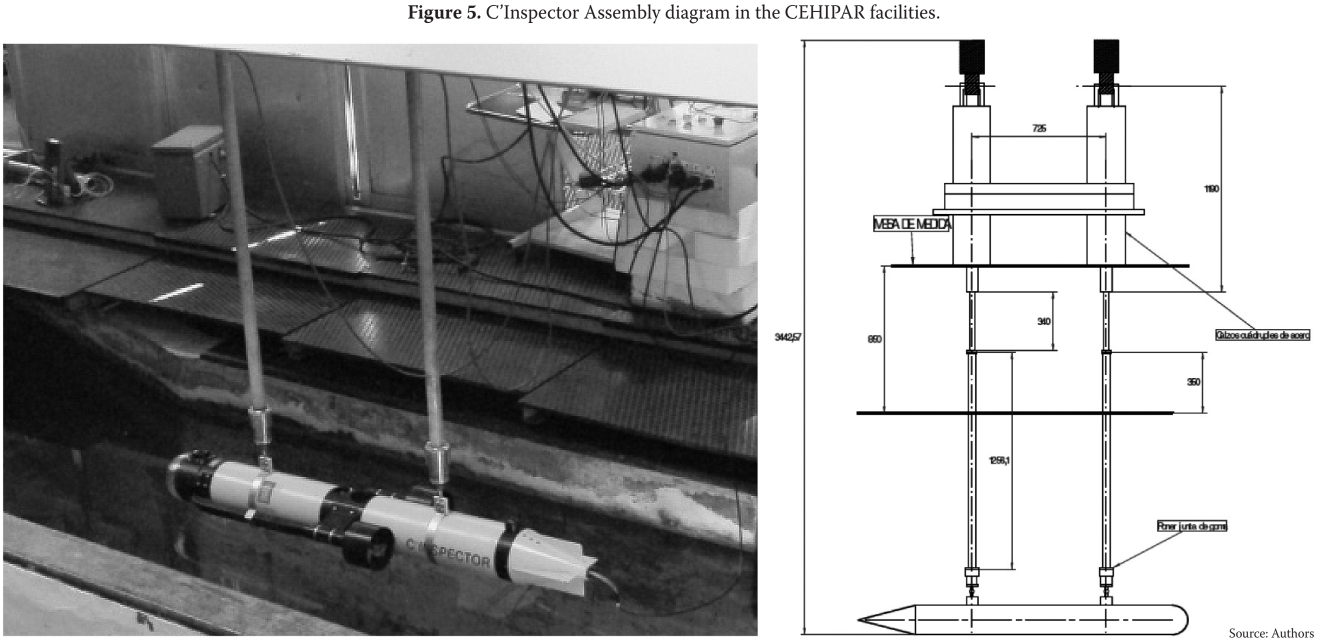


Source: Authors

axis is directed towards the bow, the Y-axis is directed to port and the Z-axis is directed upward, see Figure 6.

The different trials carried out were the following:
— Towing at different speeds.
— Static drift.
— Static pitch (as above but with the vehicle rotated 90°).
— Dynamic roll.
— Dynamic pitch.
— Dynamic yaw (as above but with the vehicle rotated 90°).
— Acceleration and braking.
— Dynamic sway.
— Dynamic heave (as above but with the vehicle rotated 90°).

Figure 5. C'Inspector Assembly diagram in the CEHIPAR facilities.



Source: Authors

Each of the tests were carried out with two or three amplitudes, as well as additional tests to characterize the thrusters.

The sections below show each of the trials performed to obtain the mathematical model previously defined. The parameters obtained in each of the trials have been estimated using least squares (Ljung, 1999).

2.4.1. Resistance and longitudinal aceleration

The C'Inspector was dragged in upright position at speeds between 0.5 and 2.0 m/s. These speeds were made in a single run, which measures the added mass during phases of acceleration and braking.

The equation for the X force is:

$$X = X_0 + X_u u + X_{uu} u^2 + (-m + X_{\dot{u}})\dot{u} \tag{6}$$

where the resistance at the nominal speed u_0 (1.5 m/s) and $u = U - u_0$, U being the real speed.

2.4.2. Self-propelled and spin thrusters trial

The self-propelled trial is carried out by towing the C'Inspector at the nominal speed while the revolutions of the horizontal thrusters are between 35% and 60% of the maximum speed. If we call T the effective thrust the measured total force is:

$$X = X_n n \tag{7}$$

where n is the difference between the actual revolutions n_r and the nominal revolutions n_n (those for which the total force is zero). The effective thrust T (in Newtons) is expressed as:

$$T = -X_0 + X_n n = -X_0 + X_n(n_r - n_n) \tag{8}$$

where X_0 is the resistance at the nominal speed.

2.4.3. Manoeuvre with vertical propeller

These trials were conducted by leading C'inspector to the nominal speed with the revolutions of the self-propelled point. The revolutions of the vertical propeller ranged from −60% to +60% of the maximum speed. The following model has been adjusted:

$$X = X_{|\mu|}|\mu|, \;\; Z = Z_\mu \mu, \;\; M = M_\mu \mu \tag{9}$$

where μ are the revolutions of the propeller in % of the maximum, with positive value when thrust is upward. There is a clear asymmetry in the force X and in the moment M between the response with the propeller pushing up or down.

2.4.4. Trim weight

This trial was made with the vehicle in a fixed position and moving the internal weight between 0 and 100% of the maximum displacement.

2.4.5. Static and dynamic pitch

The static pitch consists of the displacement of the C'Inspector at the nominal speed and varying at the same time, the angle of pitch (trim). This introduces a vertical speed given by:

$$w = U \sin\theta \tag{10}$$

being U being the nominal speed and θ the pitch angle.

The dynamic pitch corresponds to the performing of a sinusoidal trajectory in the vertical plane so that the longitudinal axis of the C'Inspector is kept tangent to the trajectory all through the trial. Thus, in the C'Inspector axis, there is only a pitch rotational movement. As before, the tests were performed at nominal speed with an oscillation period of 3 seconds. Pitch amplitudes varied between 5° and 10°. The vertical force is set according to the following linear model:

$$Z = Z_{\dot{q}}\dot{q} + (Z_q - mU)q \tag{11}$$

2.4.6. Dynamic heave

In this test, the C'Inspector oscillates in a vertical direction while it is moving into the nominal speed. The oscillation period of 3 seconds was considered as a reasonable estimate of the response time for the manoeuvre. The oscillations were carried out in the same run with amplitudes from 0.05 to 0.15 m. The vertical force is applied with a linear fit of the type:

$$Z = (-m + Z_{\dot{w}})\dot{w} + Z_w w \tag{12}$$

m being the mass and Z_w the added mass.

2.4.7. Static and dynamic yaw

In this test, the C'Inspector was displaced at the nominal speed meanwhile the yaw angle (drift) was varying. This introduces a transverse velocity given by:

$$u = U \sin\psi \tag{13}$$

where U is the nominal speed and ψ the drift angle. The results for the transverse force obtained with the best linear fit present the following form:

$$Y = Y_v v \tag{14}$$

The dynamic yaw was produced by forcing the vehicle to follow a sinusoidal trajectory such that the axis movement of the vessel consisted of a pure yaw oscillatory movement at the nominal speed with the system of self-propulsion thrusters. The same oscillation period was chosen, and the oscillations were performed in the same race with amplitudes ranging from 5° to 10°. The transverse force is modeled in the following form:

$$Y = Y_{\dot{r}}\dot{r} + (Y_r - mU)r + Y_{rrr}r^3 \tag{15}$$

2.4.8. Dynamic sway

In the dynamic sway, the C'Inspector oscillates transversely at the nominal speed with the thrusters in the self-propulsion point. The oscillations were performed in the same race with amplitudes ranging from 0.05 to 0.15 m. The transverse force takes the following form:

$$Y = (-m + Y_{\dot{v}})\dot{v} + Y_v v \tag{16}$$

m being the mass and Y_v the added mass.

2.4.9. Dynamic roll

Finally, the last test was the dynamic roll, where the C'Inspector oscillates around the X-axis while moving at the nominal speed and with the thrusters in the self-propulsion point. A period of 3 seconds and amplitudes of 10, 20 and 30 were used. The moment about the K axis has made a fit of the type:

$$K = (-I_{xx} + K_{\dot{p}})\dot{p} + K_p p \tag{17}$$

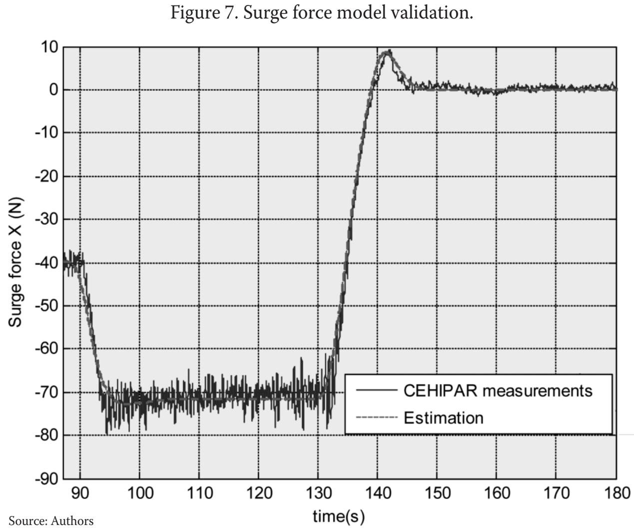
I_{xx} being the inertia moment around the X axis.

3. Model validation

In the application of the system identification theory, it is conventional to use for the model validation different data than the data used in the estimation. In this work, for economic reasons in order to avoid a large number of trials, half of the acquired data is used for parameter estimation and the other half for model validation.

There are different ways to validate a model (Ljung, 1999), one of them being to compare in the same graph the acquired measurements with the obtained model. This will verify whether the fit of the model to the data is adequate. Figure 7 shows that for the case of the surge force, the fit is good.

Figure 7. Surge force model validation.



Source: Authors

Another form of model validation is the use of statistical metrics. One metric is the coefficient of determination R^2 *(%)*, which provides information about the obtained model to the extent that it is able to reproduce the measurement data, and represents the percentage of output variation reproduced by the model:

$$R^2(\%) = \frac{\sum(\hat{D} - \bar{D})^2}{\sum(\hat{D} - D)^2 + \sum(\hat{D} - \bar{D})^2} \tag{18}$$

where D and $\bar{D}$ represent the measured data and its mean respectively, and $\hat{D}$ the data generated by the obtained model.

The following table 3 shows the model validation results, by calculating the coefficient of determination, for each of the performed tests. Thus, it is found that the obtained model is good, because in most of the trials the $R^2(\%)$ coefficient is near to 100%. It must be noted that the $R^2(\%)$ coefficient obtained also depends on the signal/noise measurement ratio corresponding to the test. This happens, for the dynamic sway trial since the signal/noise ratio is high and therefore the $R^2(\%)$ coefficient is smaller than the rest of the degrees of freedom.

Table 3. Coefficient of determination results for the 6DOF trials.

Trial	Force	$R^2(\%)$
Resistance and longitudinal acceleration	X (N)	69,23
Dynamic Pitch	Z (N)	47,93
Dynamic Heave	Z (N)	99,24
Dynamic Yaw	Y (N)	70,47
Dynamic Sway	Y (N)	96,86
	Moment	
Dynamic Roll	K(Nm)	85,55

Source: Authors

4. Control of the underwater vehicle

The control problem for an underwater vehicle is related to heading control. The heading control is usually integrated in a guidance system with the aim of following a predefined trajectory defined by a set of way points. This section outlines the design of a heading controller based on the model obtained in the previous sections and it is tested for a particular manoeuvre delimitated by way points.

4.1. Heading control problem

An automatic pilot must fulfil two functions: course keeping and change of course. In the first case, the objective is to maintain the trajectory of the vessel following the desired heading ($\psi_d(t)$ = constant). In the second case, the objective is to perform the change of heading without excessive oscillations and in the minimum time possible. In both situations, the correct functioning of the system must be independent of the disturbances produced by wind, waves and ocean currents.

The trajectory followed by a vessel can be specified by means of a second order reference model:

$$\ddot{\psi}(t) + 2\zeta\omega_n\dot{\psi}(t) + \omega_n^2\psi(t) = \omega_n^2\psi_d \tag{19}$$

where ω_n is the natural frequency and ζ, the desired damping ratio of the system in closed loop. ζ is typically chosen in the interval ($0.8 \leq \zeta \leq 1$) in order to take into account security issues (Van Amerongen, 1982). In restricted waters and for collision avoidance, the course-changing manoeuvre should have a clear start, in order to show other ships the intention of the manoeuvre and, for that reason, that manoeuvre should preferably be completed without overshoot.

The heading controller used in this work is based on a previous work (Velasco et al., 2013), where a first order network controller is tuned based on genetic algorithms.

4.2. Guidance system: los

Line of Sight (LOS) (Fossen, 1994) is a widely known navigation method, which provides satisfactory results in following a path defined by waypoints. In the LOS method, it is assumed that we want to design a guidance system based on two way points with coordinates $[x_d(t_0), y_d(t_0)]$ and $[x_d(t_f), y_d(t_f)]$, respectively. Hence, the following expression is applied to obtain the desired heading angle:

$$\psi_d = \tan^{-1}\left(\frac{y_d(t_f) - y_d(t_0)}{x_d(t_f) - x_d(t_0)}\right) \tag{20}$$

Equation (20) requires a sign test to ensure that $\psi_d(t)$ is in the proper quadrant. The autopilot follows the heading by guiding the vehicle from way point to way point.

When moving along the path, a switching mechanism for selecting the next way point is needed. The way point (x_{k+1}, y_{k+1}) can be selected on a basis of whether the ship lies within a circle of acceptance with radius R_0 around the way point (x_k, y_k) k being the actual way point. Moreover if the vehicle positions $(x(t), y(t))$ at time t satisfy:

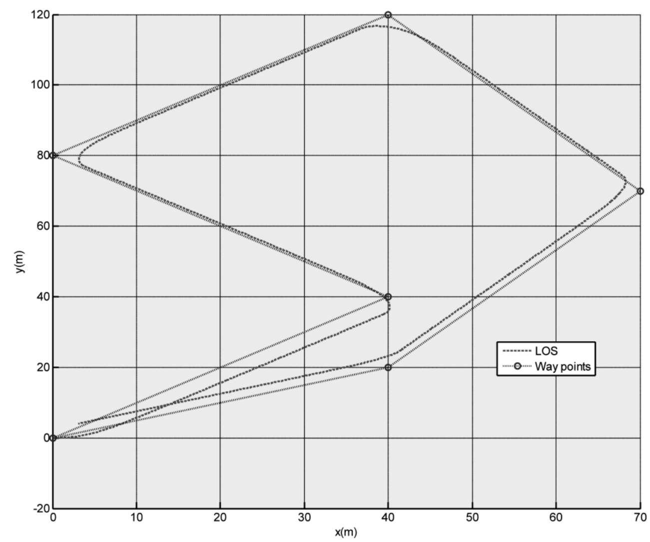
$$[x_k - x(t)]^2 + [y_k - y(t)]^2 \leq R_0^2 \tag{21}$$

A guideline could be to choose R_0 equal to two ship lengths (L_{pp}).

4.3. Simulation results

Figure 8 shows a simulation implemented using the Matlab/Simulink environment. We have implemented the model defined in section two with the estimated parameters and a guidance system based on the LOS method previously indicated. The figure shows that the system follows adequately the predefined way points path.

Figure 8. LOS guidance results with the model obtained in section 2 and the heading controller in section 4..



Source: Authors

5. Conclusions

This paper has highlighted the study in terms of modelling of an unmanned underwater vehicle through an appropriate trials program in the CEHIPAR facilities. Thanks to the acquired data, it has been possible to estimate the hydrodynamic coefficients of a six DOF nonlinear manoeuvring model of a torpedo-shaped underwater vehicle and the thruster coefficients have also been estimated.

The present work is part of a research project that has ambitiously addressed an area of growing interest, allowing the theoretical analysis in the field of simulation, and thanks to it, the design of heading controllers for a guidance system.

Acknowledgments

This project has been partially supported by the Spanish Ministry of Defence, under the programme Cooperation in Scientific Research and Development in Strategic Technologies (COINCIDENTE) which seeks to make use of civil technologies, adapting them to the specific functionalities required by the Ministry of Defence (program-1003211003100) and by the MINECO: DPI2011-27990 with FEDER funds.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 37 - 46

ISSN: 1697-4040, www.jmr.unican.es

SHIPPOL, Towards an Automatic Green House Effect Gases Tracing and Accounting System in Harbor Areas by Using AIS Technology

S. Velásquez[1] and F. X. Martínez de Osés[2,*]

ARTICLE INFO

Article history:
Received 12 July 2013;
in revised form 27 July 2013;
accepted 08 October 2013

Keywords:
GHGs, AIS, GIS, Data Base, LRIT, Global Warming, Wireless Sensors.

ABSTRACT

Identification, tracing and monitoring of ships have been widely exploited by means of the Automatic Identification System (AIS). Considerable improvements in safety, collision avoidance and vessel traffic services operations (VTS) have been reached since the system was mandatory in 2002 and applied to ships built on or after 1 July 2002 and to ships engaged on international voyages constructed before 1 July 2002[1]. Nevertheless, the possibility to storage, exchange and exploit dynamic and static information, for other reasons different to those mentioned above, can result in complementary associated phenomena analysis in shipping industry. Because of the possibility to observe and identify a vessel in a specific place and time, dynamic parameters like speed and position can be linked to the identification vessel data services in order to compute real time fuel consumption and therefore, the volume of pollutant gases emissions, providing more precise air pollutants emissions accounting different than the fuel consumption declarations. With this assumption, we have proposed a model which applies identification and speed information from AIS, and in consequence, the type of engines operating during the voyage, extracting data from public EQUASIS databases. With the help of Geographic Information Systems (GIS), real time and dynamic air pollution data can be computed and mapped in congested waters. Critical infrastructures like ports and its surroundings need other kind of data treatment because of the manoeuvring operations during berthing or piloting, most of them under different consumption conditions in the main engines. The present paper shows our first steps in analysing a suitable mathematical model which fits the three components (earth observation, communications and navigation satellite, airborne and land data acquisition) in air pollution from shipping dynamic mapping. This is our first step to approach to an Automatic Green House Effect Gases Tracing and Accounting System..

1. Introduction

Considering the current global freight and the international carriage of goods growths, maritime transport continues being the main option to carry cargo, considering its cost effectiveness, fuel consumption efficiency and low contribution to the greenhouse effect (GHG) emissions within the transport field. Nevertheless, Bunker fuel emissions from international shipping are not covered by the international regulatory framework under the Kyoto protocol (United Nations, 2010). To this respect the authors have been analysing this gap in the local, national and international frameworks regarding the global warming and the maritime transport contribution to the full picture of anthropogenic GHG emissions. Even the amounts of pollutant emissions can be well computed from the volume of fuels consumption during a voyage, and post evaluated declarations, the true effects on the vessel corridors, ports and influenced maritime traffic environments are not well studied, evaluated or declared. According to the Second IMO GHG Study 2009 (International Maritime Organization, 2009), "emissions of exhaust gases from international shipping are estimated in that study, based on a methodology where the total fuel consumption of international shipping was firstly defined. Emissions are subsequently calculated by multiplying fuel consumption with an emission factor for the pollutant in question. Fuel consumption for the year 2007 was estimated by an activity-based methodology. This is a change in methodology compared to the first IMO

[1] Project Manager at Spanish Institute of Navigation, Lecturer at Technical University of Catalonia, PhD Candidate in Nautical Science and Engineering, Spain.
[2] Director and Professor of the Nautical Science and Engineering Department, Spain. Email: fmartinez@cen.upc.edu
[*] Corresponding author.

[1] IMO Resolution A.917(22) Guidelines for the onboard operational use of shipborne automatic identification systems (AIS)

study on greenhouse gas emissions from ships, published in 2000, which relied on fuel statistics. The investigations that are presented in that study suggest that international fuel statistics would under-report fuel consumption. The difference between the fuel statistics and the activity-based estimate is about 30%. Guidebook emission factors from CORINAIR and IPCC were used for all emissions except for NOx, where adjustments were made to accommodate the effect of the NO_x regulations in MARPOL Annex VI. Estimates of emissions of refrigerants were retrieved from the 2006 United Nations Environmental Program (UNEP) assessment of refrigerant emissions from transport. The emissions of VOC from crude oil were assessed on the basis of several data sources".

This situation contributed to reinforce our idea of using a more precise and quasi real time balance of shipping GHGs emissions, in harbour areas mainly, by means of AIS data combined with in situ data acquisition techniques and Earth Observation information.

2. State of the art

The US Environmental Protection Agency (EPA) initiated a review of its guidance on developing emission inventories for ocean-going and harbor vessels operating at port areas. This methodology was based on a three step calculation. The first step apportions the time spent by a vessel in a port area to different operating modes. The second calculates fuel consumption in each operating mode. The third step calculates emissions using fuel consumption specific emission factors, which is how marine engine emission factors have been historically specified. All of these calculations are by vessel type and class, with the type specifying whether the vessel is a tanker, passenger liner, etc., and the class specifying either the weight or horsepower range.

Operating mode data on non-oceangoing vessels is not easy to characterize. Typical estimates have been based on power factors of 80 percent, 40 percent, 20 percent and idle, for cruise, slow cruise, manoeuvring, and trawling or waiting. No estimates of auxiliary loads for such vessels are available.

The operating mode data on both oceangoing and non-oceangoing vessels appears to be derived from numerous assumptions that have not been subjected to any validation by European Environmental Agency (EEA). However, this is the best available data within the time and resource constraints of this project[2].

Emissions from the maritime transport sector account for a significant portion of total emissions, affecting air quality and contributing to climate change and human health problems. The estimation and geographical characterization of maritime transport emissions are therefore important to the work of, for instance, atmospheric scientists or policy makers who try to analyze and address the problems associated with them.

In general, the level of detail achieved and achievable within a certain study depends on the approach followed (bottom-up or top down) and the specific purpose of the analysis itself.

For example, emissions of CO_2 may be analyzed at a global scale, whereas NO_x and SO_x emissions should be analyzed at a more local scale since their greatest effects are produced on the environment in which they are released.

In a bottom-up approach, each single element involved in a certain phenomenon is modeled and then the global impact is evaluated by aggregating the impacts of the different elements.

For the evaluation of emissions arising from maritime transport, two dimensions have to be considered: the quantity of emissions produced and where they are emitted.

Due to data availability, nearly all the studies evaluate emissions attributable to vessels whose gross tonnage is greater than 100.

Several inventories have been established over the past two decades. The debate on the evaluation of maritime emissions is still open and has resulted in several different estimations being made over the past decade. These are not all that easy to compare, since different contexts are analysed and different assumptions are made.

In our case, some assumptions on the convenience of using AIS data to estimate air pollution from shipping industry some considerations must be taken into account.

Further to the definition of the ships' activities, AIS data may be usefully applied for the evaluation of the vessels' speed. The service speed provided by the ships' databases is an average value declared by the ships' operators. In order to calculate ships' fuel consumption and emissions, the operational speed of a ship would be required in addition to its service speed.

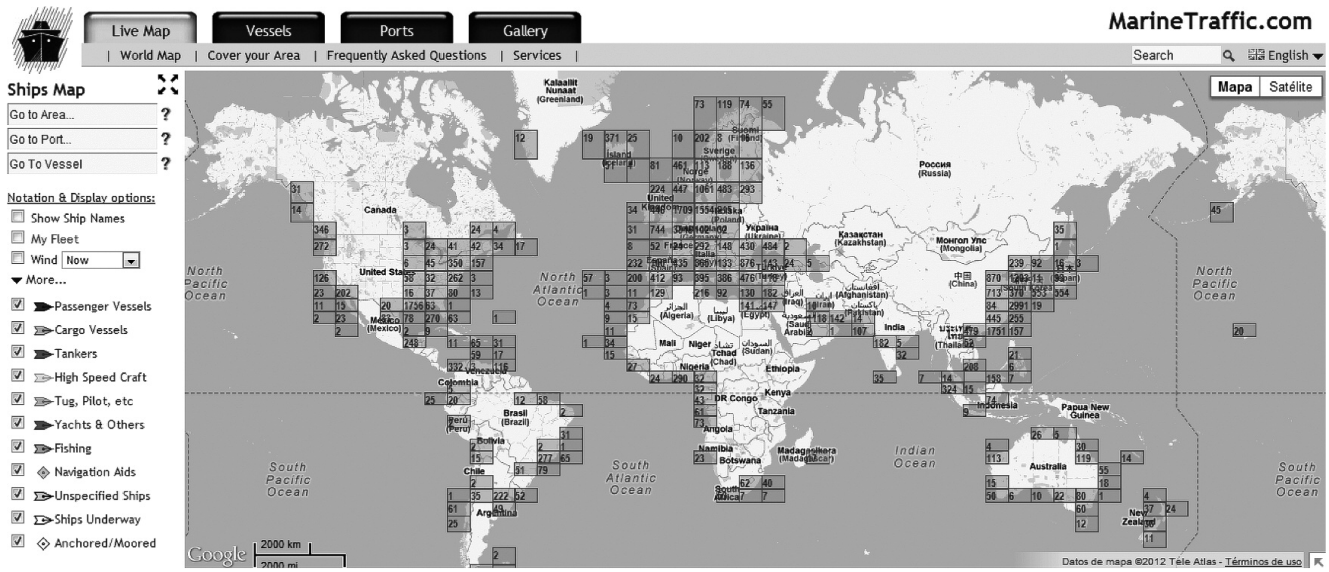
In particular, the relationship between fuel consumption and the ratio between operating speed and service speed is a cubic function (Corbett *et al.*, 2009), meaning that an estimation of the operating speed can be used to calculate an estimate of the fuel consumption and emissions. AIS data could therefore substantially improve the global estimation of emissions from maritime traffic.

However, some risks exist with AIS data. These are mainly connected to:

- Incomplete spatial coverage of maritime traffic. In Figure 1 this is pointed out. In addition, exceptions to the use of AIS data are given in the clause established in the IMO 22nd meeting of the General Assembly, resolution A.917(22);
- Penetration of the AIS technology in the fleet working in the area which is being considered. At the global level, approximately 50% of ships have this system on board (Ou and Zhu, 2008), but at the local scale the picture may be very different (for instance, according to a recent study, MARIN, 2008, the coverage rises to

[2] Analysis of Commercial Marine Vessels Emissions and Fuel Consumption Data. Office of Transportation and Air Quality U.S. Environmental Protection Agency. EPA420-R-00-002; February 2000.

Figure 1. MarineTraffic.com AIS data coverage.



Source: Authors

90% in the Baltic Sea, meaning that in other areas the percentage of coverage will be much lower).

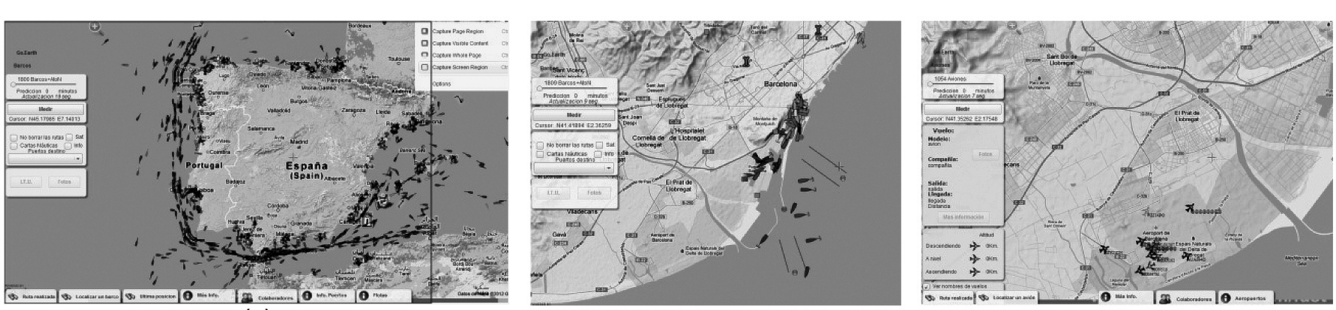
- Incomplete coverage for the entire route. For instance, the data available for the entire route may potentially only be connected with the departure and the arrival of the vessel. It is possible to have an estimate of the average cruise speed, but this is of course only an approximation. This problem can be overcome by using another data source, the Long Range Identification and Tracking (LRIT) of ships. Although the LRIT contains less frequent information (collected only four times per day) it is available everywhere. It was established as an international system in 2006 by the IMO and applies to ships engaged on international voyages (in particular to all passenger ships, cargo ships of 300 GT and above, and mobile offshore drilling units).

All these problems could be reduced if a single entity were to take responsibility for accurate data collection and distribution. In Europe this role will be filled by the European Maritime Safety Agency (EMSA), which will take care of both AIS and LRIT data. This would lead to a considerable improvement in the data accuracy for European researchers in the maritime transport field[3].

Nevertheless, local AIS web services at local level make possible to reduce our study to the harbour areas. Within this context, an isolated control boundary can be selected and several sources of information can be used. In the case of AIS information, ships, aircrafts and even trucks may be located and traced by means of localizadotodo.com, Figure 2. In the Barcelona harbour, some environment stations are deployed, both static and mobile, and the Catalan environmental service has other stations near to the airport and the port of Barcelona and all of those data are available for the public use and consultation. A combined data management method can produce satisfactory models which can be scaled to wider control boundaries as soon as LRIT and Satellite AIS are wholly operating.

[3] Regulating air emissions from ships: the state of the arte on methodologies, technologies and policy options. Joint Research Centre. Institute for Environment and Sustainability. European Commission 2010.

Figure 2. Spanish AIS webservice localizatodo.com; (a) Coverage, (b) ships' location and identification and (c) aircrafts' location and identification



Source: Authors

3. The port as a first candidate to apply an automatic ghgs emissions monitoring system

Ports are very complex and heterogeneous entities. There are ports that are even larger than their host cities, sometimes hosting important industrial assets, while others are just a part of an industrial plant or serve just a local community. The port is a context where a number of actors develop a wide spectrum of activities sharing the same facilities such as, berths, docks, terminals, cranes, piloting, towing, and safety and security operations regarding SAR, VTS and ISPS.

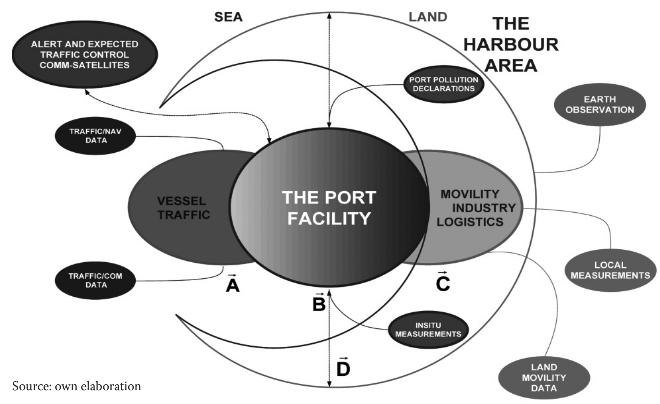
The main activities related to our research are listed in Table 1. It is also proposed to scale our research to a wider area including an Emission Control Area (ECA). The next Transeuropean Transport Network Policy promoted by the European Commission for the next 20 years require a deep analysis on the real impact on environment from the different modes of transport and the logistics networks. In Figure 3 a control boundary has been defined to apply our research activity. The port Authorities support is an essential key to establish and consolidate the data sources from official entities. The access to the public SafeSeaNet databases in order to obtain ships' information and engine data is a paramount issue too.

The port as main user will be the data source and scenario for the application of the proposed architecture. The related tasks will list the air pollution data acquired into the port facilities and its surroundings.

Users like local and national environment authorities need to improve environmental management tools in order to quantify, qualify and rule pollution from all the active and potential sources. Current climate change, global warming and pollution are on the first line agendas at political, scientific and technological level. From Kyoto to Copenhagen United Nations initiatives, the launching of satellite platforms like SMOS and GOSAT and finally, worldwide campaigns to standardize methods and data into networks like GMES are clear arguments to promote such architecture as explained in this proposal.

Because of the definition of the port, the local government and international decision makers as end users the

Figure 3. The Harbor area and the potential fields of knowledge applied to the Automatic GHGs Emissions monitoring model.



Source: own elaboration

Table 1. Impacts on air due to maritime transport and port activities, including illegal activities.

		IMPACTS OF SHIPPING ON AIR				
Activities – events/Impacts		Local Air Pollution NOx, SO_2, CO_2, CO, VOC, PM	Noise	Vibration	Odor	Global Air Pollution Impact
In Ports	Maneuvering					
	Loading/unloading operations on terminals					
	Hoteling (lighting, heating, refrigeration, ventilation, etc.)					
	Dredging					
	Land Traffic (heavy vehicle, railways, near highways, etc.)					
	Waste disposal/illegal dumping					
	Port expansion/infrastructures construction and maintenance					
	Fuels deposits					
	Air traffic (neighboring airports)					
	Bulk handling and goods movement					
	Industrial activities					
	Spills					
At Sea	Cruise					
	Spills					
	Heavy fuels consumption					

Source: own elaboration from Miola et al. (2009, p. 23)

Table 2. Gaps in the air pollution management from shipping industry and potential improvements from SHIPPOL research.

Users	Role	Current situation	Problem	SHIPPOL Improvement
Port communities	End user	In situ measurements are not enough to manage all the parameters involved in air pollution monitoring.	Air pollutants dynamics (wind, sea sorption, decomposition, accumulation)	A suitable information service. Data sources and Dynamics and Prediction Models
Local administration	End user	Lack of integrated systems to implement and apply environmental measures	Apart of its own tools, the authorities depend on the pollution declarations from all the industrial and transport actors to manage environmental indicators	To become much more operative and effective applying environmental actions
State administration, IMO and EMSA	End user	Lack of integrated systems to implement and apply environmental measures	Apart of its own tools, the authorities depend on the pollution declarations from all the industrial and transport actors to manage environmental indicators	To become much more operative and effective applying environmental actions. Correct emissions declarations and real reports

Source: Authors

following table summarizes some problems or gaps within the current scenario of shipping and port industry.

4. Legal aspects and basis

The first IMO study on emission of greenhouse gases from international shipping was commissioned following a request by the Diplomatic Conference on Air Pollution that was held at the IMO Headquarters in September 1997. The conference was convened by the Organization to consider air pollution issues related to international shipping and, more specifically, to adopt the 1997 Protocol to the MARPOL Convention (Annex VI – Regulations for the prevention of air pollution from ships). The first IMO study of greenhouse gas emissions from ships used figures for 1996 and was published in the year 2000 as document MEPC 45/8.

The 1997 MARPOL Conference (September 1997) convened by the IMO adopted resolution 8 on "CO_2 emissions from ships". This resolution invited, inter alia, the IMO to undertake a study of emissions of GHG from ships for the purpose of establishing the amount and relative percentage of GHG emissions from ships as part of the global inventory of GHG emissions. As a follow-up to the above resolution, the IMO Study of Greenhouse Gas Emissions from Ships was completed and presented to the forty-fifth session of the MEPC (MEPC 45) in June 2000, as document MEPC 45/8.

MEPC 55 (October 2006) agreed to update the "IMO Study of Greenhouse Gas Emissions from Ships" from 2000 to provide a better foundation for future decisions and to assist in the follow-up to resolution A.963(23). MEPC 56 (July 2007) adopted the Terms of Reference for the updating of the study, which has been given the title "Second IMO GHG Study 2009".

A significant potential for reduction of GHG through technical and operational measures has been identified from the report. Together, if implemented, these measures could increase efficiency and reduce the emissions rate by 25% to 75% below the current levels. Many of these measures appear to be cost-effective, although non-financial barriers may discourage their implementation[4].

From the port point of view, the regulatory basis must be applied according to each state harbour/port area definition. This feasibility study will include a deep analysis on the way how each member state can apply proposed architecture from a legal basis.

5. Shipol, a proposal for the European Space Agency

In December 2010 the SHIPPOL proposal was submitted to the European Space Agency within its Integrated Applications Promotion Program. The outline proposal has been received and iterated. The involved users leaded by the Spanish Institute of Navigation and the cooperation of Barcelona Regional Agency, Gijon Port Authority in Spain, the International Centre for Applied Numerical Methods in Engineering (CIMNE), GMV, Infoterra and the Cartographic Institute of Catalonia expressed their interest to participate in the activity.

Following the approval of the activity by the Joint Board on Communications Satellite Program (JCB) of European Space Agency, the consortium was invited to submit a full proposal according to the requirements of AO 6124 (IAP Open Call for Proposals for Feasibility Studies).

[4] PREVENTION OF AIR POLLUTION FROM SHIPS, Second IMO GHG Study 2009, Update of the 2000 IMO GHG Study Final report covering Phase 1 and Phase 2. MEPC 59/INF.10, 9 April 2009

Table 3. Regulatory basis and SHIPPOL Competency.

Regulation and Date	Issued by	Contents	Scope	SHIPPOL Competency
IMO Assembly Resolution A.963(23) Adopted on 5 December 2003	Internationa l Maritime Organizatio n (IMO)	Policies and Practices Related to the Reduction of Green House Emissions from ships	IMO's Marine Environment Protection Committee (MPEC) will identify and develop mechanisms needed to achieve limitation or reduction of GHGs emissions from international shipping	SHIPPOL tools would contribute to the mechanisms required by IMO
Decision 2/CP.3 Conference of the Parties to the UNFCCC December 1997	United Nations Framework Convention on Climate Change (UNFCCC)	The UNFCCC has adopted reporting requirements and agreed on guidelines and good practice guidance concerning methodologies for calculating the emissions from international bunker fuels	• the establishment of a GHG emission baseline; • the development of a methodology to describe the GHG efficiency of a ship in terms of a GHG emission index for that ship; • the development of Guidelines by which the GHG emission indexing scheme may be applied in practice. The guidelines are to address issues such as verification; • the evaluation of technical, operational and market-based solutions	The information and data acquired by SHIPPOL tools would complement GHG indexes from real traffic information apart from the declarations
IMO, MARPOL 73/78, Annex VI, adopted in 1997 and Revised Annex VI adopted October 2008	Internationa l Maritime Organizatio n, Maritime Pollution Convention (MARPOL)	MARPOL Annex VI sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances. The MPEC recognized that IMO guidelines on greenhouse gas emissions have to address all six greenhouse gases covered by the Kyoto Protocol (Carbon dioxide (CO_2); Methane (CH_4); Nitrous oxide (N_2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and Sulphur hexafluoride (SF_6).	At IMO, MEPC in the mid-1980s had been reviewing the quality of fuel oils in relation to discharge requirements in MARPOL Annex I and the issue of air pollution had been discussed. In 1988, the MEPC agreed to include the issue of air pollution in its work programme following a submission from Norway on the scale of the problem. At the next MEPC session, in March 1989, various countries submitted papers referring to fuel oil quality and atmospheric pollution, and it was agreed to look at the prevention of air pollution from ships - as well as fuel oil quality - as part of the committee's long-term work programme, starting in March 1990.	SHIPPOL tools would update expected air pollutants emissions from the declared fuel oil amounts against those monitored and observed

Source: Authors

The team was ready to submit a full proposal within Q1/2011, nevertheless, the economic crisis in Spain cuts some crucial resources to start this project and the SHIPPOL research is carried out under some financial limitations. It is expected to present the final results to the European Space Agency with the aim of obtain its support again for launching the service proposed in the way of a web service to improve existing decision making tools at European level.

Our approach within this research is that the information which would be provided by the SHIPPOL services will be the sensed and measured data of the real-time situations (not only modelled data but very high spatial resolution

Figure 4. Coastal edge of Barcelona harbour.

Source: Authors

sampling information) and the quality, density and distribution of such data would improve the current air pollution services that uses Earth Observation (EO)-data, reinforced with the tracking of ships coming/leaving the port using communication channels and navigation assets, ship to shore, shore to ship, like Automatic Identification System (AIS), LRIT, GMDSS, NAVTEX and finally, using communication satellite services to generate real time data collections accessible by environmental agencies and emergency missions within the harbour context. This approach has been of the interest of the European Space Agency because of its integration of several Space Assets.

6. The technical approach and research hypothesis

6.1. The service

The proposed service architecture is based on three main elements: navigation, earth observation and communication facilities. The overall concept is to correlate space and ground segment information for vessel traffic management and for air pollution monitoring and alert purposes.

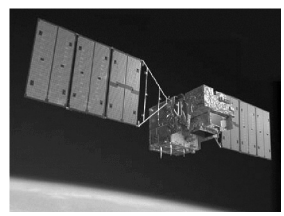
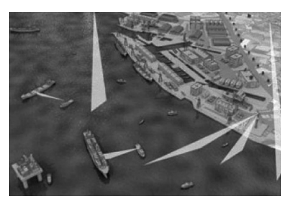
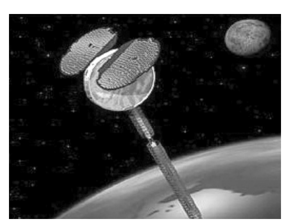
Ground information would be derived from the navigation segments (AIS-VTS coastal stations) as well as from the network of air pollution sensors deployed along the port and the metropolitan area, to this respect, Barcelona Pilots has a modern and powerful VTS service, the Barcelona Port Authority has local sensors for pollutants measurements and the Catalonian Environment Agency provides air pollutions measurements too.

Space based information would be derived from NAV-COMM satellites as well as from EO platforms that would provide regional scale vision on air pollution scenarios. Projects for specific monitoring/measurement of CO_2, NOx, SOx, VOCs, etc, like next coming GOSAT (The Greenhouse Gases Observing Satellite) as well as the recently lost Sciamachy sensor onboard ENVISAT and the next replacement payloads on board SENTINEL satellites, will provide valuable information to be contrasted in Now-cast/Forecast reports.

Satellite technology can complement terrestrial research and monitoring networks data, allowing a fast deployment of sensors and communications channels globally to uncovered services apart from search and rescue operations, tracing and tracking to facilitate transport flows, forest and agriculture management, etc. To this respect the regional and worldwide coverage of satellites offers important solutions to the growing scope of the European Union policies regarding security and defence, transportation and mobility, transport safety, research and development, environment monitoring, etc.

Sampling techniques and periodic inspections to the port emissions are not enough to generate a dynamic pollution index. Most of the measures are under the responsibility of unchained actors and integration of information is required.

Table 4. Identification of space assets.

Element	Infrastructure	Sensors	Data
Earth Observation		Fourier Transform Spectrometer, Cloud and Aerosol Imager, and X-band Antenna, Thermal, SWIR sensors	CO_2, Methane, Aerosols
Navigation		AIS transponders and receivers	Ships identification, speed, ETA, ETD, other useful navigation data
Communications		Rx: 137 – 138 MHz, 4800 bps, Tx: 148 – 150.05 MHz, 2400 bps Minimum Detectable Signal: -120 dBm, Transmit Power: 5 Watts	GSM/GPRS/EDGE cellular wireless services with LEO Satellite network, providing complete M2M network service. LRIT functions

Source: Authors

The step forward regarding environmental information on climate change and environmental monitoring systems means that a new paradigm in real time information production will reinforce the making decisions tools and policies involving all the main actors (port, local, state and European environmental authorities).

6.2. The principle

In terms of the operational aspects regarding this research, the proposed model which fits the above mentioned technologies is based on the Mass Conservation Law.

The law of conservation of mass/matter, also known as principle of mass/matter conservation is that the mass of a closed system will remain constant over time, regardless of the processes acting inside the system. A similar statement is that mass cannot be created/destroyed, although it may be rearranged in space, and changed into different types of particles. As the earth's atmosphere being a closed system in material terms, this principle must be applied.

The formal mathematical way of describing the black-box approach is with conservation equations which explicitly state that what goes into the system at specific time must either come out of the system somewhere else, get used up or generated by the system, or remain in the system and accumulate, the Figure 3 shows the streams mentioned in the mass balance applied to this research. The relationship is as follows:

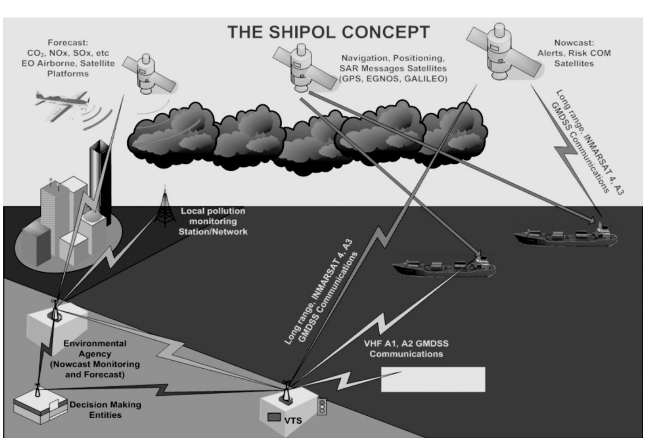
- The streams entering the system cause an increase of the substance (mass, energy, momentum, etc.) in the system, (A, C in this case)
- The streams leaving the system decrease the amount of the substance in the system (A_{out} or the amount of mass leaving the system by the effects of wind)
- Generation or consumption mechanisms (such as chemical reactions, combustion processes in the case of shipping) can either increase or decrease the stuff in the system (B, B_{out} referred as the amount of pollutants absorbed by sea)
- What's left over is the amount of stuff in the system (D)

From the energy and mass balance principles applied to the harbor area, the system must be reduced to the so called "Control Volume" or black-box in order to take into account all the mass and heat fluxes within the borders of the system and with these four statements we can state the following very important general principle:

Equation 1. General Mass Balance in the Harbour Area

$$[\vec{D}]=[\vec{A}]+[\vec{B}]+[\vec{C}]-\{[\vec{A}_{out}]+[\vec{B}_{out}]\}$$

Figure 5. SHIPOL service architecture concept.



Source: Authors

6.3. The tools

Green House effect Gases Mapping tool (Quasi real time pollutants location, discrimination and concentrations), now-casting and forecasting functions.

Episodes Alert Tool, this option will provide emergency or contingency messages according to the risky situations from extraordinary pollutant concentrations in the harbour surrounding areas. Decisions and contingency actions will be suggested too to the Port Authorities and the Local Environmental Agencies.

Traffic and Surveillance control tool, from Automatic Identification Systems (VHF and satellite), this decision support option shall regulate traffic in congested and over-polluted areas if it's the case. When an episode alert has been reported, valid and regulated mechanisms shall be activated.

Maritime transport air pollution data provider tool, this solution shall provide an active and dynamic air pollution data provider which will make possible to validate GHGs declarations from shipping industry, reinforce environmental statistics and forecast air pollution behaviour and its impact on air quality and sea and human health, near to congested waters (due to traffic and port operations). Short, medium and large scale measures and rules shall be also considered according to the users role (environmental, transport and government authorities) at local or international level. Future market based instruments as carbon credits for instance, shall be supported from the information provided by this tool.

7. Current and future steps

During the research phase, a few reasonable implementation scenarios have been analysed against technical and system operational/exploitation considerations. The purpose of this approach is to ensure that the final architecture proposed is tailored to the technical, environmental and operational needs. The work is being carried out according to the following work packages and tasks.

7.1. Evaluation of the User Needs and Requirements based on national/international environmental laws

- The port as main user is the data source and scenario for the application of the proposed architecture. This task lists the air pollution data acquired into the port facilities
- National, European and International environmental stakeholders requirements analysis
- International pollution networks integration. Analysis of GMES (Global Monitoring for Environment and Security) case and other environmental initiatives worldwide.

7.2. The methods employed includes

- Personal interviews with some Spanish port authorities and their environmental agents
- Local environmental administration interviews
- Databases, image collections and GIS software tools acquisition

7.3. Technical architecture proposal

- Inventory of current payloads and sensors for air pollution monitoring in ports and harbour areas
- Now-cast and land stations for pollution monitoring in port surroundings and neighbourhoods inventory
- Satellite forecasting and simulation technologies currently employed for global pollution monitoring
- Analysis of the navigation data, mainly from VTS, as traffic data source and pollutants calculations from maritime field (AIS)
- Inventory and analysis of current communication satellite facilities to alert environmental episodes and decision making tools.

7.4. The methods employed include:

- Internet searching of data providers
- Online pollution forecasting systems analysis
- Interview with other ports which apply similar services (Bremen port Authority is a clear candidate to be visited)
- Visit to Barcelona Pilots as VTS service provider
- Manoeuvring information within the port waters
- Algorithms reported to compare or improve own assumptions
- Free download data to verify algorithms

8. Expected results

Even SHIPPOL research is conceived at harbour area scale, a wider future vision is possible to be implemented understanding the overall scenario of air pollution monitoring and the impact evaluation of GHGs. For that reason, SHIPPOL proponents have agreed to promote the impact and the future project results among them in the three level actor's scenario (Developers, end users and Stakeholders/Policy Makers). When the service feasibility has been demonstrated, the project can be promoted to (ESA) and GEMS (EU) in order to become user of their medium scale products already delivered on a regular basis through their dedicated regional services. Apart of helping to make the connection between the local and the regional scenarios, these products will give support to the interpretation and detection of potential risk events.

The bidders expect that this collaboration will reinforce the key role of the air pollution services already developed in the frame of PROMOTE and GMES networks as well as it will generate the convenient environment for improving the services already existing by the specific added value of SHIPOL at European level.

In particular the results and recommendations of the SHIPPOL work, will most likely contribute to the achievement of the following aspects of the European Maritime Transport and its impact on environment:

- To propose a suitable architecture which will make possible to obtain remote information from ships outside controlled borders worldwide.
- To quantify and qualify how much ships pollute in a more precise way, this capability may be used to apply right taxations from emissions to the right flagged ships.
- IMO and Environmental Organisms will benefit from these future developments in order to improve international regulations and policies.
- Shipping companies and ship constructors will improve their productive activities more efficiently and will improve energy consumption making maritime transport greener and cleaner, in other words, a more sustainable transport mode.
- Now-casting and Forecasting technologies will improve their models of global warming and climate changes because they will be able to include more parameters which actually are not considered.

9. conclusions and recommendations

The execution of our research is considering all the actions needed to demonstrate the principles and prove the added value of the concepts that are developed under the SHIPPOL concept. The feasibility of the concept might consider different aspects from different groups, but in the case of SHIPPOL, the European Space Agency, the competent authorities of the Member States and the port authorities, environmental authorities and ship owners are the most important stakeholders.

The SHIPPOL concept also strives to minimize errors from the pollution declarations and monitoring information and the effects on the environment and climate change phenomena. The information that is collected through the public systems can be shared with commercial stakeholders, if they have an interactive system that can be considered of the public interest. This is part of the public authorities' wishes to improve and facilitate maritime transport pollution monitoring and control. Connection with Port Authorities Environmental Systems and other networks through the global environmental monitoring services is expected to be demonstrated.

The scenarios and processes in relation to the functional architecture in a wider approach will be used to describe in process diagrams and swim lanes the scenarios for the demonstrations. When the modelling is completed, it is possible to define the equipment and software that is required to carry out a demonstration. The test bed is used to assess and test the different components that are needed to show the SHIPPOL-concept. The initial tests will be made by means of current in-situ measurements and satellite data available on the market/public providers such as ENVISAT/GOSAT/AIS, but in other cases it is necessary to emulate functions without the use of next generation facilities like long range identification and tracking systems. Special equipment that will be tested should fulfil the requirement of portability so that tested elements can be used in the demonstrations.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 47 - 50

ISSN: 1697-4040, www.jmr.unican.es

Effect of Structural Deformation on Performance of Marine Propeller

H.N. Das1,2,*, P. Veerabhadra Rao[1,3], C. Suryanarayana[1,4] and S. Kapuria[5]

ARTICLE INFO

Article history:
Received 15 July 2013;
in revised form 30 July 2013;
accepted 16 October 2013

Keywords:
Marine propeller, structural deformation, hydrodynamic.

ABSTRACT

Propeller geometry is very crucial for its performance and a little deviation in shape can cause changes in its hydrodynamic performance. Hydrodynamic loading causes deformation to the propeller blades, which leads to change in shape. Effect of this change of shape on hydrodynamic performance of a propeller is being studied in the present paper. A five bladed bronze propeller is chosen for the analysis. Its open water efficiency was estimated for original and deformed shape. Pressure based RANS equation was solved for steady, incompressible, turbulent flow through the propeller. Numerical solution was obtained using Finite Volume Method within Ansys Fluent software. FEM based solver of ANSYS Mechanical APDL was used to make the structural calculations. Fluid-structure interaction was incorporated in an iterative manner. The study however shows very little change in its hydrodynamic performance due to the deformation of propeller blades.

1. Introduction

Geometry of propeller is very crucial for its performance. A little deviation in its geometry may largely influence the performance of a propeller. A previous study reveals that some deviation in geometry of a propeller during fitting into a ship caused variation in its performance from its original design (Das, 2008).

This raised curiosity about performance of any propeller when it is deformed under hydrodynamic loading. The present study concentrates on open water performance of a five bladed propeller. CFD analysis was carried out for undeformed geometry of the propeller to obtain hydrodynamic pressure. This pressure was then applied to the propeller to estimate its deformations. A FEM code ANSYS Mechanical APDL was used for this. A further CFD analysis was carried out with this deformed shape to get the hydrodynamic performance of the deformed propeller. This process was repeated for few times to arrive at hydrodynamic load and a compatible deformed shape of the propeller.

2. Literature review

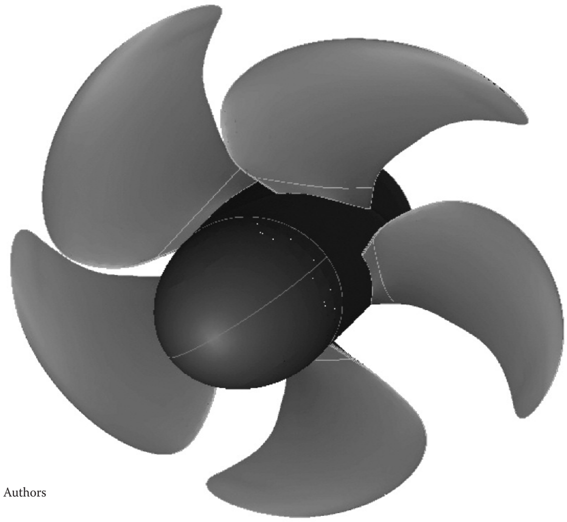
Computation of viscous flow through propeller was demonstrated in 22nd ITTC conference in Grenoble, France in 1998 (Chung et al., 1998; Sanchez Caja, 1998). In the last decade, Das et al. have carried out CFD analysis of contra-rotating propeller (Das and Jayakumar, 2002), hull-propeller interaction (Banerjee et al., 2007) and study of propeller noise (Krishna et al., 2008). Many studies on static analysis of propeller blades are available in literature. Stress analysis for isotropic material by Sudhakar (2010) and study for composite propeller by Seetharama et. al. (2012) are some examples.

3. Geometry of the propeller

A five bladed propeller is considered for the present study (Fig. 1). Considering its diameter to be as D, other geometrical parameters are expressed. The hub diameter is 0.313D. Pitch ratio (p/D) of its blades at radial section of 0.7D is 1.547. The propeller was modelled using Catia V5® software.

[1] Naval Science & Technological Laboratory (NSTL), Defence RD Organisation, Vigyan Nagar, 530027, Visakhapatnam, India. Tel +918912586373, Fax +918912559464.
[2] 2Additional Director, Email: das.hn@nstl.drdo.in.
[3] 3Researcher, Email: veerabhadrarao.peta@gmail.com.
[4] 4Head Propulsion Division, Email: suryanarayana.ch@nstl.drdo.in, Tel +918912586165.
[5] 5Professor, Indian Institute of Technology Delhi, Hauz Khas 11016, New Delhi, India. Email: kapuria@am.iitd.ac.in, Tel +911126591218, Fax +911126581119.
* Corresponding author.

Figure 1. Solid Model of Propeller.



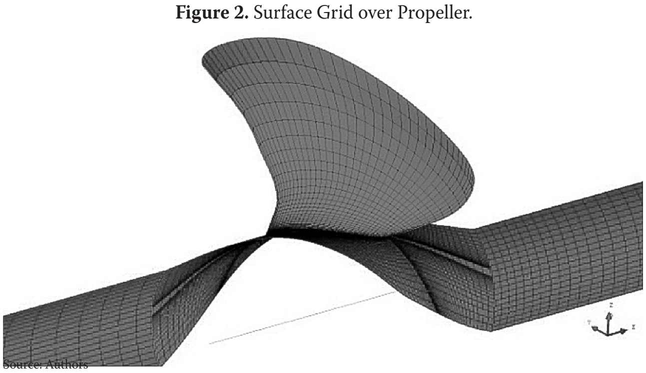
Source: Authors

4. Grid generation

4.1. Grid for Fluid Study

The surface model of propeller was imported from Catia to ANSYS ICEM CFD 12.0. A suitable domain size was considered around the propeller to simulate ambient condition. A sector of a circular cylindrical domain of diameter ~4D and length of ~7D was used for flow solution. The sector of 72° was so chosen that only one blade is modelled in the domain. Periodic repetition of this sector simulates the whole problem. A multi-block structured grid was generated for the full domain using ICEM CFD Hexa module. The grid thus generated was exported from ICEMCFD to ANSYS Fluent 12.0 solver. Extent of domain and grid over the blade is shown in Figs. 2 and 3. A grid with total 0.268 million cells were employed to descritise the flow field.

Figure 2. Surface Grid over Propeller.

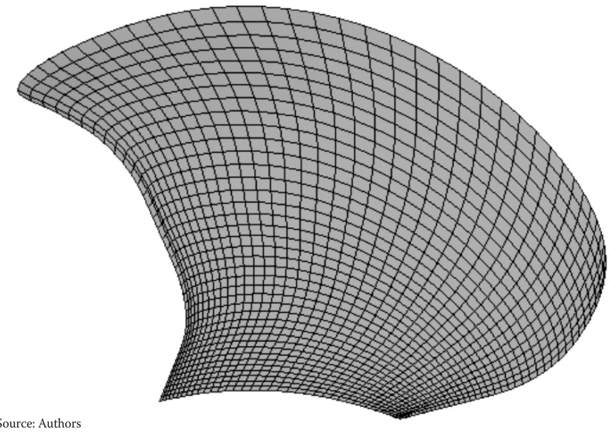


Source: Authors

4.2 Grid for Structural Analysis

The grid from only the blade surface was imported to ANSYS mechanical APDL software. A view of imported mesh is shown in Fig 5. Total 361 elements (around 400 Nodes) were used over the blade.

Figure 3. Grid over Surface of Blade for Structural Analysis



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5. Settings up the problem

5..1 Flow Solution

The problem was solved using the segregated solver of ANSYS Fluent 12.0. In brief the code uses a finite volume method for discretization of the flow domain. The Reynolds Time Averaged Navier-Stokes (RANS) Equations were framed for each control volume in the discretised form. For the present solution, STANDARD scheme is used for pressure and a SIMPLE (Strongly Implicit Pressure Link Equations) procedure is used for linking pressure field to the continuity equation. The detailed formulation of numerical process is given in (ANSYS FLUENT). The computations were carried out on an Eight Core Dell Precision T7500 Workstation (64bit Xeon E5640 Processor @2.67 GHz, 4GB RAM, 64 Bit Windows XP OS). The flow is treated as incompressible and fully turbulent. Standard K-Є model has been used for modelling turbulence. The near wall turbulence was modelled using standard wall functions and the free stream turbulence has been prescribed as follows

$$K = 10^{-4} * U_{\infty}^{2}$$

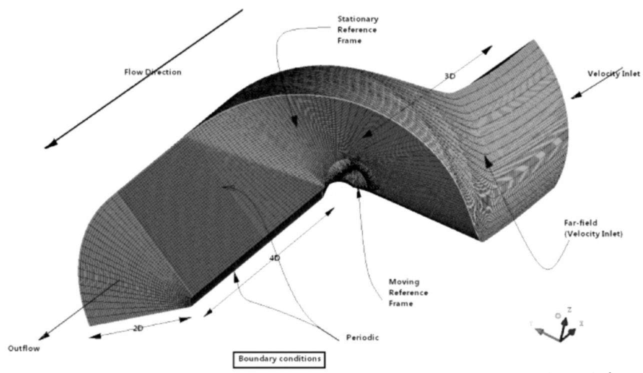
$$\varepsilon = \frac{C_{\mu}\, \rho\, K^{2}}{5\, \mu}$$

The continuum was chosen as fluid and the properties of water were assigned to it. A moving reference frame is assigned to fluid with different rotational velocities to simulate appropriate advance ratio. The wall forming the propeller blade and hub were assigned a relative rotational velocity of zero with respect to adjacent cell zone. A constant uniform velocity was prescribed at inlet. At outlet outflow boundary condition was set. The farfield boundary was taken as inviscid wall.

The following boundary conditions are used in this analysis [Fig. 4]:

(i) Velocity Inlet
(ii) Outflow
(iii) Moving Wall
(iv) Inviscid Wall
(v) Periodic

Figure 4. Extent of Domain and Boundary Conditions for Flow Analysis



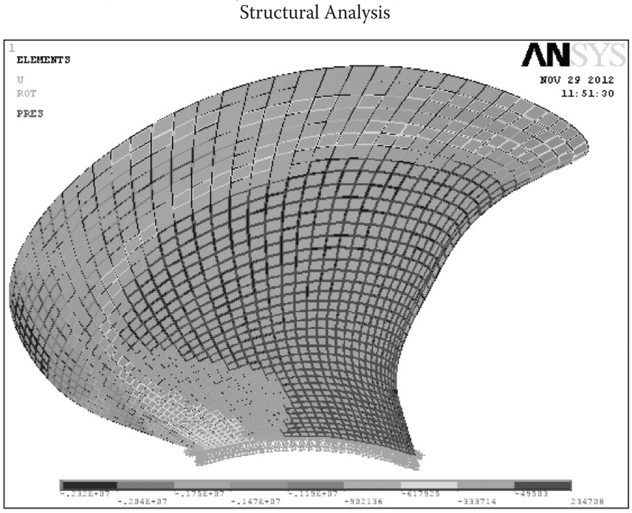
Source: Authors

5.2. Deformation Study

The deformation of the propeller blade was estimated using ANSYS Mechanical APDL 12.0 software. The solver used Finite Element Method (FEM) for descritisation. For structural analysis, only one surface of the blade was modelled. The pressure, estimated from flow solution, was applied to this blade surface. Fluent's output of pressure distribution over two surfaces of blade, face and back, was written to a file. A program picked up the pressure values from this file and put to the nearest node points over the single surface of the blade, to be used in Mechanical APDL software. An four nodded shell elements i.e., SHELL 181, available with ANSYS solver were chosen for the analysis. Propeller blade was considered as cantilever. The root of the blade was considered as fixed, restraining all degrees of freedoms there.

The blade was made of Aluminium Nickel Bronze, which has Young's Modulus 10^{11} N/m^2 and Poisson's Ratio of 0.34. A constant thickness of 0.1 m was applied for the blade. This makes the volume of the blade approximately same to the actual blade. Mesh and boundary condition for FE solver is shown in Fig 3 and 5.

Figure 5. Boundary Conditions with Applied Pressure for Structural Analysis



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5.3. Fluid-Structure Interaction

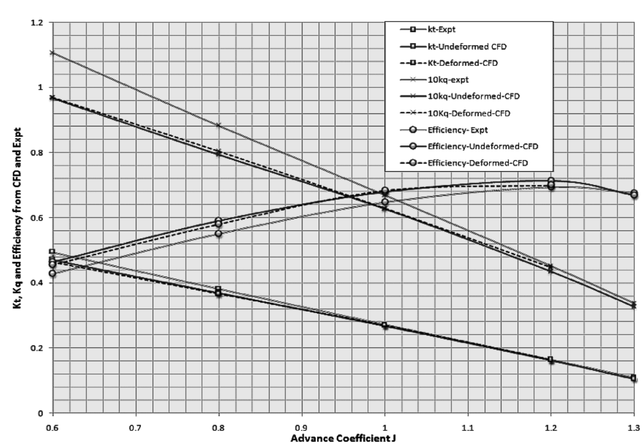
The deformed shape of the propeller blade under each operating condition was transferred to ICEM-CFD software. After developing the actual blade around this deformed surface, mesh was again generated. This mesh was exported to Fluent and corresponding operational conditions in terms of propeller rpm and linear velocity was assigned in the solver. The hydrodynamic results obtained from flow solution represent the behaviour of the deformed propeller. A new pressure distribution now develops over the blade due to the change in geometry. The new load is again exported to ANSYS APDL software for deformation analysis. The original blade geometry is considered for this. The process is repeated iteratively till the time when pressure distribution does not change any further between two successive iterations.

6. Conclusions

The present study indicates that capability of computational methods to solve complex engineering problem like fluid-structure interaction for a propeller-flow.

CFD results agreed well with experimental observations (Fig. 6) giving good validation of this study.

Figure 6. Open Water Characteristics for Deformed & Undeformed Shape.



Source: Authors

Deformation of this metallic propeller is found to be small and hence the hydrodynamic performance of propeller remains almost the same before and after deformation.

Study shows that a bronze propeller is rigid enough to hold its shape under operational conditions, so that its hydrodynamic performance is not affected due to structural deformations.

7. Future works

A composite propeller is expected to deform more than metallic one. The present propeller with composite material may be analysed to ascertain that. A detailed fluid-structure-interaction study will be carried out for this.

Nomenclature

D	Diameter of Propeller
J	Advance Ratio
K_t	Coefficients of thrust
K_q	Coefficients of torque
n	Revolution per second for propeller
p	Pitch
Q	Torque of Propeller
T	Thrust of Propeller
$U\infty$	Free-stream Velocity
η	Efficiency
μ	Viscosity
ρ	Density of Water

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 51 - 60

ISSN: 1697-4040, www.jmr.unican.es

Cost Efficiency Measures In Maritime Electronic Communications

R. Salama[1,*] and N. Şenbursa[2]

ARTICLE INFO

Article history:
Received 29 July 2013;
in revised form 15 August 2013;
accepted 30 October 2013

Keywords:
Electronic data Interchange, Maritime Electronic Communications, Transport Cost Reduction, Documents and Terms Standardization.

ABSTRACT

According to maritime specialist opinions, costs reduction thanks to technological advances and higher security on Electronic Data Interchange is one of the effects of globalization (Salama Benazar, 2009). Globalization has also promote increase in commerce and maritime transport. A forecast ending in 2020 indicates that container trade is expected to be 287 million TEUs in 2016, and to exceed 371 million TEUs in 2020 (ISL, 2008) and if efficiency measures relating communications and paper transactions are not taken, understanding and higher costs problems will be unavoidable. Due to this, it is essential to reduce paper documents in order not only to safe costs, but because of organizational and operational purposes. These facts motivated the main purpose of this study, to identify the main international organizations that have taken measures standardizing terms and documents and promoting electronic communications in order to present cost efficiency measures. The results are: a) The main measures have been taken by the United Nations, with the syntax called EDIFACT; b) even though international organizations have established parameters to facilitate maritime communications, none of the specialists consulted knew about this work and some of them use standardized abbreviations not knowing its complete meaning; c) 81,25% of the sample considered that electronic communications through standardized documents and terms, reduce the operational costs of their companies because of Savings in paper and ink consumption; 75% because of Time delivery reduction; 43,75% because of Reduction of physical files, among others. The methodology used was a documental and a field study. Documental to collect information regarding international organizations in charge of standardizing electronic terms and documents, and a field study to collect specialists opinion about costs decrease for EDI use and their knowledge of standardized terms and documents established by those organizations for electronic communications.

1. Introduction

International commerce has increased in higher percentage since 1970, with the generalized use of the container, the so called, information technology revolution and globalization (Salama Benazar and Martínez Marín 2012). During the period 2005 – 2012, the volume of world total exports grew in a higher percentage than the worldwide Gross Domestic Product GDP (World Trade Organization 2013), and taking into consideration than more than 90% of the total commerce is moved by sea (United Nations, 2010), it is evident the number of documents implied in all the transport logistic process, carrying a cost increase in the final product value. The increase in paper volume have represented a problem for maritime transport since it causes understanding (because of different documents and terms for different countries) and operational problems having to file innumerable transaction records and implying personnel hiring to perform the job. Because of this, in order to reduce costs, international organizations have been looking for trade facilitation and a better understanding among different countries, through documents and terms standardization by electronic communications. This study is useful because it shows measures took by international organizations in order to standardized documents and terms used in electronic communications, comparing them to those really used and known by maritime and logistic specialists.

It is said that if the last 50 year tendency of growth continue, instead of the 8.000 millions of Tons move nowadays, there will be a movement of 23.000 millions of Tons in 2016 (Stopford, 2010), reason why the paper reduction is essential to facilitate operations.

Other of the reason is that since its advent in the mid – 1960s, containerization has been responsible for integration within the transport chain (Brooks, 2000). Nevertheless, tra-

[1] Professor of: Multimodal Transport and International Business - Globalization. Coordinator of the Research Line in Maritime Business - Universidad Marítima del Caribe (Venezuela). Tel +584141183230 Email: rosanasalama@gmail.com.
[2] Ph.D Candidate in Nautical Science & Engineering & Master in Shipping Business, Maritime Law & Port Management by the Universitat Politècnica de Catalunya.
[*] Corresponding author.

ditionally, maritime transport comprised a well defined service of related but separate activities, with each participant being responsible for a limited part of the process (Siu Lee Lam, 2011). The maritime transport business is characterized by fragmentation of operating units and a requirement for an intensive network control (Graham, 1998).

Each of those fragments implies different documents to support the all logistic operations, including those at the port to import and export the cargoes. Referring to the output variables of the port system, most researches use the number of containers or cargo throughput to measure efficiency or assess port operation performance (Jim Wu and Goh, 2010), and a way to accomplish the port performance accelerating movements is the fast flow of information, which is possible if the electronic communication (EDI) is established.

When taking into account the input variables, several have been proposed, for example, (Tongzon, 2001) proposed the number of tugs and the amount of delay time as inputs, which also could be improved by an efficient electronic communication between liner shipping and port authorities, as well as consignees.

It could be said that information flow should occur simultaneously or previously to the passengers and goods flow, which would ensure administrative procedures simplification at the unique window, under the premise One Stop Shop (Martínez de Oses and Velásquez Correa, 2012).

Different international organizations have been looking for trade facilitation and transport costs reduction. This is why the general objective of this study is to identify the main international organizations that have taken measures standardizing terms and documents and promoting electronic communications in order to present cost efficiency measures.

Secondary objectives are: to determine maritime and logistics specialists knowledge about the work performed by international organizations in order to reduce costs through standardized terms and documents for its electronic use; to study the knowledge those specialists have about the meaning of the standardized terms and documents abbreviations they commonly use in their daily work and, to determine the reasons why they consider that terms and documents standardization and its electronic use are measures to accomplish cost efficiency in their enterprises.

2. Methodology

The methodology used to identify the main international organizations that have taken measures in standardizing terms and documents and promote electronic communications was a documental research.

The other methodology used to accomplish the secondary objectives was a field research through the survey technique, applying a questionnaire to an intentional sample of 16 maritime and logistic specialists from international companies of the sector.

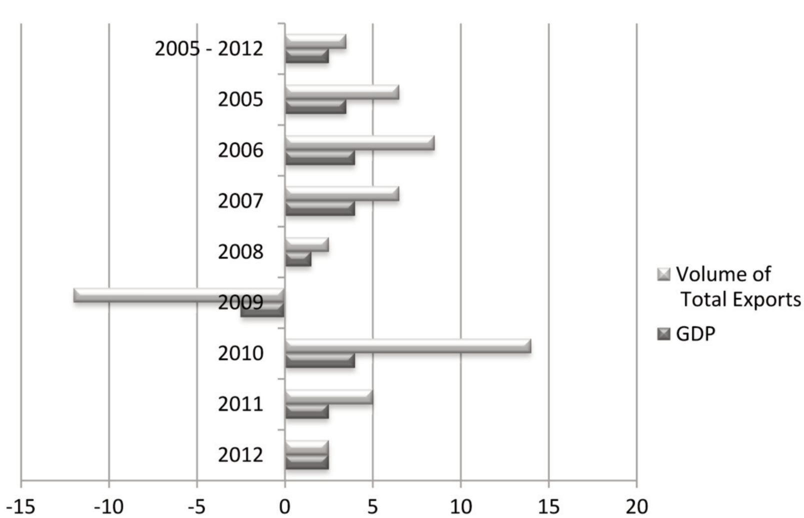
2.1. Maritime Transport Tendency

As mentioned above, volume of total exports has grown faster than Gross Domestic Product, GDP, which is a measure that represents the monetary value of gods and services production of a country during a period. This means that commence (which implied transport), have grown faster than production, originating a variety of documents to import and export between different countries. Graphic 1 shows the relation among the volume of total exports and GDP from 2005 to 2012.

According to Figure 1, world merchandise exports and gross domestic product (GDP) both grew by 2.5 per cent in 2012. World merchandise exports and GDP have recorded positive growth, except in 2009 due to the financial crisis, and from 2005 to 2011, World merchandise exports grew faster than GDP.

Such increase has also brought together a bigger demand on transport, creating a demand not seen before and a problem because of a higher volume of paper communications. Figure 2 shows the worldwide fleet increase by type of ship.

Figure 1. Volume of world merchandise exports and gross domestic product, 2005–2012.



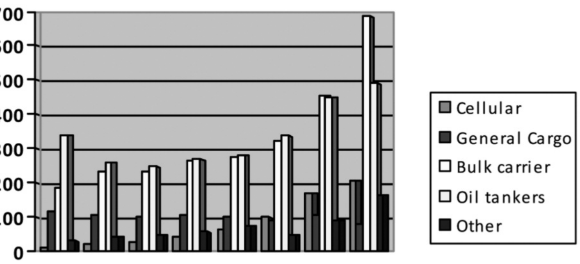
Source: World Trade Organization, 2013.

Bulk carriers and cellular ships represent the biggest increases in number of tons transported, which also have implied a documental increase in logistics and communications.

Container ships carry an estimated 52 per cent of global seaborne trade in terms of value and their share of the world fleet has grown almost eightfold since 1980, as goods are increasingly containerized for international transport (United Nations, 2013), reason why we refer to this type of ship in the present research when talking about documents and standardized electronic communication to safe costs in maritime transport.

On a related matter, and recalling that container trade remains largely serviced by regular liner shipping services, it appears worth noting that a recent study by the Economic and Social

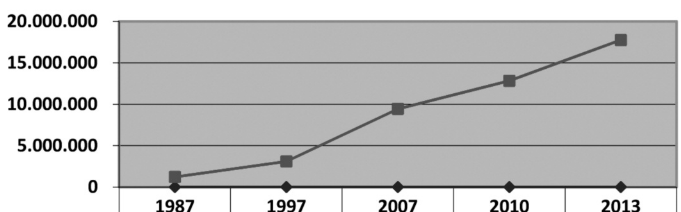
Figure 2. World Fleet at the beginning of each year (Merchant ships bigger than 100 GT. In millions of DWT).



	1980	1985	1990	1995	2000	2005	2010	2013
Cellular	11	20	26	44	64	98	169	207
General Cargo	116	106	103	104	101	92	108	80
Bulk carrier	186	232	235	262	276	321	457	685
Oil tankers	339	261	246	268	282	336	450	491
Other	31	45	49	58	75	49	92	166

Source: United Nations, 2013

Figure 3. Number of vessels and the total TEU´s moved worldwide in the period 1987-2013



	1987	1997	2007	2010	2013
Number of Vessels	1052	1954	3904	4677	5963
TEU´S Capacity	1215215	3089682	9436377	12824648	17750729

Source: Own construction based on (United Nations, 2010; Alphaliner, 2013).

Commission for Asia and the Pacific and the World Bank (Arvis, et al., 2013), covering more recent data, found that liner shipping connectivity – measuring the capacity of a country to carry its containerized foreign trade using liner shipping – had a stronger impact on trade costs than the indicators for "logistics performance", "air connectivity", "costs of starting a business" and "lower tariffs" combined (United Nations, 2013).

Such connectivity, to improve its efficiency, should be accompanied by a good understanding and rapid communications that can be accomplished thanks to documents standardization and Electronic Data Interchange (EDI) promoted by international organizations.

Regarding liner shipping, Figure 3 shows the number of vessels and the total TEU´s moved worldwide.

In 1987 the total number of TEU´s (Twenty Feet Equivalent Units) was 1.215.215, while in 2013 was 17.750.729 TEU´s, which represents a remarkable increase in quantity and volume. Such movements of containers have made ports to improve the way they work, since modernizing its infrastructures to change its operational activities, including paper form – filling and communications procedures. Improving port efficiency and productivity has become a critical yet challenging task in the development of many countries (Turner et al., 2004).

Taking into account Ships order book, it grew in a level without precedents, 42% in 2009 and 49% in 2010, compared to 2008, despite the economic crisis in 2007. (United Nations Conference On Trade and Development ,UNCTAD (2010, p. 15). By Marzo 2013, the total ship order book from 2013 to 2015 was 445 new ships. See Table 1.

Table 1 shows that until 2015 there is an order for 86 vessels between 3 and 5 thousand TEU´s, 90 orders for ships between 8 and 10 thousand TEU´s and 64 orders for vessels between 12.500 and 16 thousand TEU´s. This means that ports have to be prepared for more movements per ships arrivals, having the appropriate infrastructure as well as the capacity and adequate communications systems that help the cost reduction already got with the economy of scale due to bigger ships. A way to accomplish such costs reduction at ports is to eliminate paper documents, since it also implies personnel reduction to file documents. As studies performed in 2009 (Salama Benazar, 2009) and 2012 (Salama Benazar and Martínez Marin, 2012) showed, standardizing documents

Table 1. World Cellular Ships until Marzo 2013 by range of capacity in TEU´s.

Teus Size Range	In service today		On Order 2013		On Order 2014		On Order 2015		Total Ship on order	Total TEU´s on order
	Nº	TEU´s	Nº	TEU´s	Nº	TEU´s	Nº	TEU´s		
0 - 1.499	1.796	1.470.008	25	21.209	12	12.880	2	2.200	39	36.289
1.500 -2.999	1.214	2.648.592	47	99.932	16	33.740	4	8.800	67	142.472
3.000 - 4.999	953	3.910.309	67	284.434	11	50.736	8	29.500	86	364.670
5.000 - 7.999	606	3.686.379	26	160.868	18	95.500	2	13.800	46	270.168
8.000 - 9.999	284	2.432.948	42	368.178	39	343.156	9	81.400	90	792.734
10.000 - 12.499	52	568.028	10	104.800	12	120.000	3	30.000	25	254.800
12.500 - 15.999	119	1.601.293	23	305.916	31	412.686	10	139.350	64	857.952
Over 16.000	1	16.020	7	122.040	10	176.000	11	190.000	28	488.040
Total	5.025	16.333.577	147	1.467.377	149	1.244.698	49	495.050	445	3.207.125

Source: (Informa PLC, 2013, pp. 18-19).

and terms, and using EDI in communications, help to reduce costs in maritime transport and logistics.

Maritime transport is very cyclical and goes through periods of continuous busts and booms, with operators enjoying healthy earnings or struggling to meet their minimum operating costs.(World Trade Organization, 2013), reason why they continuously look for the way to reduce transport cost through trade facilitation.

2.2. International Organizations looking for cost efficiency measures through Standardizing Terms and Documents in Electronic Communications

The use of different modes to transport the cargo grouped in the container, represents an increase in the variety of documents and terms used for the entire process of delivering goods, which caused understanding problems, costs increases and goods delivery delays. Due to such problems it was necessary to harmonize processes, standardize terms, formats, and reduce the number of paper documents involved in the supply chain and the different modes of transport. International Organizations, based on information and communications technologies developments, have promoted terms, documents and processes harmonization, using electronic languages and codes to reduce paper in different transactions.

One of the recommendations to optimized administrative processes and-information flow is to use as often as possible electronic communication processes between operators and carriers. Certain transport companies will even offer the carrier reductions to use electronic communication for administrative tasks relative to transport. Furthermore, this mode limits typing errors and contributes to shipment errors reduction (Free Logistic, 2013).

In the area of trade facilitation intensive work on a global agreement continues under the auspices of the World Trade Organization. In this context, results from UNCTAD's research on national trade facilitation implementation plans illustrate that trade facilitation remains a challenge but is also seen as a priority area for national development by developing countries themselves. (United Nations, 2013)

Nowadays the use of individual modes of transport have been put aside by the integration logistic services and the multimodal transport, searching for security, costs reductions and just in time deliveries. The XXI century have also been characterized by the so called third revolution (Castells, 2006), making reference to the technology information advances that has allowed to facilitate communications regardless of the language and distance.

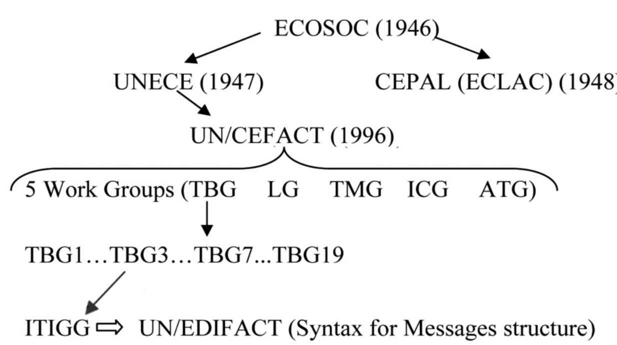
There have been standardizing initiatives in most sectors; i.e. mechanics, industrial, health, financial, among others. Concerning the maritime and multimodal transport area, it could be taken as a base the initiative of the United Nations (UN) through its different commissions, sections, subsections, working groups and projects, created for different fields regarding the maritime area.

Referring to the economical area, the UN Economic and Social Council (ECOSOC) have set up five Economic Commissions. The commission for Europe was set up in 1947, and called United Nations Economic Commission for Europe (UNECE). The Commission for Latin America was set up in 1948 and called Economic Commission for Latin America (ECLA). Lately, in 1984, the commission scope was broadened to include the Caribbean countries and its name was changed to Economic Commission for Latin America and the Caribbean (ECLAC) - the Spanish acronym is CEPAL. Although both commissions were established for economical aspects, it is the European one that has been focused toward trade facilitation through electronic business standards, working not only to facilitate trade in Europe, but worldwide. ECLAC, the Latin American Commission has been aimed mainly to social aspects.

According to the 19th UN/CEFACT Forum description, UNECE serves as the focal point to trade facilitation recommendations and electronic business standards, covering both commercial and government business processes that can foster growth in international trade and related services.

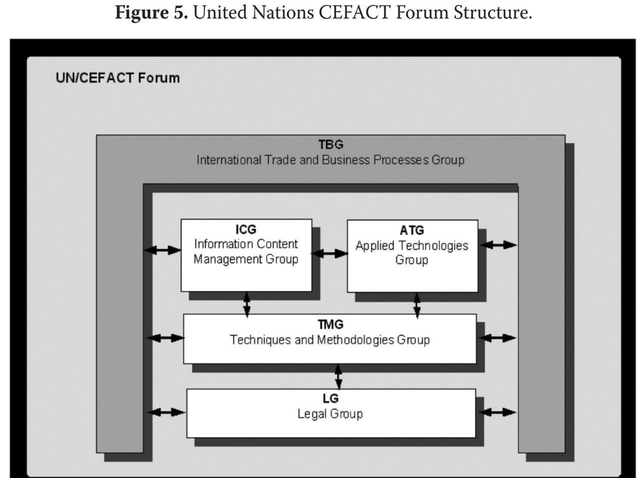
UNECE has more divisions, and UN/EDIFACT (United Nations/Electronic Data Interchange for Administration, Commerce and Transport) has been in charge of standardizing terms through electronic messages. A structure of United Nations Division for economic and transport terms standardization is shown in figure 4, 5 and table 6.

Figure 4. United Nations Structure for facilitating Trade and Commerce.



Source: (Salama Benazar & Martínez Marin, 2012)

Figure 5. United Nations CEFACT Forum Structure.



Source: (Vankenmel, 2009)

Table 2. Composition of the UN/CEFACT TBG Groups.

TBG 1 Supply Chain / e-Procurement	TBG 10 Healthcare
TBG 2 Digital papers (UNeDocs) *created Marzo 05*	TBG 11 Social Security, Employment & Education
TBG 3 Transport/Logistics	TBG 12 Accounting and Auditing
TBG 4 Customs	TBG 13 Environmental Management & Safety
TBG 5 Finance	TBG 18 Agriculture *created Marzo 05*
TBG 6 Architecture, Engineering & Construction	TBG 19 e-Government *created Sept 05*
TBG 7 Statistics	Others: Harmonization, Business Process Analysis, International Trade procedures…..
TBG 8 Insurance	

Source: (Vankenmel, 2009)

The TBG3 has an official subgroup created in 1995, the International Transport Implementation Guidelines Group, ITIGG, which mission is to provide principles and rules for production of consistent and harmonized implementation guidelines and user´s manuals of UN/EDIFACT and XML transport messages throughout the world.

Some standardized electronic messages created by EDIFACT per area, are the following (Free Logistic, 2012):

Besides of the United Nations Committees, there are also the UN Agencies and the main one related to maritime transport is the International Maritime Organization (IMO), with responsibility for the safety and security of shipping and the prevention of marine pollution by ships. IMO has its background in a UN Conference held in 1948, when it was decided to adopt a convention exclusively to maritime matters. It was adopted ten years later, in 1958, (International Maritime Organization, 2012). Then, due to the concern of maritime nations regarding the number of separate documents required

Tabla 3. Electronic messages created by EDIFACT

Production and Logistics	**Dangerous Goods Movement**
DELFOR Delivery Schedule Message	IFTDGN Dangerous Goods Notification Message
DELJIT Just-In-Time Delivery	IFTIAG Dangerous Cargo List Message
DESTIM Equipment Damage/Repair Estimate Message	SAFHAZ Safety and Hazard Data Sheet
PRODEX Product Exchange Message	**General Transport**
QALITY Quality Data Message	BAPLIE Bayplan - Occupied and Empty Locations Message
RECADV Receiving Advice Message	BAPLTE Bayplan - Total Numbers Message
Customs	GATEAC Gate and Intermodal Ramp Activities Message
CUSCAR Customs Cargo Report Message	IFTMAN Arrival Notice Message
CUSDEC Customs Declaration Message	IFTMBC Booking Confirmation Message
CUSEXP Customs Express Consignment Declaration Message	IFTMBF Firm Booking Message
CUSREP Customs Report Message	IFTMBP Provisional Booking Message
CUSRES Customs Response Message	IFTMCS Instruction Contract Status Message
PAXLST Passenger List Message	IFTMIN Instruction Message
SANCRT Sanitary/Phytosanitary Certificate	IFTFCC International Freight Costs and Other Charges
Container Movement Messages	ITRGRP In-Transit Groupage Message
CALINF Call Information Message	ITRRPT In-Transit Report Detail Message
COACOR Container Acceptance Order	MOVINS Stowage Instruction Message
COARCO Container Arrival Confirmation	REACTR Equipment Reservation, Release, Acceptance and Termination Message
COARIN Container Arrival Information	VESDEP Vessel Departure Message
COARNO Container Arrival Notice	**Forwarding**
COARRI Container Arrival Message	HANMOV Cargo/Goods Handling and Movement Message
CODECO Container Departure Confirmation	IFCSUM International Forwarding and Consolidation Message
CODENO Container Customs Documents Expiration Notice	IFTCCA Forwarding and Transport Shipment Charge Calculation Message
CODEPA Container Departure Message	IFTRIN Forwarding and Transport Rate Information
COEDOR Empty Container Disposition Order	IFTSAI Forwarding and Transport Schedule and Availability Information
COHAOR Container Handling Order	IFTSTQ International Multimodal Status Request
COITON Container Inland Transport Order Notice	IFTSTA International Multimodal Status Report Message
COITOR Container Inland Transport Order	**Transaction**
COITOS Container Inland Transport Response	COMDIS Commercial Dispute Notice Message
COITSR Container Inland Transport Space Request	DESADV Dispatch Advice Message
COOVLA Container Overlanded	INVOIC Invoice Message
COPARN Container Pre-Arrival Notice	ORDCHG Purchase Order Change Message
COPDEM Container Pre-Departure with Guidelines Message	ORDERS Purchase Order Message
COPINF Container Pick-Up Information	ORDRSP Purchase Order Response Message
COPINO Container Pick-Up Notice	PARTIN Party Information Message
COPRAR Container Pre-Arrival Message	PRICAT Price/Sales Catalogue Message
COPRDP Container Pre-Departure Message	QUOTES Quotation Message
COREOR Container Release Order	REQOTE Request for Quote Message
COSHLA Container Shortlanded Message	SLSFCT Sales Forecast Message
COSTCO Container Stuffing Confirmation	SLSRPT Sales Data Report Message
COSTOR Container Stuffing Order	PRICAT Price/Sales Catalogue Message
	QUOTES Quotation Message

Source: Authors

from port to port, its variety, number of copies and, as bigger burdens, the language of each one, the paper size and governmental requirements for all vessels traffic, they decided that the situation could not be allowed to deteriorate further and, to take action, governments turned to IMO by the early 1960´s. As a consequence, the FAL 65 was adopted to assist the facilitation of international maritime traffic. Among its objectives are "to prevent unnecessary delays in maritime traffic, to aid co-operation between Governments, and to secure the highest practicable degree of uniformity in formalities and other procedures" (International Maritime Organization, 2012). In particular, the Convention reduces the number of documents which could be required by public authorities to ship. Some of them are:

Table 4. Documents which could be required

• IMO General Declaration	• Cargo Declaration
• Ship's Stores Declaration	• Crew's Effects Declaration
• Crew List / Passenger List	• Dangerous Goods

Source: Authors

The 1992, 1996 and 1999 FAL´s 65 amendments include documents and processes standardization and electronic Business as follows:

Table 5. Documents and processes standardization and electronic Business

1992	1996	1996
Electronic data processing / electronic data interchange (EDP/ EDI)	Passenger list	Arrival, stay and departure of ships
Submission of pre-import information	Pre-arrival clearance,	Passengers, crews and cargo
Clearance of specialized equipment	Pre-import information	The use of electronic data interchange (EDI) for ships clearance purposes

Source: Authors

The last amendments (2005), include a Recommended Practice for public authorities to develop the necessary procedures in order to use pre-arrival and pre-departure information to facilitate the processing of information, and thus expedite release and clearance of cargo and persons; a Recommended Practice that all information should be submitted to a single point to avoid duplication; also encourages the electronic transmission of information· (International Maritime Organization, 2012)

UN/CEFACT works together with other organizations standardizing processes, for example, the ISO and OASIS. Those international organizations also have taken cost efficiency measures through paper reduction standardizing terms and documents and promoting EDI as is explained below.

2.3. International Standardization Organization (ISO)

ISO, founded in 1946, is the world's largest developer and publisher of International Standards. Its abbreviation "ISO", derived from the Greek isos, meaning "equal". It is a non-governmental organization that forms a bridge between the public and private sectors.

It works through Technical Committees. The ones related to transport are:

Table 6. Technical Committees

TC 8 Ships and Marine Technology	TC 104 Freight containers
TC 22 Road Vehicles	TC 122 Packaging
TC 52 Light gauge metal containers	TC 154 Processes, data elements and documents in commerce, industry and administration
TC 96 Cranes	TC 172 Document management applications
TC 110 Industrial trucks	TC 184 Automation systems and integration
TC 101 mechanical handling equipment	

Source: Authors

The EDIFACT syntax rules were agreed in the ISO Committee TC154, to be an international standard (ISO 9735) in September 1987.

Some countries, as Venezuela, are not signatory countries of ISO; nevertheless standardization established by ISO is applied in different fields, including the maritime and industrial one.

2.4. Organisation for Advancement of Structured Information Standards (OASIS).

OASIS is a not-for-profit consortium that drives the development, convergence and adoption of open standards for the global information society. The Consortium hosts two of the most widely respected information portals on XML and Web services standards, Cover Pages and XML.org (Organisation for Advancement of Structured Information Standards, 2012).

OASIS, together with the UN/CEAFCT, launched a project in 1999, the ebXML that stands for Electronic Business Extensive Markup Language. The project objective is to define specifications for a XML exchange architecture. Standardization roles split between (Vankenmel, 2009):

— UN/CEFACT: semantic contents, data and business models based on the considerable asset of EDIFACT, and
— OASIS: technical infrastructure allowing to share registries /dictionaries.

The ebXML is also related to ISO, since its Technical Committee 154 (TC154) has published specifications for ebXML. ISO TC154 supports development and maintenance of application specific standards for: process specification (in the absence of development by other technical committees); data specification with content; forms-layout (paper / electronic), (OASIS, 2012).

With its focus on e-business, ISO TC154 is involved in work that relates to many OASIS Technical Committees and the UN/CEFACT

The last ISO bulletin related to maritime transport standardization data from February 2011. It is the ISO 28005-2:2011, which contains technical specifications that facilitate efficient exchange of electronic information between ships and shore for coastal transit or port calls. It is intended to cover safety and security information requirements related mainly to the relationships between the ship, the port and coastal state authorities. It can also be used for information exchanges between the ship and the ship agent, the port and ship operator or manager, but not necessarily cover issues such as customs clearance of imported or exported goods or transport service provisions to goods owners. It does not define the message structure, but contains definitions of data elements for Port Electronic Clearance. Those elements are reported as defined in other International organizations such as IMO through: FAL 65, ISPS code (International Ship and Port Facility Security), Resolution A.862 Bulk loading and unloading code, Resolution A.960 ETA reporting to pilot stations. (International Organization for Standardization, n.d.).

Besides international organizations initiatives, there is also a software platform for e commerce called INTTRA which is used by the largest global Freight Forwarders and Shippers. It is used at least by over 30 active carriers, representing 75% of global capacity and originated 15% of global container freight in 2011. (Bunch Rayonier, 2013)

Some of the benefits of using INTTRA are (Bunch Rayonier, 2013):

— To shorten the Booking Cycle: Submit booking requests to all your carriers through one system and receive confirmations online.
— To improve Data Quality and Compliance: Submit shipping instructions with standard templates and set notify parties within a single form.
— To Minimize Transit Delays: Receive and process Bills of Lading quickly
— To achieve Cost Savings: Use INTTRA's eInvoice to save time and money through bill presentment and automated dispute resolution.
— To increase Visibility Track your INTTRA processed shipments and create standard reports to view all your booking and SIs by carrier or by date

"INTTRA has played a key role in standardizing booking and documentation processes. It has enabled both carriers and shippers to take cost out of the supply chain and improve the services provided to our ultimate customers." (Bunch Rayonier, 2013).

2.5. Survey Results

Referring to the questionnaire applied to maritime and logistic experts, it was chosen an intentional sample composed by 16 experts from different international maritime and logistic companies in order to identify what standardized terms (EDIFACT messages) and documents they know and use through Electronic Communications and why they consider its use as a tool to safe costs in maritime transport and logistics, including port operation and efficiency.

It is important to say that an EDIFACT message is a single business document. Each message is identified by a six character name. The specialists interviewed did not know about the existence of this syntax, but they did mention among the harmonized documents and terms used, some of those from UN/EDIFACT and other standardizing initiatives. In other words, EDIFACT syntax was use, however specialists interviewed were not fully aware of the terminology used and level of standardization implemented. In some cases they use the abbreviations without knowing the meaning but just what it was use for.

Bellow are presented the documents mentioned by the specialists of the survey and that match with those defined by the EDIFACT, even though they do not know that those are terms defined by an international organization to accomplish cost efficiency measures.

Table 7. Stan dardized documents used by maritime and multimodal specialists.

Standardized documents used by maritime and multimodal specialists	**EDIFACT Message**
Purchase Orders	ORDERS
Instruction Message	IFTMIN
Arrival Notice	IFTMAN
Invoices	INVOIC
Customs Declaration	CUSDEC
Quotation	QUOTES
Sanitary/Phytosanitary Certificates	SANCRT
Delivery Order	DESADV (Despatch Advice Message)
Stowage Plan / Bay Plan	BAPLIE
Booking	COPRAR

Source: Authors

Other important documents, due to its extended use, are harmonized in different maritime glossaries, including that presented by ISO and mentioned before, the Bulletin ISO 28005-2:2011. That is the case for the fallowing documents mentioned by the specialists of the sample: B/L (Bill of Lading); HBL and MBL (House B/L and Master B/L); AWB (Airway Bill), NOR (Notice of Readiness), CM (Cargo Manifest), FC (Freight Certificate), EMC (Electronic Manifest Corrector); DRV (Daily Report of Vessels); SCD (Single Custom Declaration or DUA in Spanish); LOP (Letter of Protest); LOI (Letter of Indemnity); MOA (Memorand of Agreement); Packing List; Shipping List; SOA (Statement of Account).

When asking the interviewed specialists what standardized terms they commonly use in their daily work, the answers were:

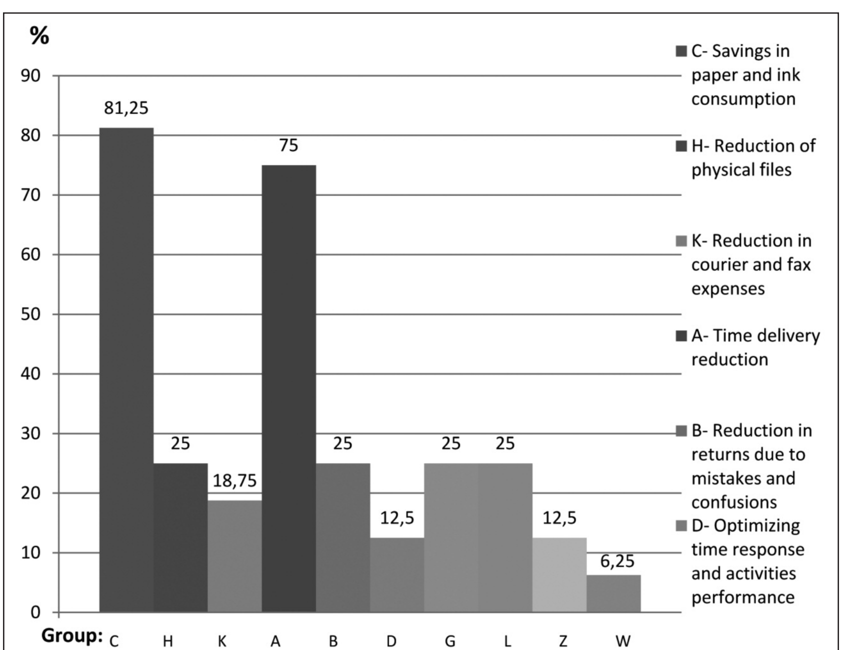
BAF (Bunker Adjustment Factor); Ballast (Ballast water); Bkr (Broker); CBM (Cubic Meters); CFR, (Cost and Freight); CFS (Container Freight Station); Chrts (Charters); CIF (Cost, Insurance and Freight); CIP (Cost and Insurance Paid); Cnee (Consignee); CP (Charter Party), DD (Dry Dock), Demurrage, Detention; DDU (Delivery Duty Unpaid), INCOTERM already out of use ; ETA (Estimated Time of Arrival); ETD (Estimated time of Departure), EXW (Ex Works); FAS (Free along Side Ship),; FCL (Full Container Load); FEU (Forty Equivalent Unit); FIFO (Free In and Free Out); FIOST (Free In, Out, Stowed and Trimmed); FOB (Free on Board); LNG (Liquefied Natural Gas); M/V (Moto Vessel); NOA (Notice of Arrival); NVOCC (Non Vessel Operator Common Carrier); ORC (Origin Charge); POD (Port of Discharge); POL (Port of Load; SOF (Statement of Facts); SS (Special Survey); TEU (Twenty Equivalent Unit); THC (Terminal Handling Charge); ULCC (Ultra Large Crude Carrier); VLCC (Very Large Crude Carrier), Wharfage.

When asking the sample about three reasons that they considered electronic communications and documents/terms standardization to have act as cost efficiency measures, the main answers of specialists are shown in Figure 6

The answers represented in Figure 6 were those reasons why maritime and logistic specialist considered that standardized terms and documents used in electronic communications are cost efficiency measures that reduce costs in their companies.

The percentages are: 81,25%: savings in paper and ink consumption; 75%: Time delivery reduction; 43,75%: reduction of physical files; 25%: speed in information interchange vital for the company; 25%: reduction in returns due to mistakes and confusions; 25%: minor personnel hiring; 18,75%: reduction in courier and fax expenses; 12,5%: speed locating information; 12,5%: optimizing time response and activities performance, and 6,25%: precision to accomplish efficiency .

Figure 6: Maritime and logistics specialist opinion about why they considered electronic communications and documents/terms standardization to have act as cost efficiency measures in their enterprises



Source: Own construction based on data from questionnaires applied to specialists (2012)

3. Conclusions

The initiatives to harmonize documents, terms and processes in maritime and other modes of transport, looking for cost efficiency measures in maritime electronic communications, data from 1948, with inquire of various maritime countries governments that went to the UN looking for regulations, then, 10 years later, IMO was created in order to attend maritime requirements. The documents harmonization commonly use is that established by the United Nations, mainly through the EDIFACT syntax, as well as those established by the ISO.

The interviewed maritime specialists do not know about the existence of the EDIFACT syntax as a measure for cost efficiency, but they do use harmonized documents defined by UN/EDIFACT and considered that its use contributes to costs reductions. The main documents used by specialist of the sample and defined by EDIFACT are: ORDERS, IFTMIN, INVOIC, CUSDEC, QUOTES AND BAPLIE. The most common document use as a standardize one is the waybill (Bill of Lading and Airway bill), harmonized by shipping lines and IATA (International Air Traffic Association) respectively and controlled by special rules.

Regarding the standardized terms mentioned by the specialists interviewed as the most used in its daily work are those corresponding to the INCOTERMS (International Commerce Terms), not knowing about the disappearance of some of them in the new INCOTERMS 2010; also, those related to liner freight rates surcharges. As examples are: DDU (INCOTERM out of use); THC, ORC and BAF: Surcharges to the freight rate; FIFO, LIFO and FIOST: Liner terms. In some cases specialist do not know the meaning of the standard abbreviations th ey use, but they do know what are they used for.

Maritime and logistic specialists consider the following reasons why EDI and standardize documents and terms (paperless) contribute to costs reductions in their companies:

- Savings in paper and ink consumption
- Time delivery reduction
- Reduction of physical files
- Speed in information interchange vital for the company
- Reduction in returns due to mistakes and confusions
- Minor personnel hiring
- Reduction in courier and fax expenses
- Speed locating information
- Optimizing time response and activities performance, and
- Precision to accomplish efficiency

Recommendations

This study could be amplified including other international organizations in charge of standardizing terms and documents shared by electronic communications, as well as applying the questionnaire to a bigger sample located in different countries

A suggestion to specialists is the review of the already existing standardized terminology in order to use it by electronic media and achieve a cost efficiency performance.

It is also recommended an study to identify the reasons why specialists do not know about the existence of a syntax language created by the United Nations and other organizations in order to facilitate commerce, and find out about what could be done to divulgate, to specialists, the common standardized terms and documents used in maritime and logistics electronic communications and its meaning, since its use points to cost efficiency measures.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 61 - 68

ISSN: 1697-4040, www.jmr.unican.es

Maritime Transport: A Theoretical Analysis Under a System's Approach

J. E. Martínez[1,*], M. L. Eguren[2]

ARTICLE INFO

Article history:
Received 02 August 2013;
in revised form 17 August 2013;
accepted 3 November 2013

Keywords:
Maritime transportation, competitive advantages, value management, systems approach.

ABSTRACT

Historically, maritime transportation has been the most common method to transport significant volumes of goods and creating commercial relationships between markets.

However, as a consequence of the evolution of the international commerce, other models have increased their relevance due to certain factors: specialization of the customer services (door to door), technological evolution, and geopolitical changes which extends the logistics chains beyond the port. Land transportation (by truck), the use of the rail transportation to move significant volumes of goods, air transportation for specialized cargo and shipping which require fast delivery, and the appearance of Intermodal transport, as the Motorways of the sea, in the case of Europe, show the need to analyzed and understand in details the current model on maritime transportation in order to identify and maximize their competitive advantages thru the identification of the value drivers.

In the value management, the most used and known methodology is the Porter Value Chain, for which all the system's approach methodologies are applicable. Using this scope, a theoretical analysis will be performed over the activities and maritime process, identifying stakeholders, value drivers and competitive strategies.

1. Introduction

Historically, shipping has been the most common method used to move large volumes of merchandise and create business relationships between different markets, coming to carry more (under the WTO) over 90% of the goods moving worldwide.

However, due to the evolution of international commerce, have taken relevance other transport models due to the specialization of customer service (door to door), technological developments and geopolitical restructuring, extending the supply chain beyond the port. Ground transportation (Truck), the use of rail transport for significant volumes, air travel for specialized loads which require a limited time, and the emergence of mixed models (intermodality) such as motorways of the sea like the Mediterranean Corridor, makes it necessary to analyze and understand in detail the current shipping model to detect and enhance their competitive advantage through the identification of value drivers.

The study of the supply chain considering the context implies going beyond the operators who execute the process, as a deeper analysis is required considering the relevance of the whole system from an economical perspective.

To make the overall system a good performance of each of the components that comprise it is required, this, in the logistics chain is applied to each of the nodes within it.

From the origin of the chain within the manufacturer until the final customer at the destination point, several processes are performed, each of them of vital importance without which it would be impossible to reach the objective. If we add to this the importance of cost reduction strategies, which in times of crisis (Martinez and Eguren, 2009) is one of the most important tasks of shipping companies, a great pressure is generated into the process to avoid unnecessary costs directly affecting all the components of the supply chain.

This situation generates value management requirements, which is the study of this investigation.

Within the value analysis, the most commonly used method is the Porter value chain, on which systems analysis methodologies (Eguren and Castán Farrero, 2011) are applicable. For this reason, the theoretical analysis presented in this research will consider both sides, one side chain model of the actual value and the other, the systemic approach.

Due to the nature of this article, no case studies or practical cases developed. However, it is a possible line of research for future collaborations.

[1] Department of Nautical Sciences & Engineering. Faculty of Nautical Studies of Barcelona. Universitat Politècnica de Catalunya. Pla de Palau 18, 08003, Barcelona, Spain. Email: jemartinez@cen.upc.edu, Tel +34627292448.
[2] Universitat de Barcelona, Faculty of Business & Economy; Department of Economy and Business Organization. Av. Diagonal, 690-696 08034 Barcelona, Spain. Email: mleguren@gmail.com, Tel +34626397877.
* Corresponding author.

2. The value chain

According to Fernández et al. (2006) value chain is defined as the set of activities performed by the company in order to transform raw materials into finished products that are then distributed to final consumers.

In this sense, the value chain of a company includes a series of activities, processes, resources and objectives that relate to each other generate "value" for the company. According to Porter (1985) that value is the amount that buyers are willing to pay for what the company provides.

Considering all those processes and activities that somehow are involved in the process of transformation and value creation, it can be seen following the scheme of Porter (1985) that such activities can be classified into two groups:

2.1 Primary Activities

Those directly involved in the production process of the company, understood in this sense as Navas y Guerra (2007) those activities that are physically part of the process of production, transfer and post-sales service to the customer. The main areas that are included in this sector are:

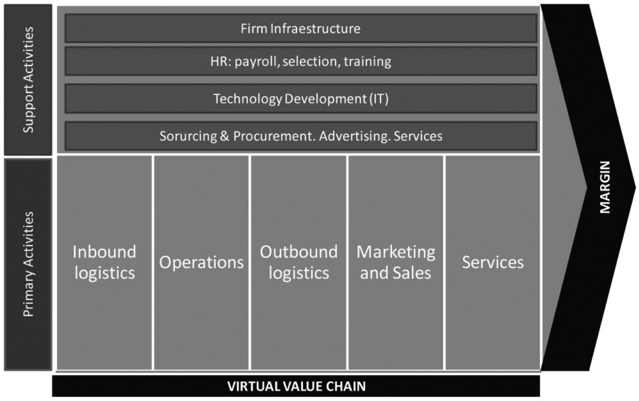
- Inbound logistics or input factors: receipt, storage, inventory control and internal distribution of raw and auxiliary materials.
- Operations / Production: transformation of factors into products or services.
- Outbound logistics: warehousing and distribution of finished product to the customer.
- Marketing and Sales: activities aimed at selling the product.
- After-sales service: Customer-oriented to service and maintain their satisfaction once made the sale activities.

2.2 Support Activities

As indicates its name are the activities which collaborate and support the primary activities. Among them are:

- Procurement and Sourcing: procurement activities both productive and non-productive material (including services and advertising)

Figure 1. Porter Value Chain.



Source: Porter (1985)

- Technological development (IT): activities involved in the development and improvement of new products and production processes and management.
- Human resource management: activities that include all the administration of the human resources of the company (recruitment, training, etc).
- Firm Infrastructure: company business activities oriented management, planning and control of all primary and support activities that sustain it.

From the above it can be seen that the value chain is a vision of the company according to the activities and processes that accompany it in its vital development from the acquisition of raw materials to the sale and service-after sales of the final product.

In this sense, the value chain of the company, is an analysis tool that allows you to view the same position within their environment and internally at all the processes that compose it, making way for a number of possibilities that we will see below, which relate to design, incorporating or not activities, their interrelationships and subcontracting among others.

If the company in its environment is analyzed, we could observe from a general approach that it consists of its own activities, relationships with suppliers and customers and relationships with external agents that somehow have an influence on the company.

In this regard, the activities of an enterprise "start" on a sequential basis at the time that the "raw material" is acquired and ends at the time that "sells" the product or part thereof which it is made . However, a company may not include the entire process from the exploitation of raw materials from nature to sell the product to the final consumer.

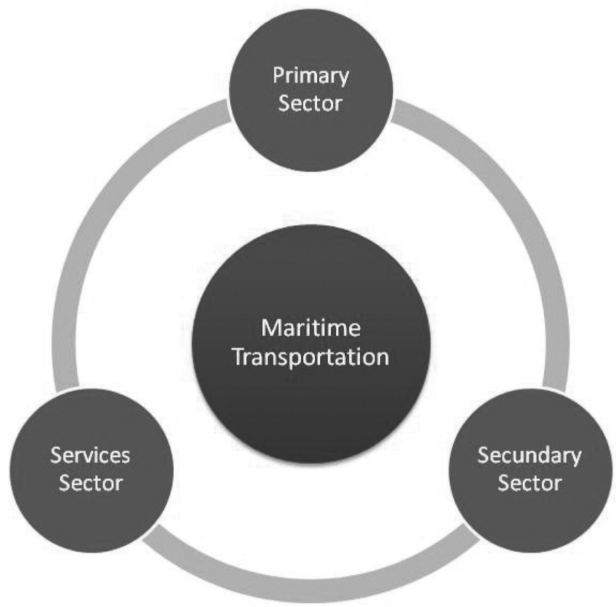
Because of this distinction must be made between two concepts: the value chain explained previously and that includes those activities of that company and the value system (Guerras and Navas, 2007) consists of all activities (and value chains of different companies) contained from the exploitation of the raw material in nature to final sale.

As a first consideration, the shipping process itself is part of the value system of the majority of companies that require transporting goods from one place to another. As can be seen, it is a rather broad definition and is involved in all economic sectors: primary (agriculture, livestock, mining, fisheries and forestry), secondary (manufacturing and processing of raw materials into finished products or semi-finished) and services as well as applied to different types of business (small and medium enterprises, multinationals...). This is one aspect to consider in the analysis and development of competitive strategies based on vertical integration.

Taking the above into consideration, the process of shipping (considering the activities included from the source provider and target client) can be described by the following scheme:

Which can be seen as a symmetrical process, initially considering the processes performed in the geographical area of origin and destination. Additionally, and as discussed below, these processes develop in defined areas and logistics with the help of actors and agents required to support each of the processes involved:

Figure 2. Maritime Transportation and their value systems.



that this function is performed by an agent with legal and professional capacity (Freight), which is acting on behalf of the shipper, deals with the necessary steps to make the goods available to the vessel contracted for transport.

2.2.3. Freight forwarder
A professional who plans, coordinates controls and directs all actions necessary to perform the international freight operations, as well as complementary services, by any kind of transportation; is usually known as "The Architect transport ". Should be remarked that includes the ground transportation required in the process as well as the maritime transportation required. This stage of the process will be discussed later in developing competitive strategies associated.

2.2.4. Shipping Agent
It is the natural or legal person duly registered in the administrative agencies, serving the needs of ships while in port / s of the country inhabited by the consignee. Owner and represents their interests before the authorities of the country where the ship is. Responsible for provisioning the ship, and

Figure 3. Maritime transportation process.

Source: Own elaboration

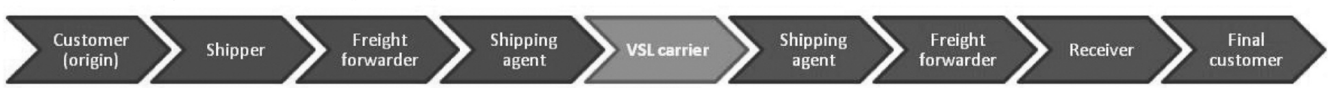
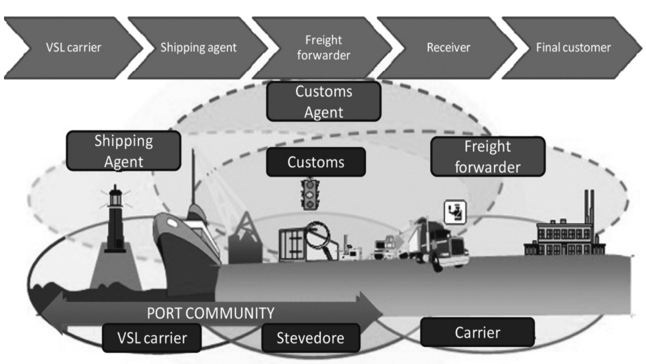


Figure 4. Scopes of maritime transportation.



Source: Own elaboration adapted from several authors.

It is therefore necessary to define the main activities within the above process:

2.2.1.Client (origin)
Natural or legal person initially owns the goods to be transported to the final customer. Normally, this process will delegate transport actors below.

2.2.2. Shipper
According to the spanish code of commerce, is the natural or legal person that delivers goods to the ship-owner, the master of the vessel or its agent at the port of loading to be transported by sea. In the bill of lading (English Bill of Lading or their initials BL), is defined as "Shipper". However, in practice it can be said

for handling all matters of legal representation, and attention to the ship's crew.

In the case of shipping containers, for example, are responsible to provide containers suitable for charging customers, if a shipping no containers can not meet the needs of the customer (Martinez and Eguren 2009), those needs are affected for various reasons, but the priority is that there is always equipment available in good condition to meet the demands of an export line.

2.2.5. Vsl carrier
In this case we refer to the vessel operator (which is not always the owner), which is responsible for transporting the goods from the source port to the destination port. In general, it is the natural or legal person who takes a commitment of transporting goods by sea from one place to another through a contract with the merchant that is embodied in the Bill of Lading.

2.2.6. Consignee -receiver
In this case we refer to the vessel operator (which is not always the owner), which is responsible for transporting the goods from the source port to the destination port. In general, it is the natural or legal person who takes a commitment of transporting goods by sea from one place to another through a contract with the merchant that is embodied in the Bill of Lading.

2.2.7. Final customer
Natural person or entity receiving or end buyer of the goods transported from the initial customer.

In order to proceed with its analysis under the value chain model, it is necessary following the systemic approach to first define the elements that compose it.

3. Value model application

As previously mentioned, as part of the systemic methodology, the first step is the identification and definition of the various components of the system, their common objective, scope and limitations:

3.1. Objective

Transporting a good from the place of origin to its final destination in this case assuming that no physical transformation along the process is performed.

3.2. Scope

The process starts from the initial customer and ends at the end customer

3.3. Limitations

Cases in which the good undergoes a physical transformation along transportation is not contemplate.

3.4. Raw material (system inputs)

Good to be transported.

3.5. Final product (System outputs)

Considering that the product undergoes no transformation throughout the process, physically it will be composed of the same physical good transported more value those elements incorporated throughout the process.

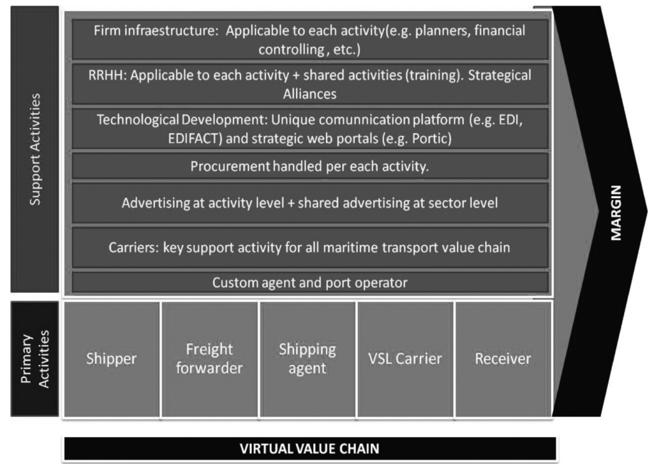
Additionally, different flows should be considered applicable to the system, from a logistical point of view and are defined as follows:

- *Flow of physical load:* Is that corresponds to the movement of the goods from the source of production to consumption.
- *Flow of transport:* The different modes of transport with their vehicles and routes between different nodes of the system.
- *Flow of information:* it must be parallel to the load current.
- *Financial flow:* to be established according to the contractual arrangements defined in each stage of the process and should be aligned with the flow of the physical load.

Once defined the parts that define the system, the specific processes that links it in order to identify the value drivers and therefore of possible competitive advantages. The result of this analysis is shown in the following figure is explained below:

As can be seen, we have proceeded to identify key processes and activities under the conceptual framework of

Figure 5. Maritime transportation modeled by Value Chain.



Source: Own elaboration.

the value chain under both types of activities covered by that methodology: primary activities and support activities.

4. Primary activities

As can be seen, the names of the activities defined match the different links above. However, it should not be confused with the concept of the concept of activity actor. In this case we refer to the functions performed by each of these figures within comprehensive process of shipping.

As discussed above, an object of study is the degree of integration between the different activities and their strategic management as regards the various support activities. This theme will be developed further in the next section.

5. Support activities

According to Porter's methodology, this section includes all those transversal activities that support the main process (primary activities). It's important to remark a key factor when modeling theses activities and this is their scope of application: in many cases these activities are common but specific to the activity mentioned, but in other cases, and given the level of integration is related to strategic activities affecting several primary activities.

In this regard and as a first approximation defined the following activities:

5.1. Company infraestructure

By definition, consists of all activities of management, planning and control of primary and support activities. For each of these activities would be made by the specialized profiles however we would not be talking about an integrated but rather particular for each function. This group would be included profiles such as planners, financial controllers, auditors, inspectors and others.

5.2. HR

As in the previous case, both the management of payroll and personnel is specific to each of the activities, however for training and education deserves special attention. In this case we speak of training and strategic training commonly accepted and designed specifically for the sector. Additionally, and given its strategic and competitive importance, such programs are often provided with public uprisings and the European Community (in the case of Europe).

5.3. Technical development (IT)

For this activity one can speak of a high degree of maturity in their horizontal integration. The existence of standardized communication protocols (such as EDI, EDIFACT) and strategic portals (eg Portic) allowing the use of a single system allow to increase process efficiency by reducing bureaucracy, paper use errors in data communication and thus by reducing the cost.

5.4. Procurement

Each of the activities is responsible for the process of indirect purchases. However, it seems to be a very relevant topic or endowment studied as it has been proven to perform this investigation. And precisely because of this, it can be one of the potential sources of competitive advantage to consider as will be discussed later.

5.5. Advertising

As in the case of infrastructure and human resources, should be considered the actions of individual advertising each of the specific activities and otherwise be considered strategic actions at the sector and various associations.

5.6. Carriers

The most relevant support activity for all primary activities. Inside it should be considered trucking companies and rail transport. Its strategic value should be considered in the development of intermodal mixed models as well as various strategic alliances under the win-win approach and quality service as a competitive strategy.

5.7. Customs

Activity performed by the customs agent that is defined as follows: Current legislation recognizes the "Representative Customs", whose definition is to be specified, however, functions can be defined as follows considering at all times the current legislation Local and implement "are natural or legal persons, depending on the specific laws of each country, which provide the necessary management before state agencies that collect taxes (Customs) on behalf of importers." Services activity affecting all primary activities mentioned above, plus according to its management can directly affect the costs associated with the goods transported and therefore its associated value. In this sense, the strategic actions on this activity should take place in a legal and educational framework that allows proper management and cost estimation and risk.

5.8. Port operator

Formally on the "legal person who operates or manages, as applicable, the grant of the port terminal and operates its services in the port of origin / destination". Its functions are common to all the primary activities and their competitive advantage depends on their relative vs. local or other ports in direct competition due to the routes used. In this regard the development of their competitive strategies should be developed in all areas, reduced costs, increased quality of service and strategic alliances.

6. Competitive advantages and opportunities

According to Guerras and Navas (2007), the value generated by the company (also called margin or profit) is derived from the value generated by each of the activities on the final product minus the costs associated with each:

$$\text{Value Created by the company} = \sum (\textit{Activity Value-Activity Cost})$$

In this sense, when analyzing how value is being generated the following items should be considered:

- The interrelationships between the activities of the company
- The interrelationships within the system value.
- The interrelationships between business activities in diversified firm

According to Porter (1985) relationships within the company, is a factor in achieving competitive advantage in two main ways (Guerras and Navas, 2007):

- Optimization: Doing an activity differently, can enable cost reduction in its activity and other activities.
- Coordination: A high degree of coordination allows the activities involved behave more efficiently.

The degree of interaction between the different activities and their alignment with a common goal, is fundamental to the operation of the company (Gimbert, 1998) factor. A company whose communication and activities are aligned with the objective understanding of each resolves itself will be able to create more efficient processes and therefore strong and competitive strategies; this is the basis of the horizontal relationship.

Moreover, the vertical interplay is based on the fact that the company's relationship with its customers and suppliers can be a source of competitive advantage to the extent that benefits both parties equally.

The alignment of the activities of the company as well as creating synergies and strategies may allow the company to increase its efficiency and market position. Additionally (Guerras and Navas, 2007) its use as a tool of analysis allows the company to identify strengths and weaknesses according to which an appropriate strategy can be designed and thus creating more value.

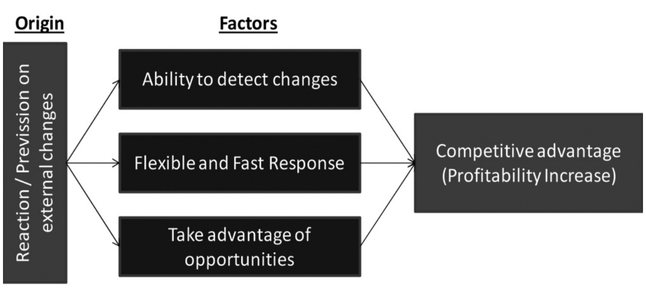
The definition of "competitive advantage" is a relative concept which sets the position of the company in relation to competition. According to Guerras and Navas (2006), a competitive advantage can be defined as "any property of the company apart from other placing it in a relatively superior position to compete."

In this sense, it delves into the concept of relative position a company has a competitive advantage over another "when you get (or have the potential to get), persistently higher profits" (Grant, 2006). It turn out that unlike profitability this benefit can translate to factors such as market share, technology, brand image, etc..

According to Porter (1985) the basic competitive advantages are obtained through cost leadership and product differentiation. In both cases the application of these strategies should consider external factors and internal factors (Grant, 2006)

A company cannot generate competitive advantages in efficient markets (Grant, 2006), since by definition does not allow for rents to average and above the industry average (Guerras and Navas, 2007) long term. Therefore, the competitive advantages to be imperfect market can be developed. These factors and strategies are summarized in the following illustration:

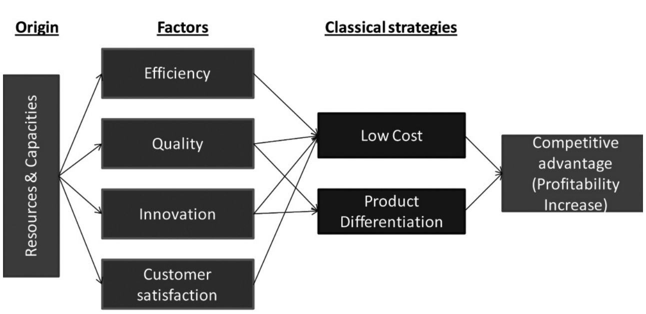
Figure 6. External Factors for creating a competitive advantage



Source: Guerras and Navas (2007, p.271)

As most part of the competitive advantages are not in this level (Guerras and Navas, 2007), the internal factor which generates competitive advantages should be considered as defined in this figure:

Figure 7. Internal Factors for creating a competitive advantage



Source: Guerras and Navas (2007, p.273)

Additionally, there are strategies based on the degree of integration of activities such as outsourcing and vertical integration strategies.

Outsourcing consists in transferring to a third party the performance of a specific activity originally done by the company. Such strategies (Gimbert, 1998) can be implemented, if the company after analyzing the value chain shows that such activity will not generate a competitive advantage, that is, that neither their costs are competitive enough nor their ability to make such activity differentiates sufficiently competitive.

To implement this type of strategy, several aspects should be considered: the feasibility of strategic alliances with the company that will handle the outsourced processes (reliability, exclusivity contracts, etc.), the strategic convenience to take the process out from the company chain (in some cases it could mean falling into the hands of competitors, for example), the flexibility of the company to adapt its structure and processes, among others.

By contrast, the integration strategy consists in incorporating business activities that previously were not performed. If the chain value is observed as the sequence of a series of activities, vertical integration is to incorporate activities that are in the limits / ends of the value chain. If done "backwards" related to the activities performed by its suppliers are incorporated, and whether activities of its customers is "forward".

To consider a strategy of this type, it should be analyzed at medium and long term the potential impact of this within the activity of the company and the sector. Overall integration provides guaranteed availability, elimination of duplication in controls, greater coordination between areas, generation of barriers to entry and reduced transaction costs. By contrast, the integration involves loss of creativity and adaptation of the company, implementation and maintenance investments, loss of bargaining power with former suppliers, loss of visibility in certain costs and increased fixed costs, loss of competitive advantage related to experience to be incorporated as new knowledge and this has a ripple effect, loss of external synergies (Fernández et al., 2006).

Additionally, due to the fact that companies are open systems, subject to environmental turbulence (Febles et al, 2008) and increasing complexity in societies that interact (De Quevedo et al, 2005); and by other side directly affected by the degree of interaction and communication generated by globalization; makes that mixed strategies based on negotiation and strategic factors achieve more importance and strength.

Whereas the level of cost reduction strategies implemented in shipping are mature and do not have great opportunities in establishing competitive advantage, therefore should pursue strategies to generate more value with innovative models and strategic nature.

7. Competitive advantages in primary activities

As already mentioned there is a strong relationship between the various activities that make up the primary activities of the value chain shipping. Therefore the development of their competitive strategies should be right in this line.

The integration of various functions (such as charger and freight) or service establishment owned or leased by the consignee as far as legally possible transport make their activities more competitive and efficient.

In addition, vertical integration regarding the various economic sectors in which it operates shipping opens the door to multiple strategic alliances that can make the differentiating factor in the marketplace.

8. Competitive advantages in support activities

8.1. Infrastructure of the company

Whereas the current business structure is based on an infrastructure of personnel management for each of the functions could be considered the creation of a business unit of Joint-Venture type specializing in financial management and planning. This unit could use existing IT infrastructure platform and create competitive advantages between the port area and another.

8.2. HR

Considering the integral training programs already implemented in various professional associations (Freight forwarders, shippers, etc.) and the growing need for specialized profiles in the area, the strategies should continue to strengthen initiatives that style as a tool for differentiation and increased service quality.

8.3. Technological development (IT)

Considering the high degree of maturity and integration in this area, the development of competitive advantages should go on line to increase the perceived quality of service and operational excellence.

8.4. Procurement

Not commonly considered, perhaps for not being initially considered too relevant. However, the great potential to develop competitive advantages lie in the fact that focus aspects have not been identified before, allowing competing on several fronts at once. In this sense his depth analysis is recommended in order to assess future possibilities.

8.5. Advertising

Similarly as discussed in relation to competitive opportunities in training, development and strengthening of joint strategic advertising campaigns that allow positioning at the regional level is recommended.

8.6. Carriers

Using the resources and experience of carriers, analysis should be increased in the development of intermodal mixed models to implement cost reduction strategies and value creation. Additionally, with a high strategic value to regional level and with a direct impact on auxiliary sectors not discussed in this research.

In addition to these activities usually work on models of price competition these complementary strategies based on creating value should be strengthened.

8.7. Customs

As specific activity and highly regulated by the applicable laws, strategic actions should be developed promoting training multi disciplinary actions and strategic initiatives of the hand with the competent authorities.

8.8. Port operator

As discussed above, given the nature of its operations and its impact on all the activities of the shipping process, strategies should be continued and clear in all possible areas. On the one hand maintain a competitive cost structure, with a steady increase in the perceived quality of service and the development of strategic partnerships with various actors around him.

9. Conclussions

The main findings presented throughout this research are the following:

- The shipping process is a system, and therefore the analysis methodologies existing systems are applicable for study. Also for this reason, it can be modeled using the Porter value chain. You can tell which part of the value system of the majority of companies that require transporting goods from one place to another, taking part in every economic sector (primary, secondary and services) being also independent of the size and type of company. This is one aspect to consider in the analysis and development of competitive strategies based on vertical integration.
- Possible lines for the development of competitive strategies have been observed, , both at primary and secondary activities. At the level of primary activities the main competitive opportunities are observed at the strategic level, vertical integration and economic sectors horizontally or strategic agreements between primary integration activities.
- As for support activities have been observed multiple options in developing competitive advantages, since the development of intermodal mixed models to existing blanketing such as communication platforms (IT) strategies. It is important to note at this point that progress in this area, are taken in consensus with the entire port community, that is, with all the actors who perform international trade, for maximum adaptation of the entire system, new technologies, on the other hand, considering the current situation of uncertainty and globalization, flexibility and adaptability of the marine transportation system is essential to maintain its leadership and efficiency in the market.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 69 - 78

ISSN: 1697-4040, www.jmr.unican.es

The Influence of the Induced Maritime Accidents on the Maritime Safety

R. Montes de Oca[1] and E. Madariaga[2,*]

ARTICLE INFO

Article history:
Received 11 August 2013;
in revised form 22 September 2013;
accepted 08 November 2013

Keywords:
Maritime Accident, Production Pressure, Risk Homeostasis, Safety Margin.

ABSTRACT

Humanity system of life is highly supported by maritime transport when circa 8 thousand million people require about 8.800 million tons of merchandises by sea, going in some 105.000 merchant ships of over 100 GT. Those vessels sail every thinkable dangerous waters 365 days year 24 hours day. All that Enormous activity plus others different factors produce accidents, as is shown in an ascendant 1.7 rate related to ships lost with big number in life and cargoes losses, and pollution. That is why this study pretend to detect causes factors of maritime accidents, to try to reduce them, and with that target in mind it was tested the new theory of Induced Maritime Accidents, crossing its proposals with relevant sinisters of different times and circumstances, as Andrea Doria, Torrey Canyon, Costa Concordia, among others. Those cases were re evaluated to establish the key points of such theory, as they are the Production Pressure, the Risk Homeostasis, technological advances and the rupture of safety margin. Cases studies gave as result the existence of referred key points, in a manner combined that the chain of events derived to the fatality, and more than that highlights the possibility that been suppressed to acceptable limits the production pressure or the risk homeostasis, a permissible safety margin were been maintained, avoiding catastrophe

1. Introduction

The International Maritime Organization, IMO, in Resolution MSC.255 (84) (International Maritime Organisation, 2010) establish that a marine casualty means an event, or a sequence of events, that has resulted in any of the following which has occurred directly in connection with the operations of a ship:

1. the death of, or serious injury to, a person; .
2. the loss of a person from a ship; .
3. the loss, presumed loss or abandonment of a ship; .
4. material damage to a ship; .
5. the stranding or disabling of a ship, or the involvement of a ship in a collision;
6. material damage to marine infrastructure external to a ship, that could seriously endanger the safety of the ship, another ship or an individual; or
7. severe damage to the environment, or the potential for severe damage to the environment, brought about by the damage of a ship or ships.

[1] Universidad Marítima del Caribe. 3ra Av. Con 10ma Transversal de Los Palos Grandes. Caracas, 1060, Venezuela. montesdeocar44@yahoo.com.
[2] Department of Sciences and Technologies of the Navigation and Shipbuilding. School of Maritime Engineering. University of Cantabria. Gamazo, 1. 39004 Santander. Spain. Email: madariagae@unican.es.
* Corresponding author.

However, a marine casualty does not include a deliberate act or omission, with the intention to cause harm to the safety of a ship, an individual or the environment.

This match with Hammurabi Code of Babylonian wrote between 1955 1912 BC when stabilising that the accident is not an intentional act: In the sentences meted out to each offense, the code distinguishes whether or not there is *intentionality*, and which is the "category of the victim and the aggressor" and also: The penalty is increased if it has been done *deliberately* if you have been an accident and if the victim is a free man instead of a slave (clasica)

2. Dissemination of accidents

In regard to the public knowledge of these accidents, previously, cases such as Titanic, took more time to be disclosed, however at the present time, cases such as Prestige or Costa Concordia, among others, they do so in real time, which promotes a reaction of the public opinion more swift and forceful, and that joined with the maritime transport system supports to a large extent the life forms of humanity, whose international trade is transported by more than 90 %, by sea (International Shipping and World Trade[1]) some 8408 million tons of various loads transported in 2010 (UNCTAD Review of

Maritime Transport 2011, p.7) on board of 104304 = >100 GT merchant propelled ships, highlights the fact that this is not a system of which we can dispense with, and therefore it is essential to know the causes that motivate the marine casualties to minimize its recurrence.

This core activity of the maritime transport has been adapting to commercial and technological requirements, transforming what it in the past it was considered by society as a safe activity, to an insecure and high-risk in the present. The modest size of the vessels of the past, in contrast to the enormous today, in themselves represent greater risk potential, either by the loss of lives and/or goods, environmental pollution, etc.

Upcoming major technological advances to the ships to reduce the consumption of fuel, the use of liquefied gas as fuel, the hull lubrication by air to decrease the friction with the sea and consequently reduce the fuel consumption. In the bridge is already normal the use of integrated systems ECDIS (Electronic Chart Display and Information System), AIS (Automatic Identification System), LRIT (Long-range identification and tracking of ships), to electronic navigational charts, new methods of tracking of vessels, among others.

These technological advances assumptions to improve maritime safety probably are activated, as they did in the past, the adaptation and balance of the safety margin accepted by the operator (Homeostasis of risk) which could compromise for a period of time, the safety. (Montes de Oca and Martínez Marín, 2013, p. 42)

3. Fatal statistics & casuistry

The maritime accidents have left huge amounts of dead, in 1820 during the winter of the North Sea, more than two thousand (2,000) ships foundered with the consequent loss of the lives of more than twenty thousand (20,000) people[2], by then the United Kingdom (UK) adopted the Passengers Act, which led to the English Parliament to research on the causes of shipwrecks, focused on ten determinants, as the inadequate equipment, failures of construction, excess load or inappropriate assurance of the same, inadequate maintenance, incompetence of the Captain, etc. Boisson (opcit, p50). Later during 1848 France and the United Kingdom agreed to in writing the first regulating navigation at sea on the navigation lights, continuing with regulations to avoid collisions at sea. However, the reiteration of maritime accidents and multiple actions or regulations to minimize them, gender in the global maritime community, the need for their research and to identify causes and avoid as far as possible its recurrence. This has helped the international cooperation and the advent of the common ways to investigate them and in January 2010 came into force the Resolution MSC 255(84) that imposes mandatory internationally, the Code for the Investigation of Marine Casualties.

In spite of these efforts, however, the rate of losses of vessels has increased, from 1.3 in 2006 to 1.7 in 2010 (relation of ships lost/total number of vessels = >100GT) (IMO document CWGSP12/3) and the index of spills to the sea from 1970 to 2011, indicates that the 2% are product of fires or explosions, another 2% due to collisions, groundings 3 %, failure of the hull 7 %, equipment failures the 21% and surprisingly 64% of the causes of such spills, it is for another reason or the cause is unknown (annual statistics from the International Tanker Owners Pollution Federation, ITOPF's) and even more, from 1989 to 2010 were lost (totally) 4443 ships and 18189 lives as a result (UPC, 2012) (Montes de Oca and Martínez Marín, 2013)

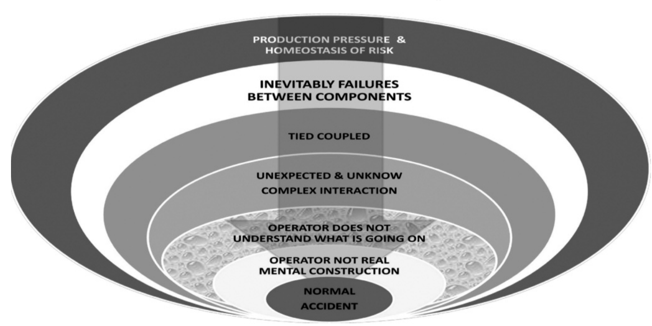
4. Analitical review & proposals:

Faced with this concern in various branches of industry, the scientific world has produced alternating thoughts, among them as indicated by Charles Perrow in his book (Perrow, 1999) which presents the theory of why accidents occur and some of them inevitably (the so-called Normal Accidents or System's Accident) due to the fact that the productive systems that builds society, are too complex and their components or parts can interact in unexpected ways by their designers or operators, thus leading to the accident. He also claims that with this new approach, it could be finalized with charges to persons and/or wrong factors, as commonly happens in the present, and also stop the attempts to repair the systems in a way that only make them more risky. (Montes de Oca and Martínez Marín, 2013, p. 43).

It is based on the fact that there isn't a good management of high-risk technologies, which the patient research of many disasters proves that in a certain time no one knew what was happening in reality, and even though they acted with the best practice, the results were worse. Highlights the gap between the human being and the technology (where the operator is left behind in the understanding of the given system). Perrow concludes, that the true cause of the Normal Accident is the complexity of the system because all the failures may be small in themselves and each to have a backup, but on the whole, it is their interaction (complex coordination of failures) that explains the accident, and these occur because the system is complex. (Montes de Oca and Martínez Marín, 2013 p. 43)

According to our interpretation of Perrow, (adding the risk homeostasis) develops this graph representing a possible sequence toward the accident. (See Graph 1)

Graph 1: Normal Accidents - Sequence.



Source: Montes de Oca and Martínez Marín (2013)

[1] Facts and figures (2009 p.7).

[2] Boisson (In "Le Courrier" 5 mai 1822, quoted in "Le Bureau Veritas 1828-1928, Editions du Centenaire, Paris, 1928, p.10).

Another production of the scientific world that we might consider, in addition to Perrow, are failures of design raised by Henry Petroski (2010) or at the same time include on this vision of Petroski, modifications to the original design that might influence the failures, and negatively impacting on the couplings of some of the parts of the system before pointed out by Perrow, making them strongly bound or rigid, what would facilitate the generation of unexpected or unknown interactions. In order, we can assume the matrix of Perrow, enhanced by the vision of Petroski and this lead to the wrong mental construction of the operator and then take the wrong decision (although the operator was thought to be correct) and consequently detonate the sinister. (See Graph 1)

Recalling the case of the collision in July of 1956 of passenger ships Stockholm and Andrea Doria, it might be clear to us that if the ships had not had radar, the Andrea Doria has sailed at a slower rate in the dense fog prevailing, and none of the two has produced such changes of course. In the meantime the presence of radars and detection one each other, then the speed remained high, and in ships approximation both operators, of both bridges, generated mental images erroneous to the reality and consequently manoeuvred toward the collision, although they tried to avoid it. Resulting in loss of lives, the sinking of the Andrea Doria and considerable damage to the Stockholm.

In considering the catastrophic sinister happened to the oil tanker Torrey Canyon in March of 1967 that ran aground and break his hull with the consequent total loss of the ship and its cargo spill, generating this dreadful pollution in the waters around the semi-submerged reef Seven Stones, near the English coast.

With Dörner Dietrich´s theory (Dietrich, 1996) we could consider that there was the decisions of the Captain of the oil tanker, when taking an unusual route and not recommended in defeat toward the port of Milford Haven, besides accepting as true the position given by guard's Pilot in the approach to the reef, as the cause of the catastrophe.

With the theory of Henry Petroski, we might want to consider that was the modification of the physical characteristics of the ship's hull (lengthening of its length for greater load capacity) leading to this loss of manoeuvrability due to that the rudder is not restructured for the new size of the vessel, which in the end caused the incident to not be able to fall on the port side quickly and avoid the reef.

With the theory of Charles Perrow (1999), we would consider that still so many commercial pressures and inaccuracy of the equipment that you've set up a gap in the dynamics of navigation that concluded in disaster.

It should be noted that in all theoretical scenarios of this case, the mental image wrong was present.

We can also infer that the operators of the bridge in the luxurious and ultra modern passenger ship Costa Concordia, generated, believed and decided according erroneous mental images, which allowed his ship will contact the submerged rock with the catastrophic consequences known. (Montes de Oca and Martínez Marín, 2013 p. 44)

Just thinking in the last three exposed cases, allows us to glimpse something prior to the act itself, had accumulated and inter linking in parallel and with the consequent reduction of the appropriate margin of safety, to the point of inducing decisions that led to the accident.

If focussing on this final phase (decision) we can get closer to the theory of Dietrich (1996), recognizing and avoiding error in complex situations) in which he said that we are so prone to make mistakes ... Our brains are not fundamentally defective; quite simply, we have developed bad habits. When we fail to solve a problem, we do so by the tendency to make a mistake here, a small error beyond, and these accumulate, thus contributing to fail. Although he further maintains that the violation of safety standards by the operator is due to the fact that frequently has already violated before (negative reinforcement) it is well that Dorner postulates the complexity and operational intelligence. In summary, Dorner argues that the causes of our mistakes when handling complex systems are: the slowness of our thinking and the small amount of information that we can process in a given time, our tendency to protect our sense of competence, the limited capacity of income flow of information to our memory, and to our tendency to focus only on the immediate problems.

We have so that the human being is to some extent lags behind in the technological advances, and as a possible reaction the operator acts to balance its area of conformity / satisfaction (homeostasis of risk) which to my way of seeing is not another thing that modify the Risk (increasing), by the way of what I would call the Margin of Safety (downwards) (formerly did not have radar onboard and maintained highly careful attitude, while having them, increases the speed, or changes in direction, etc.) To this end, the proposal of the Slow Shipping to retrieve a greater margin of safety, lost through the rapid technological progress, the homeostasis of the risk in combination with the pressures of production, or in other words, keep the previous preventive attitudes (when the risk was greater without present technology) in conjunction with the positive technological advances in the decline of the risk. In this way avoiding failures (increasing the margin of safety by lowering the pressure of production with the Slow Shipping) could be generated sufficient time to adapt persons and systems to avoid errors in complex situations, which require that the design of such systems taking advantage of our natural talent of perception, presenting our attention to the precise information that we require at the exact moment.

5. The theory of the induced accidents

This leads me to try to launch the configuration of a new theory, which I will call initially as Induced Accidents, (Montes de Oca and Martínez Marín, 2013) based on the fact that accidents occur motivated to the infringement, decrease or absence of an acceptable margin of safety, generated among others due to the pressures of production, technological progress and the homeostasis of the risk. (See Graph 1 & 2) in an at least two of three combination.

As can be seen in graph 1, human being (in this case individual part of a ship crew) is doing his job on board to reach target production with safety. What happens (first stage) is that in a particular moment these production pressures arise, pushing to more risky decisions, as per example to change a route with plenty room for a dangerous path because of thinking in an early arrival to profit the tide or pleasure because of shore close proximity, or to do not reduce speed or to do not make a clear change of bearing with enough time because of trying to maintain the schedule, or to do not use in parallel generators or helm mechanism in some special circumstances because thinking in save paying fuel payments or overtime, or because of the fact that these equipments were not 100% available due to insufficient or poor maintenance. *But what reason allows a person agree to take these risky decisions?* Well because each person (in our cases individual part of a ship crew – Routinely the Master, the Chief Engineer, the personnel in watch) have his own individual capability to accept risk, ICRSR (See Graph 1, Second stage), what we shall call individual comfort safety range to accept risk, or just: *Comfort to the Risk,* Being that this comfort to the risk in a normal situation in a well-trained crew is maintained within a range of preventive and precautionary. This range of comfort to the risk, it can be disturbed by both the pressures of production such as the sense of greater safety generated by technological advances, for example when the advent of radar, also appeared the super power of the vision even in thick fog or seeing through darkness, or with AIS appears specific ship in specific location, etc.

After receiving the influence from one or both of these factors (production pressure and/or technological advance) we arrived at the stage two. This variation of comfort to the Risk range is so called Homeostasis of the Risk (Balance before the feeling of risk).

When in this second stage, the individual comfort to the risk range became bigger (so person accept more risk in a comfort way), it means to that member of the crew he will accept a smaller operational margin of risk (Third Stage), which will take us closer to the risk with the consequent increased likelihood of the occurrence of the incident. (See Graph 2, PP+TA Cone)

5.1. Homeostasis

The concept of homeostasis was created by Claude Bernard, often regarded as the father of physiology, and published in 1865.

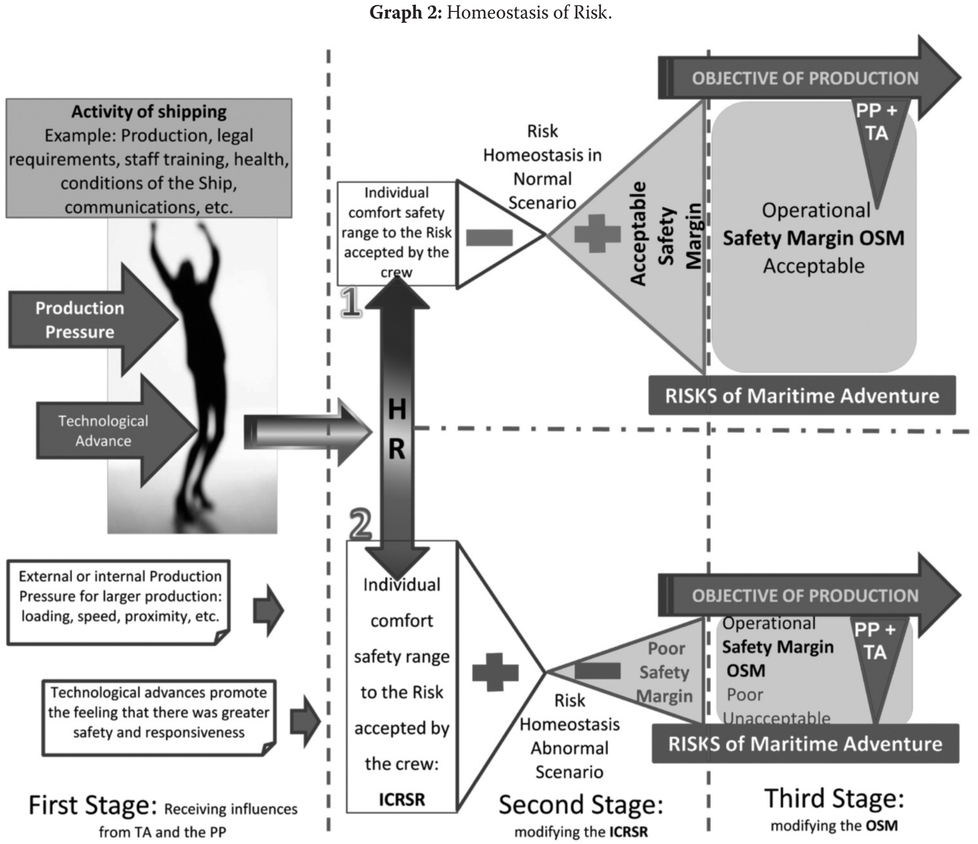
The Homeostasis is a characteristic of a system, either open or closed, attributed to a living organism, either biological or social. This characteristic, this trend to balance allows them to regulate the internal or external environment to maintain a stable condition and constant that in our case of the proposed theory of induced accident we shall call as a individual comfort zone, more specifically *Comfort to the Risk*. The multiple adjustments of dynamic balance and self-regulating mechanisms make the homeostasis possible. (Bransiforte, 2009)

In the homeostasis participates all the systems and apparatus of the organism from the nervous system, endocrine system, the digestive apparatus, respiratory system, the cardiovascular system, etc. and responds to changes in the domestic environment if we are talking about a living organism and in the external environment if we are talking about interactions between agencies or individuals. The homeostasis is not synonymous with inaction or stillness. In reality, to produce and sustain homeostasis is required for a permanent job in the environment, due to the fact that every field has a constant dynamic and a trend toward the imbalance. When is disarmed or breaks this state of equilibrium is immediately put into action several mechanisms that try to reset it.

5.1.1. Psychological Homeostasis

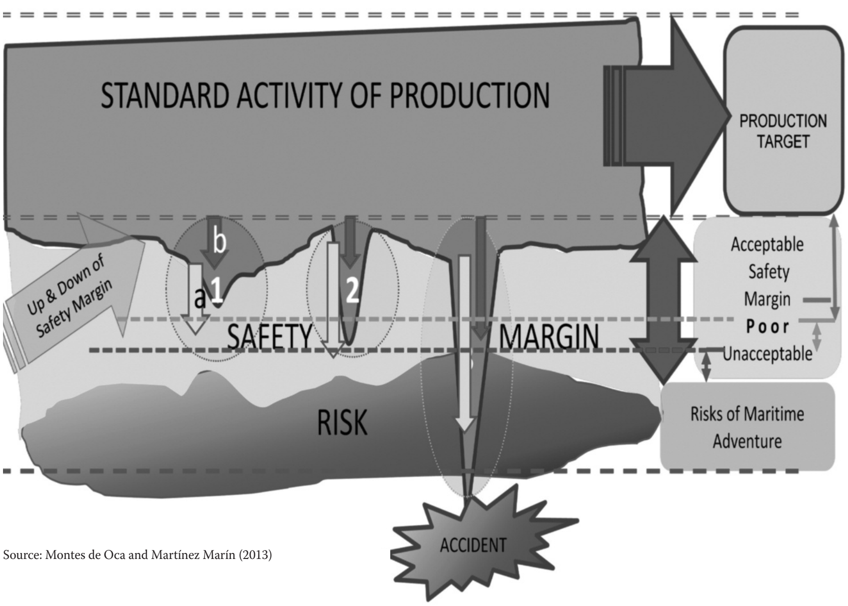
The term was introduced by W. B. Cannon in 1932, appoints the general trend of any organism to the restoration of internal balance each time it is altered. These internal imbalances that can occur

Graph 2: Homeostasis of Risk.



Source: Montes de Oca and Martínez Marín (2013)

Graph 3: Induced Accidents / Risk and Safety Margin.



Source: Montes de Oca and Martínez Marín (2013)

both in the physiological level and psychological, are produced by a timely damage or because of a need. In this way, an organism's life can be defined as *a constant search for balance between his needs and his satisfaction* which we have named in this proposal of theory of (Induced Accident) as the individual range of comfort to accept risk. Any action aimed at the search of the balance is, in the strict sense, behaviour. What leads us to think of this as the necessary deployment to achieve homeostasis again, either external or internal.

Interaction between animal and environment: responses to changes: Normally, to alterations in the environment, an animal responds with one of the three possible answers: *avoidance, conformity* or *regulation*. This last is the one that has received more attention; in fact, one of the main themes of the physiology is the study of the mechanisms that are used by the organism to maintain a stable internal environment.

Avoidance: avoiding organism: minimize the internal variations using some behavioural escape mechanism that allows them to avoid environmental changes, either space (looking for microhabitats not stressful like caves, burrows; or on a larger scale, migration) or temporary (hibernate, drowsiness), As example from our case, when watch at the bridge avoids issuing contrary to the opinion of the captain when he commands the maneuver. *Conformity:* Conformist's organism: the internal environment of the animal changes in parallel with the external conditions. There may be a functional compensation with the acclimation or the acclimatisation, recovering from the previous functional speed to change. *Regulatory:* regulatory organism: a disturbance triggers compensatory actions that keep the internal environment relatively constant.

5.2. Risk

Risk is defined as the combination of the probability of occurrence of an event and its negative consequences. The factors that compose it are the threat and vulnerability (CIIFEN, 2010)

Threat is a phenomenon, substance, human activity or dangerous condition that can result in death, injury or other impacts to the health, as well as damage to property, loss of livelihoods and services, social and economic disruption, or environmental damage. The threat is determined depending on the intensity and frequency.

Risk: (Related to security instead of safety) The possibility of loss resulting from a threat, security incident, or event. (ASIS, 2003).

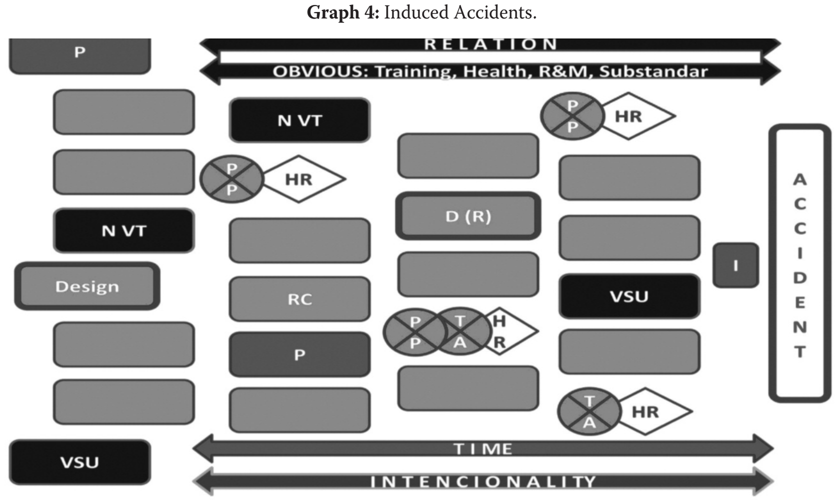
Margin of Safety up and down (Oscillating) (See Graph 3): Increase and decrease of margin of safety, because of technological progress and the Homeostasis to the risk of the operator, who perceive the higher margin due to technological progress, then decreases with his more risky actions. . (Montes de Oca and Martínez Marín, 2013, p. 45).

a: Reduction of the Margin of Safety by homeostasis of the operator with the consequent increase of the Risk
b: Reduction of the Margin of Safety by the increase in the pressure of production with the consequent increase of the Risk

In cases 1 and 2, the safety margin was enough to make the system will recover, while in case 3 the Homeostasis to the risk of operator in combination with a pressure increase of production, decreased the margin of safety to the point of deleting it thereby undermining the system causing the disaster.

As can be seen in Graph 4, there are many causes that could lead to the disaster, many of those are show as blue rectangles. Also we can see failures of design or redesign (D®),

Graph 4: Induced Accidents.



Source: Montes de Oca and Martínez Marín (2013)

ones so called immediate cause (I), others so called proximate cause (P), Root cause (RC), etc.

The ones we are talking about are from Production Pressure (PP), Technological Advance (TA), Homeostasis of Risk (HR), circumstances or events not very tied (NVT), circumstances or events very strong united (VSU). As told before Homeostasis of Risk (HR) can be generated by the Production Pressure and/or Technological Advances, so in a first consequence HR vary to accept a individual wide range of comfort to the risk, and in a second consequence to a shorter operational margin to risk, that in some cases lead to the disaster.

We should increase the margin of safety, one way could be by the "SLOW SHIPPING" which means e.g. Not recklessly increase the speed or changes of heading course due to technological advances that provide us with better information than before, encourage our biological tendency to balancing our sensations, and in this case, the risk.

The technological progress makes us feel safer and then the operator actuates until that feeling reach to the level of previous risk, with the following consequences already known: Fatal Accidents that cause damaged to the Human, to the Vessel, and very important also: To the Marine Environment.

To analyze, and open discussions on the academic's filed, having in mind the sail's experience, and also issue an study on board the vessels with the crews, will help to improve the maritime safety, knowing the human attitude with the new Technological advances.

5.3 Giving bases for the theory proposal

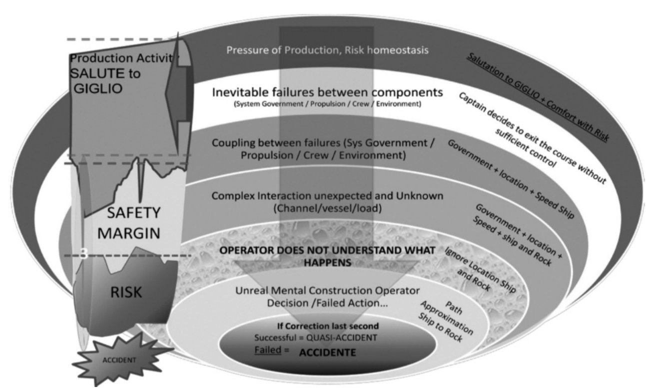
The study within the three theories of accidents of the authors Perrow (1999), Petroski (2010) and Dietrich (1996) have been carried out with a vision for epistemological to establish a specific structural base on the applicable concept to all of them. The same validation will have to be done with the theory proposal (Induced Accidents).

As planned, on the methodology of scientific research programs, from Lakatos (1978), in which there is a structure composed of: a *Strong Core*, where reside the basic assumptions or general hypotheses of the theory, center from which rotates the mentioned theory. A *Protective Belt*, with hypothesis assistants, definitions, basic conditions that serve to describe the uniqueness of the situation, since the basic assumptions contained in the nucleus are insufficient to predict or explain details. So that the belt is responsible for defending the core to be distorted. A *Positive Heuristics*, which represents the operational techniques, mathematics with which one can develop the research program on a methodology to enable it to explain and predict in cases before the reality of the proposed scenario. A *Negative Heuristic*, which puts the framework of what not to do because it is in conflict with the strong core (Lakatos, 1978, pp. 13, 66).

Subsequent to that part of the filter parameters of Lakatos, which made it possible to accept or not theories, then selected contrast them; we take cases of marine casualties for based on them, begin to experience the search for causes.

The famous case of the BT TORREY CANYON, in which after a sequence of events that inter reacted unexpectedly, the operators of the bridge (we assume) generated an unrealistic picture of the reality that once they realized the same and they tried to correct, it was already too late. By applying the principles set forth in these theories we perceive that the incident is interpreted differently, depending on the precepts of the theory used. Not excluding each other, but rather, in my view, complementing each other. And so going deepen in these theories and begun to build and to propose one of our own, as has been outlined in previous pages of this study, the theory of induced accidents, motivated to the treatment given (or not given) to the margin of safety, in which not necessarily the factors involved are in the order plotted, these can happen or interact or interconnect, in a different order, free. (See Graph 4), as well as infer that the erroneous image was present as a factor, through the theory proposal, we can also observe how was violated the safety margin.

Graph 5: Induced Accident / Costa Concordia.



Source: Montes de Oca and Martínez Marín (2013)

In graph 5 is show a view of proposal of induced accidents theory, it is associate to the loss of the Costa Concordia, observe how the safety margin was declining violating the margin of safety to a point to be unrecoverable and the accident occur (in spite of the effort, in extremis, carried out by the captain to evade the obstacle).

To these effects of validation, the theory proposal of the induced accidents, suggests that:

Strong Core:

— That accidents are built hard by its protagonists (and/or predecessors) without them being truly aware of this;
— That this construction of the accident is based on the decrease of the margin of safety desirable;
— That accidents happen because the margin of safety, decreases to a intolerable point that enables us to reach the strip of risk, materializing the sinister (or quasi-sinister, if a successful last second action);
— Such a reduction of the margin of safety is product mainly (not exclusively) of the interaction of the pressures of production, the homeostasis of the risk, and technological progress (two of three at least).

Protective Belt:

— The events or actions (that weaken the safety margin real or that increase the real risk) (not the actors still

truly aware of this) will occur before or during the phase between the conceptual and the regular operations of the case which is concerned; overwhelming and entering a stage of sudden emergency that leads to the quasi-sinister (if mediate any providential action last second) or irreversibly the accident;
— The existence of a network of faults (factors that undermine the safety margin) that accumulated tuned violate suddenly the margin of safety;
— The margin of safety does not appear as a primary factor of decisions, in the chained actions toward the accident.

Positive Heuristics:
— The scope of calculation and determination of the level of risk in setting the margin of safety associated with a given scenario;
— The actions/decisions, training, skills, abilities, capabilities, environment, production requirements, health, fatigue, etc. Method: 1. -establish risk level 2. -establish wide safety margin 3. -set normatively 4. -set them on the conscience of the protagonists 5. -set them in the culture of the company;
— Set the Margin of safety as a primary factor of priority in operational decisions.

Negative Heuristics:
— When the intervening events or actions that lead to sinister are carried out with the intent to cause harm, may not be considered in this theory of induced accidents.

Looking at the foundations of the theory proposal of the induced accidents, you can highlight the concrete fact that the decisions taken in the approach to the sinister have arguments or databases that of undesirable and unconscious way, thus denying the reality that decision makers are living and coming increasingly. For this reason this theory points to a specific rationale, firm, and accurate for those decision-making in such circumstances of much information and time restricted to decide; as it was to rely (to focus) on the safety margin built, or set it to play previously.

As well it should never the Costa Concordia have such a degree of proximity to the coast, or the Andrea Doria wait so approximation to decide its navigation route, or the Torrey Canyon will lead through the restricted passage, or Titanic maintain speed.

6. Case study

CS Costa Concordia:
The information of the events comes from the report of the research carried out by the technical body of maritime accident investigations of the Italian Ministry of Infrastructure and Transport of the incident (MIT) that occurred on January 13 2012 Cruise Ship COSTA CONCORDIA - Email: investigativo@mit.gov.it Tel: +39 06 5908 3447 - The Investigative Body: investigative.body@mit.gov.it

This body of research operates under the authority of the Ministry of Infrastructure and Transport (the Administration) conducts investigations of accidents at sea and reported to the Administration of the circumstances and causes of the accident or incident. It has the responsibility to collect and analyze information relating to maritime safety, and uses the results of the research for the improvement of the safety of navigation and maritime transport. As well as the responsibility for the maintenance and update of the European Platform of maritime accidents (EMCIP) and the Global integrated system of information of Maritime Transport (GISIS).

Details of the incident: 4229 people were on board the ship - *Type of event:* Contact, Break, Loss of all Power - *Hour and Date:* January 13 2012 to 9:45:07 PM hours (VDR) - *Location of the accident:* contact against the rock "Le Scole", Island of Giglio, Mediterranean Sea – Italy – *Position:* LAT. 42 ° 22 ' 20 N - LONG. 10 ° 55' 50 E - *Weather and Sea conditions:* ROUGH - NE 4; Wind 17Knts E-NE, Visibility Partly cloudy to good. - *Operations:* In Navigation in part of the day from Civitavecchia to Savona - *Affected area of the ship:* left side of the hull at the stern - *Implications:* very serious accident, 32 people were killed or missing, 157 injured, of whom 20 required medical care in hospital, total loss of the Ship.

With the purpose of this induced accident theory study we shall use as example some of the information from this report, as follow:

According to the report of research mentioned above, summarizes the human element (whose key members of the crew showed a poor technical expertise) is the root cause in the accident, both in its first phase, as determined by the *non-conventional actions* that led to contact with the rock, as well as in the 2nd part of the management of the overall emergency later. (1- Underline by author – 2- For the objective that we occupies in relation to the theory proposal -Induced Accidents- we will only take into account the 1st phase of the sinister - "contact with the rock'-).

According to the verified evidence, it is established that the CS Costa Concordia on the afternoon of 13 January 2012 at the time of his departure from the port of Civitavecchia, fulfilled completely with all of the SOLAS[3] requirements applicable. During the crucial phase prior to impact, in which successive actions that gave rise to the incident when the captain who guided the ship toward restricted shallow waters, and then a very small space in a parallel path to, and in a perpendicular too close to the coast by changing the course of navigation in a way very soft with the rudder to generate a small variation and leisurely pace of the course, but at the same time very wide.
— In the previous paragraph we can establish that the ship had sailed with all its margin of safety (see figure 2 yellow stripe) product to comply with all the enforceable requirements internationally in the area of maritime safety. However, it is observed the soft maneuver of Captain (usually for the best comfort of the trip).
— a - *View from induced accidents theory*: in this case involves the ignorance of the danger that was stalking and

[3] SOLAS: Safety Of Life At Sea – Convenio Internacional de Seguridad de la vida en el mar.

which subsequently is expected to converge. These actions assist to decrease the margin of operational safety.

In regard to the organization, identifies the following problems:

— While the ship is heading quickly toward the coast, the Captain took the helm with sufficient time to enable it to have corrected the dangerous course on which the ship progressed, (not having corrected the maneuver represents an aggravating factor in his nautical conduct);

— b- *View from induced accidents theory*: allowing the ship forward toward the danger without any action to counter it, this is consuming the safety margin up to decrease it to an intolerable point.

The difficulties of the captain to read the radar (according to the testimony of the first officer, because at the time the lack of the reading lenses); c - *View from induced accidents theory*: if he does not know with precision (but assume that he knew) the location of the intervening elements (Ship/coastline) sailing now by his own image (unreal) of the scenario. Here we are in front of the decline of the margin of safety due to two reasons: (a. - ignore locations and b. - homeostasis of risk in the Captain overrating his control over the situation and continue with his navigation route.

— The use of a mapping (navigational charts) totally inadequate and the inappropriate use of the navigation systems (ECDIS[4] and radar in the correct scale of rapprochement); d - *View from induced accidents theory*: Not knowing with precision (but assume that he knew) the location of the intervening elements (Ship/coastline) sailing now by his own image (unreal) of the scenario. We can see now the decline of the margin of safety by: (a. - which is, or represent homeostasis of risk in the Captain when overestimated his capacities and feeling in control of the situation ignoring to verify positions. Allow this condition reinforces the idea of the presence of the homeostasis of the risk in the Captain to sustain their decisions only in the belief of their expertise (by perhaps feel comfortable with a individual range of increased risk accepted and a safety operational margin declined - homeostasis of the risk) and did not corroborate with the navigational charts or require position to its team of bridge. This certainly puts yet another link in the progressive reduction of the margin of safety.

— The distraction of the captain due to the existing presence upon arrival at the command bridge, people of the department of hospitality and the telephone conversation sustained by one of them with a colleague from ashore; e. -*View from induced accidents theory*: Allow this situation implies the assumption that it had already happened before and it looks normal to them, also that the approximation or greeting to Giglios was not considered a restricted maneuver but a navigation at open sea. Both of these considerations contribute to the decline of the operational margin of safety that should be, on the one hand due to waste of precious moments to the captain to realize the true situation, on the other hand the condition of normal navigation instead of manoeuvre conditions did not promoted the best attention from the staff of navigation on the bridge.. In our view because of an increased comfort to risk range of the Master and perhaps of all the bridge team on watch (Homeostasis of risk).

— The orders given by the Captain to the helmsman, assigning a course to follow, instead of telling the angle of the rudder. f. -*View from induced accidents theory*: Implies that the helmsman seek (to his own knowledge and understanding, at their own pace) to follow the course dictated by the Captain, while that of the Captain having ordered by position of the rudder, was direct order in condition for manoeuvre to be made directly and without any delay, which would place the ship on the course quickly. It also notes that the captain did not earn greater danger and therefore sailed comfortably. On the one hand and without doubt the safety margin is diminished with this form of sailing in these conditions and reveals the possible risk homeostasis in the Captain showing serenity when facing the facts and his control over them.

In regard to the specific requirements learned of the procedures of the ISM[5] code, it is clear the failure of:

— The conduct of the attention to the watch on the bridge on the distraction of the motivated staff to the presence of strangers in the bridge; g. - *View from induced accidents theory:* Above-mentioned as promoted by the captain to navigate as if it were in the open sea, which, however, did not prevent the human team of the command bridge, to maintain a conduct to a great deal of attention to the navigation environment (perhaps the avoidance, as one of the three possible answers in the physiological homeostasis: *avoidance, conformity* or *regulation*). Coupled with the aforementioned distraction. This helped a lot to allow the gradual decline and increasingly alarming of the margin of safety.

— In addition the fails in regard to the verification of the position of the vessel, which was never done in this case (at least according to the audio recordings). h. - *View from induced accidents theory*: Exposed reflects the attitude of confidence of the Captain in the knowledge of the area and control of the situation (he supposed to have) generated by the possible homeostasis of the risk that he was invaded with).

Then, in this context looks clear anomalous the attitude of the Master not to check the original navigation plan (already failed as a result of the rapprochement to half nautical mile (0.5 nm) using a navigational chart totally inadequate) and go beyond the point of rotation provided without checking the actual

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[4] ECDIS: Res A.817 (19) de la OMI, es un Sistema de Información y Visualización de las Cartas de Navegación Electrónicas.

[5] ISM: International Safety Management Code.

Graph 6: Costa Concordia / Safety Margin.

Source: *(Chart)* investigative.body@mit.gov.it - *Explanation draw: The Author: RMR*

distance to the coast (despite that was supported by the navigational equipment and bridge team). The audio recordings in conjunction with the collected evidence (2nd and 3rd deck officers, as well as the 1st officer, do not match) show the differences of the human team of navigation with the government of the ship. The passive attitude of the members of the navigation team of the bridge is reprehensible, and even the greater authority (after the Captain) the first mate (still in his watch) alerted or urged the captain to close/speed up the turn of the ship, nor did he give information of the imminent danger in spite of the fact that before the arrival (of the Captain) to the bridge had been sharply criticized and defined as a true madness the decision to follow that route so close to the coast. *View from induced accidents theory*: In regard to the attitude of the first pilot, it is clear that for this maneuver it was not a open sea case, however did not make any warning to the Captain, the reasons for such attitude we do not know (perhaps the avoidance, as one of the three possible answers in the physiological homeostasis: *avoidance*, conformity or regulation), but the fact of silent entity (not contradicting the captain, the captain is owner of command) can be between them. Without doubt, this contributed to the subsequent decline of the margin of safety. (Similar to the silence of the 1st pilot of the Torrey Canyon although before change correctly the course of the Oil Tanker).

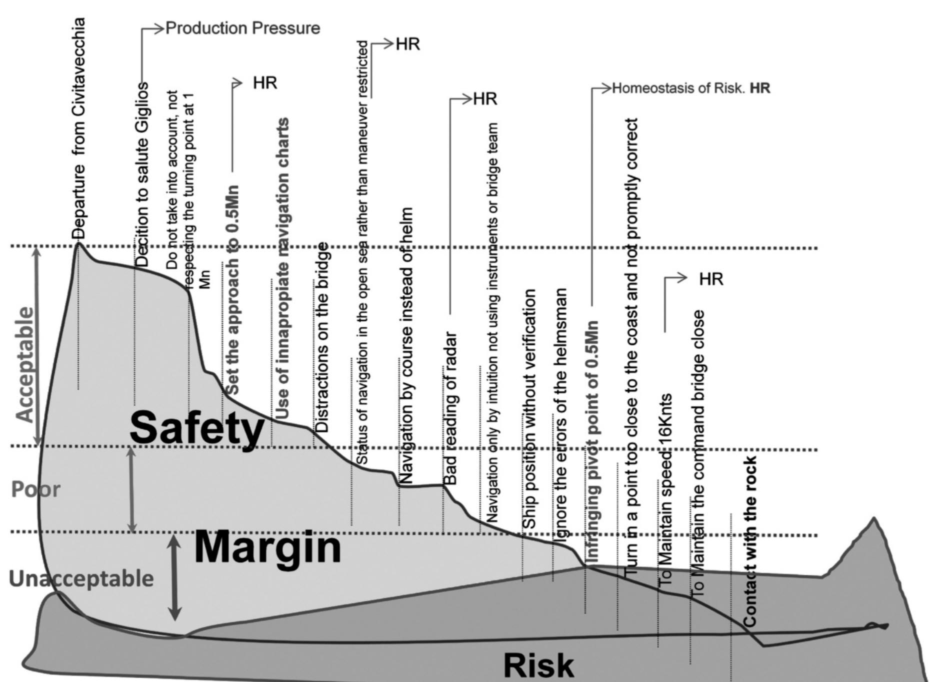
It is also reprehensible the bad use of the three decks officers on the bridge, both during the phase of the watch of the first officer, such as when the Captain arrived at the bridge and took command of the vessel. Even if in the latter scenario, the first officer could have used the staff of the bridge to warn of the dangerous rapprochement to the coast, rather than simply repeat the commands of the captain at the helm, or change the speed (perhaps the conformity as one of the three possible answers in the physiological homeostasis: avoidance, *conformity* or regulation).

As seen in graph 6 the Costa Concordia were complying her normal production activity but in point (A), Instead of turning to starboard within her normal activity of production and maintain its margin of safety, she decided to continue strait ahead approaching the coast (area of risk) of Giglios and reducing the acceptable safety margin in search of the previously calculated new turning point (B) (now located in a small safety margin) and not respectful continued her navigation up to another turning point (C) extremely close to the coast which totally violated the safety margin; After this, and with the failure of last second reaction to avoid the catastrophe, this became inevitable.

Can also be seen in graph 5 the production Pressure and Homeostasis of Risk (PP+HR) cone which represents the combination of factors which possibly led to the crew in charge of navigation to take those very wrong decisions. When production pressure push to salute Giglios it turn to a bigger Individual comfort safety range to the Risk accepted by the Master, and as a consequence to a smaller operational safety margin SM. Then after the breakdown of the SM the catastrophe befell.

In graph 7 can be seen a sequence of how the operational safety margin is loss when the decision maker (crew in charge of navigation) when they changed for a bigger than normal their individual comfort range of acceptance of risk, possibly as a result of the pressure of production by greet Giglios (homeostasis of risk), and as a result allow a safety margin very small to unacceptable limits (See point 2 of Graph 1)

Graph 7: Costa Concordia sequence of the loss of the margin of safety.



Source: Montes de Oca and Martínez Marín (2013)

Table 1: Induced Accident Analysis.

CASE STUDY	Production Pressure	Technologic al Advance	Homeostasis of Risk	Results	Induced Accident
Costa Concordia	Approach to the coast of the island Giglios (Yes)	Ultramodern vessel (Advantages Not used)	Decide upon a individual intuitive navigation type of the open sea without use of modern facilities of the ship, nor order condition of restricted manoeuvre, do not require support of staff on duty at the bridge, accept excessive proximity to the coast	Two of three (PP & HR)	YES
Torrey Canyon	To profit tide on arrival march 18th or must wait till the 24th to enter Milford Haven – Much time on board without vacations – Lengthening of ship (Yes&Yes&No)	Automatic steering (Yes)	Change from a plenty room navigation route to a dangerous path	Three of three (PP&TA &HR)	YES
Andrea Doria & Stockholm	To maintain arrival time - To take a shorter route to destination (Yes & (Yes)	Presence of Radar on both vessels (Yes)	The acceptance by both parties of an inadequate passing distance (too close) - Do not consider two ships navigations as a system - Do not slow speed - Do not make a clear change of bearing with enough time	Three of three (PP&TA &HR)	YES

Source: Cahill (1992, p197) – Collisions and their Causes pp – 3, 4 and analysis from authors

This sinister of Costa Concordia with others cases of study as Torrey Canyon and Andrea Doria / Stockholm are resumed in Table 1.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 79 - 82

ISSN: 1697-4040, www.jmr.unican.es

Maritime Transport as a Key Element in the Automotive Industry

A. Ortega[1,3,*], O. López[2,4] and A. López-Diaz[2,5]

ARTICLE INFO

Article history:
Received 16 August 2013;
in revised form 31 August 2013;
accepted 20 November 2013

Keywords:
Automotive Industry. Maritime transport. Logistic Cost. Inbound logistic. Outbound logistic. Low Cost Countries. Parts Consolidation Center. CKD regime.

ABSTRACT

Nowadays, Automotive Industry is one of the most competitive sectors. Manufacturers try to reduce production costs without any decrease in quality standards. On average, 7% of the final cost of a vehicle is divided into both, the logistic cost derived from the transportation of pieces and components to factories and the cost derived from the transportation of vehicles from factories to selling points and dealers. At this point, logistics and maritime transport play an important role in the improvement of competitiveness.

In this paper, we will try to prove how maritime transport cost is much lower than ground transport (either for pieces and components or manufactured vehicles) despite of the fact that distances, most of the times, may be much longer in maritime transport. This study has been particularly developed for the Japanese Nissan trucks factory in Ávila (Spain).

1. Introduction

In the current industrial environment, the automotive industry is today one of the most competitive. Manufacturers continually seek to reduce costs and cheapen their products with no loss of quality offered to customers (Zielinski, 2008).

There are different elements that make up the final cost of the vehicle, such as the purchasing of parts to suppliers, labour for assembly, painting and vehicle mount – manufacturing cost –, development costs, marketing and advertising, etc.

If we think this carefully, it is clear that another important cost factor in the total cost of the vehicle is the logistic cost, resulting from both the transport of parts and components to the manufacturing plant –what is known by the term "Inbound Logistic"– such as the movement of finished vehicles from the manufacturing plant to various car dealers or points of sale – called "Outbound Logistic". All this logistic cost represents approximately 7% of the total cost of the vehicle.

This logistic cost is even more important today because of the current phenomenon of globalization, which vehicles manufacturers do not escape, since many of the components are received from countries known as LCC (Low Cost Countries) such as China, India or Thailand, and vehicles can be exported from the point of manufacture anywhere on the globe, so going from a more local logistic model to a more global one.

2. The role of containers and ro-ro ships on competitiveness

In this context, logistics, and maritime transport in particular, plays a key role in the continuous improvement of competitiveness. A few years ago, it was very difficult to think that a manufacturer located in Europe, would rise the possibility of bringing pieces from as far away places as mentioned above, because transport costs were much higher than savings obtained in manufacturing costs. It has been in recent years, with the rise and improvement of competitiveness experienced for maritime transport mainly due to the phenomenon of containerization (Nortteboom, 2007) and the progress in the design and performance of the Ro-Ro ships (for road transport), when manufacturers have raised that possibility that is already a reality.

[1] University of Cantabria. School of Maritime Engineering. Dept. Sciences and Techniques of Navigation and Shipbuilding. Dique de Gamazo, 1. 39004 Santander.
[2] Catholic University of Ávila (UCAV). C/Canteros s/n - 05005 Ávila.
[3] Email: ortegar@unican.es, Tel +34942201350.
[4] Email: oscar.lopez@nmisa.es, Tel +34920251020.
[6] Email: alfonso.lopez@ucavila.es, Tel +34920251020.
[*] Corresponding author.

3. Nissan logistics

The light trucks manufacturing plant that the Japanese company Nissan has in Avila (Spain) is not an exception. Three basic models are currently produced in its facilities: the Cabstar, a chassis-cab Nissan brand with a range of PMW (permissible maximum weight) from 2.8 to 4.5 MT, the Maxity, basically the same range as the previous one but marketed under the Renault Trucks brand, and finally the Atleon, also a cab chassis-cab but with different cab, mechanical design and covering a range from 3.5 to 15 MT of PMW, all them with a huge variety of engines, options and specifications.

The first -Cabstar- is a vehicle that is manufactured in Spain and whose main market is Western Europe, but also it has been marketed in Mexico and most recently in markets such as Russia and Ukraine. Furthermore, this model is a "global" model, that is to say, manufactured in other plants to other markets, in this case in Japan for its own market and in Taiwan for the Asian market. As discussed below, this model of global manufacturing has some important implications in logistics, especially in shipping due to the location of the various production centers and suppliers.

The second -Maxity- manufactured to Renault Trucks is also destined, in addition to the above mentioned for the Cabstar, markets of North Africa countries (Tunisia, Algeria and Morocco).

Finally, Atleon, is a product only for the European market, but it has a variant in CKD regime for Colombia. What does regime CKD (Completely Knocked Down) mean? In our case it means that Nissan sells part of this vehicle - in this case the chassis and all mechanical parts – disassembled so as to a third party, a manufacturer based in Colombia, assemble and do the bodywork to market it, in this case like a bus, no longer being Nissan.

Only on the basis of the above, we can see the diversity of markets that the finished product - whether complete or under CKD regime - is to be transported. In the entire distribution network, shipping is one of the most important and fundamental to distribute vehicles in an efficient and competitive manner.

Thus, vehicles for the European market are transported by rail to the port of Barcelona, and hence by sea to countries like Italy, Greece, and Israel. It is also distributed from there to the Balearic Islands and to the Canaries Islands.

Another focal point for maritime transport of vehicles produced by the plant is the port of Santander. From here, vehicles manufactured for Russia, Ukraine, Germany, Belgium, Holland and the UK, leaving the peninsula towards their destinations by sea routes touring northern Europe. Also from the same port, this time across the Atlantic, units bounded to Mexico are shipped.

The same goes for units supplied to Colombia in CKD regime. The components are stowed in the most optimized way possible in containers, which are transported from the plant to the port of Bilbao, where they are shipped by sea to Colombia.

4. Transportation costs

The following table (Table 1) shows the transportation cost per unit depending on the destination, to the main markets in which these vehicles are marketed. In the table is separated the cost of road transport and the cost of shipping (already included other associated costs such as port charges, storage in distribution open fields, insurances, etc.).

The road transport costs, including the transport cost from factory to port of origin plus a distribution average cost from the port of destination to the various sell points in that country. Clearly, with a single glance at the table, we can see that the shipping costs is much less than the distribution by road costs, even being distances much more higher in the case of maritime transport.

Table 1. Transportation costs per container according to the destination.

Destination	Road transport costs	Maritime transpor costs	Total transport cost
Spain	230 €	——	230 €
France	580 €	——	580 €
UK	216 €	250 €	466 €
Germany	290 €	190 €	480 €
Austria	370 €	190 €	560 €
Italy	520 €	160 €	680 €
Russia	530 €	480 €	1.010 €

Source: Authors

Now let's look around at the side of the supply of components and parts to the plant (Gonzalez-Rodriguez, 2007), Inbound Logistics. As mentioned above, one of the models produced at the plant in Avila-the Cabstar- also is produced in Japan and Taiwan. This model was first industrialized in Avila -the mother plant for manufacturing light truck in Nissan- and later in Japan and Taiwan. To do this possible, so that the total cost of the vehicle was as competitive as possible, the various parts and components are manufactured at a single point and delivered to different factories, that is to say, one piece, made for example in Spain, will be provided to Avila, Japan and Taiwan. Similarly, there are parts manufactured by providers located in Japan which will be supplied to the other plants. In the case of European model, approximately 15% of the parts are received from Japan, in what is called KD regime.

What is the reason for this? It is very simple. To make a piece requires a very important investment in tooling -injection molds, stamping dies, etc. -. In the period of design, development and assignment of parts to suppliers, when the overall profitability of the project is studied, it is found that it is much more profitable to transport parts from a single point to different plants than make this investment in different suppliers to fabricate the same piece. In summary, the logistic costs, particularly sea transport, outweigh the depreciation charges of investments.

Let's look at some real facts that explain themselves indicated above. For a 40-feet container, with a capacity of about 60 cubic meters, and assuming a minimum percentage optimization of 70% -that is, we have been able to use at least 70% of usable space in the container- we have the following shipping costs (Table 2) expressed in €/m³, depending on the point of origin and having as destination the port of Barcelona. These prices are already included port taxes.

Table 2. Maritime transport costs

China	70 €/m³
Japan	49 €/m³
India	56 €/m³

Source: Authors

5. Logistics studies

Let's compare now these costs with the road transport ones. The following table (Table 3) shows the average transportation cost per cubic meter from different parts of Europe and Spain, where are located different suppliers of the plant, to the center of the peninsula.

For Nissan's plant in Avila, the total cost of transporting parts from Japan would be the sum of the cost of maritime transport plus the cost of road transport from Barcelona to Avila, ie, 49 +19 = 68 € / m³, from India 56 +19 = 75 € / m³. As can be seen, this logistics costs is less than the cost of bringing pieces from European countries.

Table 3. Road transport costs

Madrid	8 €/m³
Spanish Northwest area	21 €/m³
Barcelona	19 €/m³
France	47 €/m³
UK	81 €/m³
Germany	82 €/m³
Poland	95 €/m³
Hungary	88 €/m³
Italiy	80 €/m³

Source: Authors

In the case of India, in addition to this logistical savings, better pricing on parts is achieved due to the large difference in the cost of labor.

In the case of Japan where the labor costs is similar or slightly higher than in European countries, to the benefit of the logistics costs with respect to these countries is added, as already indicated above, the reduction of investments and development expenditure.

These costs are paid once, and depreciation costs are shared between the vehicle parts manufactured in Japan and manufactured in Europe. Thus, parts of high cost and high complexity of technological development -control units, ABS systems, instrument panels- which can only be developed by very specialized suppliers such as Robert Bosch, Siemens or Magneti Marelli, are clear candidates to be developed on a single place -either Europe or Japan - and supplied by sea to the other part of the world.

Let's see an example analyzing the case of the instrument panel. During the development phase of product first costs studies of the piece are performed to determine who will be the part supplier and where it will be manufactured, considering the planned life for the product and the number of units planned to manufacture during it and the development, logistics and manufacturing costs offered by the provider. For a life cycle of about ten years, is estimated a production in this period of about 24,000 units/year between Japanese and European model, which represent about 240,000 units in the whole period, distributed over an estimated 150,000 units in Europe and 90,000 units in Japan. Thus is determined that the manufacturing cost is almost the same in a location that at another, so that the decision will be given by other factors. For this piece, the costs of development and industrialization -tools and production equipment- is estimated about 250,000 euros, this means, making a simple calculation of the depreciation charges, a cost of 1.05€/piece throughout its life. If those tools would be doubled in Europe and Japan, the costs would rise to 500,000 euros, which would imply that the costs would raise to 2.1€/piece.

When is carrying out the logistics study, the optimum packaging for this piece is designed, calculating that with the dimensions obtained we can put 90 pieces per cubic meter. As we have seen before, the logistics cost from Japan, including transport by land and sea from port to plant, is less than the transport from European countries. For the worst case -for example, a part fabricated in Barcelona- we have the following situation:

The logistics cost per part from Japan is 68€/90 parts or 0.75€/part. If the part would be fabricated in Barcelona, the logistics cost per part would be 19€/90 parts or 0.2€/ part. Clearly in this case is 0.55€/piece cheaper to transport from Barcelona than from Japan, but the savings in development costs of 1.05€/piece is greater. As a whole, we are getting a saving 0.50€/piece for the model manufactured in Spain -this increase in logistics cost does not exist for the model manufactured in Japan- which is along the product life savings of 0.50€ x 150,000 units = 75,000€ in Europe and 1.05€ x 90,000 units = 94,500€ in Japan, making a total of €169,500 savings in life product.

This is a clear example of the competitive advantages thanks to shipping are available.

6. Opening new markets

But shipping, allows not only savings in development costs. As we have already explained before, thanks to it, we have been able to open channels to the LCC countries.

To explain this we are going to see another example with much simpler and smaller volume parts, as can be brake hoses, small plastic parts, etc. Let's suppose the brake hoses. The average cost of a part made in Barcelona or Madrid is about 3 or 4 €, depending on the size of the tube. This cost, is reduced an average of 0.45€/part if produced in China, due to lower labor costs in this country (about 4-5€/hour compared to 20€/hour on average the auxiliary automotive sector in Spain). It is estimated that about 500 pieces per cubic meter can be carried. Thus, the logistics cost per piece will be:

Barcelona: 19€/500 parts = 0.04€/part
China: 89€/500 parts = 0.18€/part

The increase in logistics cost is 0.14€/part, well below the savings achieved in the part of the part, representing a total saving 0.31€/piece.

Consider a more concrete example of a large metal support, with stamping, welding and black-painted piece previously made by a supplier in Madrid –Table 4- that has been decided to move its production to Taiwan –Table 5- in order to the overall reduction in part costs that is achieved.

Table 4. Breakdown of cost per part in the event be manufactured in Madrid

Manufacturing costs	Road costs Madrid- Avila	Total cost
19.1 €	0.10 €	19.2 €

Source: Authors

Table 5. Breakdown of cost per part in the event be manufactured in Taiwan

Manufacturing costs	Depreciation charges	Maritime transport costs	Taxes	Road costs Bcn-Avila	Total costs
10.8 €	0.70 €	0.32 €	2.8 €	0.29 €	14,91 €

Source: Authors

7. Establishment of PCC

As we have seen in every case previously shown, maritime transport proves to be highly profitable and competitive. Because of this, PCC (Parts Consolidation Center) has been established by Nissan, logistics centers that are located in different countries where different parts coming from various area providers are received in a suitable packed way, and loaded into containers, optimized to the maximum to be sent to the destination (Kisiel, 2008). For these consolidation and posterior parts distribution centers, locations close to the sea are searched, with easy access to the port for quick and economic dispatch of cargo containers.

Thus, in the case of Cabstar, Nissan has established a PCC in Barcelona, where parts are received from suppliers in Spain and Europe, are loaded into containers that are sent to the port of Barcelona for shipment to Japan and Taiwan.

The same is true in Japan where there is a PCC for parts made there, which come to the port of Barcelona by sea and after are transported to the plants in Avila and Barcelona.

Likewise, commercial vehicles like van NV200 – also mounted in Japan - or Navarra and Pathfinder 4x4 - also assembled in the USA- are mounted at Nissan plant in Barcelona.

Obviously and despite all the above, not for all the parts supply KD is profitable, so that, once put into production and began the marketing in Europe, for every part are carry out studies about which is the optimal provider and location for manufacturing, taking into account the factors we have discussed above, in order to optimize the vehicle total costs.

8. Conclusions

The first conclusion that can be drawn from this study is that the rise of maritime transport and its shown competitiveness, jointed to the low manufacturing costs in emerging countries, have brought, that increasingly, component manufacturers in such countries are seeking, because despite the distance and as we have seen, it is generally more economical (Canup, 2007).

All this has also made that Nissan, like other manufacturers, adapt to the new situation by reorganizing its organizational structure to the new scenario. Thus, in addition to strengthening the logistics and transport departments, Nissan already has among its workforce with staff dedicated to the management of customs of all the material that is daily moved by sea from one point to another on the Earth.

Also by sea, and using again the port of Bilbao as destination point, components for assembly are received from suppliers located in Mexico. There is a particular case, which shows clearly what we have mentioned in the previous paragraph. The provider - a major multinational engaged in the manufacture of components for the automotive industry - with production plants in Spain, Europe and America, in the face of the continuing demands to improve competitiveness and cost reduction, decides, according to Nissan, move their production from its plant in Spain to another plant in Mexico, where obviously will need to transport its production by sea from. The result is that both the supplier -getting cut costs and improve its margin- and Nissan -getting a reduction in the purchase price of such parts - obtain benefits of the transaction, all thanks to a lower manufacturing costs and competitive logistics costs associated to the maritime transport.

Therefore, Nissan continues to explore new opportunities to exploit the advantages offered by maritime transport, considering the possibility of establishing in the future new PCCs, in Thailand, India or Mexico.

As a final conclusion, note that although it is not the case for the plant of Nissan light trucks in Avila -a plant with many years of history- currently, most vehicles production plants and especially those of new construction, are located as close to the sea as possible or with good access. This is the case of Nissan and Seat in Barcelona, Ford in Valencia, PSA in Vigo, or in other countries Nissan in Sunderland (UK) or the new plant that the mark has been established in St. Petersburg, because it is a clear competitive advantage, since as we have seen earlier, saves logistics costs of land transport of parts from port to factories and finished vehicles in reverse.

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JOURNAL OF MARITIME RESEARCH

Vol. X. No. 3 (2013), pp. 83- 94

ISSN: 1697-4040, www.jmr.unican.es

Analysis of Oil Spill Risks in the Islands of Lanzarote and Fuerteventura Due to Exploration Under Adverse Weather Phenomena

J.I. Gómez[1,2,*], J.M. Calvilla[1,3], J.A. González[1,4] and J.R. Bergueiro[5]

ARTICLE INFO

Article history:
Received 22 August 2013;
in revised form 04 September 2013;
accepted 27 November 2013

Keywords:
Oil Spill, hydrocarbon, Canary Islands, prospection, Repsol.

ABSTRACT

The 23rd January 2002 BOE (n#20) published the Real Decreto 1462/2001, of 21st December, a resolution by which the Spanish Government allows the Repsol Company to search hydrocarbon, in the areas near to Lanzarote and Fuerteventura. This permission is the so-called CANARIAS 1-9. A large amount of institutions such as the councils of Lanzarote and Fuerteventura, the Canary Government, ecologist organisations, political parties and citizens have shown their opposition to this imposed measure due to the impact it would have upon these coasts.
This project aims to analyze the risk that oil prospection and extraction would suppose in the bordering ecosystems, since they would take place so close to the littoral of Lanzarote and Fuerteventura. Actually, this study concentrates on the possible consequences of oil prospection during an episode of adverse meteorological phenomenon, like the ones in December 2013. It is clear that these weather conditions are being more frequent in recent years.

The Model of Hydrocarbon Transport Simulation (Modelo de Simulación de Transporte de Hidrocarburos), or TESEO provides information about hydrocarbon deterioration and also about objects floating freely in the sea.

1. Introduction and approach

One of the main handicaps Spain faces in relation to its development is the high energetic deficit, close to 4% of the Gross Domestic Product (GDP) in 2011 (INE, 2011). It means a serious obstacle in order to adjust a common deficit. Therefore, to reduce the electricity bill is one of the main economic challenges specially taking into account the perspectives of price maintenance in energetic properties. In fact, in cases of elevated levels, the origins are related to the recent problems in Middle East, which provoke an increase in the price of Brent – referential to Europe- that has reached its highest value, up to $116 per barrel (Intercontinental Exchange, 2013).

The importance of the energetic sector in Spain goes further than its participation in the total production. It is a strategic segment from which all the economic activity depends and thus, a key factor to any kind of service or property production. For this reason, the poor energetic resources have limited the economic development of Spain (Gutiérrez Jodra, 2003). To be more precise, it is because of the lack of gas and liquid hydrocarbon and the bad quality of the existing coal. Such scarcity of resources has traditionally condemned the Spanish energetic system to a situation of deficit and dependence from others. There are few deposits in Spain and the little amount of oil extracted is directly exported to other countries. Some oil and gas deposits have been found both in land and sea. The first one occurred in 1964, in Ayoluengo, Burgos. The next ones progressively appeared along Mediterranean Sea, Valencia Gulf, Bay of Biscay, Guadalquivir Valley and Gulf of Cadiz. The interior oil production during 2011 increased to 100.000 Tm. (approximately 733.000 barrels), which meant a reduction of the 18% in respect to the previous year. This production only supposes the 0,16% of the primary consumption of oil in Spain. The current production fields are: Lora (Burgos), Casablanca-Montanazo (Casablanca), Rodaballo and Angula-Casablanca (Boquerón), which belong to the Casablanca platform in front of Tarragona in the Mediterranean Sea. (Boletín estadístico de hidrocarburos. Informe resumen, 2011).

[1] CONSEMAR Research Group, Escuela Técnica Superior de Naútica, Máquinas y Radioelectrónica Naval, University of La Laguna, 38001, Santa Cruz de Tenerife, España. Tel +34922319807.
[2] Senior Lecturer, Email: jigomez@ull.es.
[3] PhD Student, Email: jmcalvi@ull.es.
[4] PhD student, Email: jagonal@ull.es.
[5] Senior Lecurer, University of Islas Baleares, Cra. De Valldemossa, 07002, Palma de Mallorca, España. Email: ramon.bergueiro@uib.es, Tel +34971173240.
[*] Corresponding author.

For more than 30 years, experts have believed on the existence of an oil reserve near the coast of the Canary Islands. Recently, they have decided to launch a project to start a formal exploration. The central government has given Repsol their authorization to look for oil in waters located in front of the eastern coasts of Lanzarote and Fuerteventura. (Alenta, 2013). The company, following the current law, has published the results of the first environmental research required before exploring for oil, which is likely to occur in 2014. Repsol (2013) estimates the Canary reserve to have about one thousand million oil barrels, which would mean between 11 to 15 per cent of Spain's annual supply (that is 38 million barrels per year). In such case, it would take a period of 25 to 30 years of exploration. This would be the biggest oil discovery in our country. If the declaration of environmental impact done by Repsol, currently under discussion, was positive, the exploration would be carried out with a dynamic positioning ship. To do so, the first step would be an exploratory perforation in an area of 6100 km² and 61 km from the coast of Fuerteventura. The depth of this perforation would take between 3000 and 3500 meters (approximately 900 meters of water sheet and 2000 meters of underground).

The Canary Islands are typified by good weather conditions during the majority of the year; however, this situation is occasionally interrupted by extraordinary meteorological phenomena which cause adverse circumstances to the whole community. The adverse meteorological phenomena (A.M.F), contained in the Plan Específico de Protección Civil y Atención de Emergencias de la Comunidad Autónoma de Canarias por Riesgos de Fenómenos Meteorológicos Adversos (PEFMA) (BOC 114, 23th January 2007), produce situations which completely modify the daily life and affect human activity like the interruption in communications, electricity cut-off, etc. Of course, this has direct consequences in economy and in people's properties.

The following are the situations of risk associated to atmospheric phenomena which represent a potential danger due to the fact of being outside the normal parameters, as (Dorta) explains:

–Rain	–Storms	–Heat waves
–Snow	–High temperatures	–Cold waves
–Wind	–Low temperatures	–Tropical storm
–Dust in air		

And among coastal phenomena:
–Wind in coastal areas
–Wave height in windy weather
–Wave height in groundswell

Since Deepwater Horizon platform accident in Gulf of Mexico, the 20th April 2010, we have been intensively studying all the events occurred, including the attempts to close the cracks that were provoking oil-spill. We have also been analysing the flowing of hydrocarbon in the sea and its recuperation with absorption skimmers, as well as the elimination of some oil through burning techniques. In addition, both cleaning labour and the restoration of the environment have been studied too. This research is contained in the following publications: El siniestro de la plataforma "Deepwater Horizon" en el Golfo de México (ISBN; 978-84-694-2225-0); Modelos De Simulación Y Gestión Utilizados En El Vertido De La Plataforma "Deepwater Horizon" En El Golfo De México (ISBN: 978-84-694-3381-2); Acontecimientos Acaecidos Durante el Vertido de la Plataforma Deepwater Horizon en el Golfo de México (ISBN: 978-84-694-9690-9) ; Modelos Complementarios Utilizados en la Gestión del Vertido de la Plataforma Deepwater Horizon (ISBN: 978-84-694-9689-3). During this accident, the fight against pollution was affected and interrupted in two occasions because of adverse meteorological phenomena. The first time, it was hurricane Alex in July 2010 and later on, tropical storm Bonnie in august that same year.

2. Methodology

The application of hydrocarbon drift models aim to answer the question generated directly after an oil spill: what is the trajectory of the spill and which areas will be affected? Knowing this beforehand provides essential information about the protection of ocean resources and allows the authorities to establish a successful intervention plan.

The exact prediction of the movement and behaviour of an oil spill is a quite difficult task, due to the interaction of several physical processes which in many cases carry incomplete and random information. The TESEO* model allows us to predict the trajectory of oil spills. A graphic interface developed by the Hydrographical Institute of Cantabria manages all the

Table 1.

SONDEO EXPLORATORIO	CARACTERISTICAS		SONDEO EXPLORATORIO COORDENADAS UTM (EUROPEAN DATUM 50, ZONA 28 NORTE)		DISTANCIA MÍNIMA (Km)	
	Tipo de Sondeo	Profundidad (M)	X	Y	Lanzarote	Fuerteventura
Plátano 0	Somero/Vertical	852	685577	3175826	50.0	69.6
Sandía 1	Somero/Desviado	870	677455	3160589	56.0	62.2
Chirimoya 1	Somero/Desviado	1093	665302	3153274	55.7	50.5
Cebolla 1	Somero/Vertical	1148	717880	3206287	67.8	104.5
Zanahoria 1	Somero/Vertical	1018	671260	3157240	55.1	56.2
Naranja 1	Somero/Desviado	1420	722593	3232048	68.8	117.4

Source: RIPSA, 2013.

necessary operations for the use of a numerical model of transport and alteration of hydrocarbon. In order to operationally obtain ocean and weather data, the TESEO system is connected via ftp to AEMET (National Meteorology Agency) and to the regional system of Puertos del Estado (State Seaports).

The drift reproduction is a Lagrangian bidimensional model which estimates the oil movement, as well as any object or person floating freely in the sea. This model is based on the PICHI model, developed by the University of Cantabria during the Prestige accident. Transportation is reproduced through particles moving independently because of wind, waves and water currents. To imitate the aging progression that the oil spill suffers, they consider certain emulsion and evaporation processes. With the purpose of calibrating the model they used an evolution method and different search groups. The final measuring was achieved thanks to the algorithm SCE-UA (Shuffled Complex Evolution Method – University of Arizona) (Duan et al., 1994) adapted for oceanographic application (Abascal et al., 2009).

The center of the system is the Oil Spill Transport and Fate Unit. The model considers the influence of the aging processes in the evolution of oil spill. On the one hand, the drift processes are described through the approximation of the stain to a system full of many particles, where the position of each one is obtained from the following vector equation:

$$\frac{d\vec{x}}{dt} = \vec{u}_a(\vec{x}_i, t) + \vec{u}_d(\vec{x}_i, t) \tag{1}$$

where

$\vec{x}_i$ is the coordinate (x,y) of the particle i.

$\vec{u}_a$ and $\vec{u}_d$ are the advective and diffusion speed.

Advective speed, $\vec{u}_a$, is calculated from a line combination of current velocity, wind speed and Stoke drifting produced by waves.

$$\vec{u}_a = \vec{u}_c + C_D\vec{u}_w + C_H\vec{u}_H \tag{2}$$

where

$\vec{u}_c$: surface current speed

$\vec{u}_w$: wind speed 10 meters over sea surface

$\vec{u}_H$: Stokes trawling

C_D: coefficient of wind trawling

C_H: coefficient of waves

According to Dean y Dalrymple (1991), the Stokes trawling is taken from

$$u_H = \frac{gH}{8C} \tag{3}$$

g : gravity

H : wave height

C : speed of wave train associated to the main period (m/s)

The turbulent diffusion is obtained using a random sampling of Montecarlo in the speed rank $[-\vec{u}_d, \vec{u}_d]$, which is assumed proportional to the diffusion coefficients (Hunter et al., 1993). The fluctuation of speed in each moment is:

$$|\vec{u}_d| = \sqrt{\frac{6D}{\Delta t}} \tag{4}$$

Where D is the diffusion coefficient.

After oil is spilt on the sea surface, this is affected by different physical and chemical processes which depend mainly on the spill circumstances and the environmental conditions. The aging processes mentioned before interact in different degrees of time and their influence is explained through mass balance. The model developed identifies the amount of oil that has impacted into the coast. Quantities are deleted from the computing process.

. In the current model, evaporation is calculated according to the analytic model proposed by Stiver y MacKay (1984). In their formulation, the evaporation tax is related to steam pressure, the spill area and a mass-transfer coefficient which depends of wind speed, the surrounding temperature and the type of oil spilt.

The evaporation speed is estimated using a basic kinetic law:

$$\Delta F = \exp\left[6{,}3 - \frac{10{,}3}{T}(T_0 - T_G F)\right]\left(\frac{kA\Delta t}{V_0}\right) \tag{5}$$

where

F is th e evaporated fraction; k is the mass-transfer coefficient; A corresponds to spill area; V_0 is the volume spilt; T is the surrounding temperature; and T_0, T_G are the fixed value of distillation.

The emulsifying model is based in the calculation proposed by Mackay et.al(1980):

$$\frac{dY}{dt} = -k(W_{10} + 1)^2\left(1 - \frac{Y}{Y_f}\right) \tag{6}$$

Where

Y is the water content; Y_f the maximum content of water admitted by oil; W_{10} is wind speed 10 m over sea surface; k is the constant depending on the oil type.

The physical-chemical properties of oil change due to aging processes. In TESEO, the viscosity evolution and the oil density are calculated according to temperature, evaporation loss and water absorption. The formula used to calculate density variations and viscosity are described by Comerma (2004). As a consequence, density intensification is calculated taking into account the following equation:

$$\rho = Y\rho_w + (1-Y)\rho_0\left(1 - C_T(T - T_0)\right)(1 + C_F F) \tag{7}$$

Where: ρ is the pollutant density; ρ_w is the water density; ρ_0 is the initial oil density to T_0. T_0 is the oil reference temperature; C_(T,) C_F are regulatory parameters and Y is oil in water.

Viscosity is determined according to the emulsion content in water, the atmosphere temperature and the evaporation.

$$\upsilon_f = \upsilon_0 \exp\left(\frac{C_3 Y}{1-C_4 Y}\right)\exp[C_5(T-T_0)]\exp(C_6 F) \qquad (8)$$

Where: υ_0 is the initial oil viscosity to T_(0 ,) C_(3 ,) C_4, C_5 and C_6 which are regulatory parameters.

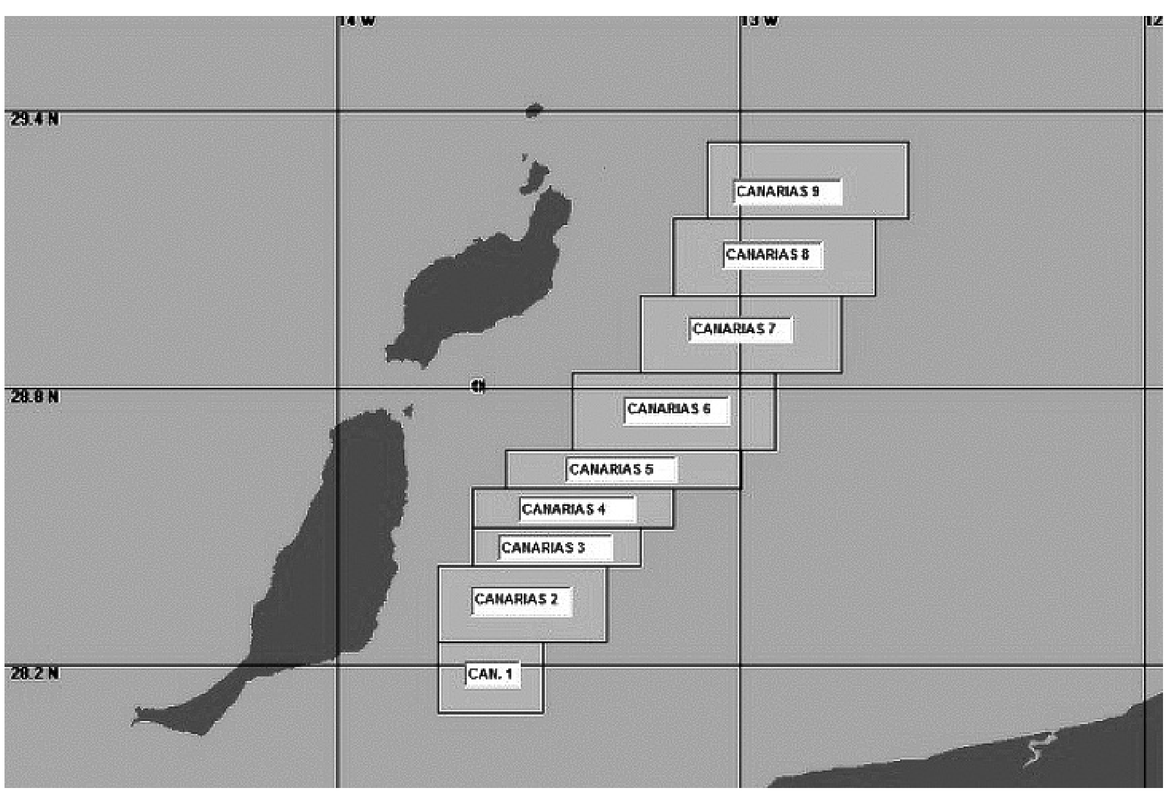
3. Development (application and results)

This project has been carried out taking into account the data collected from the episodes of weather alerts ordered by the Canary authorities in December 2013. Moreover, we have considered the case of oil spill produced by oil exploration in the areas established by Repsol and the trajectory of the supposed spill during an episode of Adverse Meteorological Phenomena like the ones occurred in the last decades. Furthermore, we point out the possibility of oil spill in one of the most interesting locations in what has to do with oil research for Morocco, the coast of Cape JubBy.

SIMULATIONS CARRIED OUT WITH TESEO MODEL
DATA: WINDS, WATER FLOWS, WAVES (AEMET - ESTATE PORTS)
EXPLORATION AREAS: SANDÍA 1, CHIRIMOYA 1, CEBOLLA 1, CAPE JUBBY (MOROCCO)

Oil spill characteristics:
- Name: Arabian Light
- Type: Crude
- Spill volume: 960 m^3
- Density: 869 kg/m^3 (20°C)
- Viscosity: 12 cSt (38°C)
- Maximum evaporation: 35%
- Minimum evaporation: 0%
- Maximum emulsion: 85%
- Simulation length: 10 days

Figure 1. Prospection Areas.



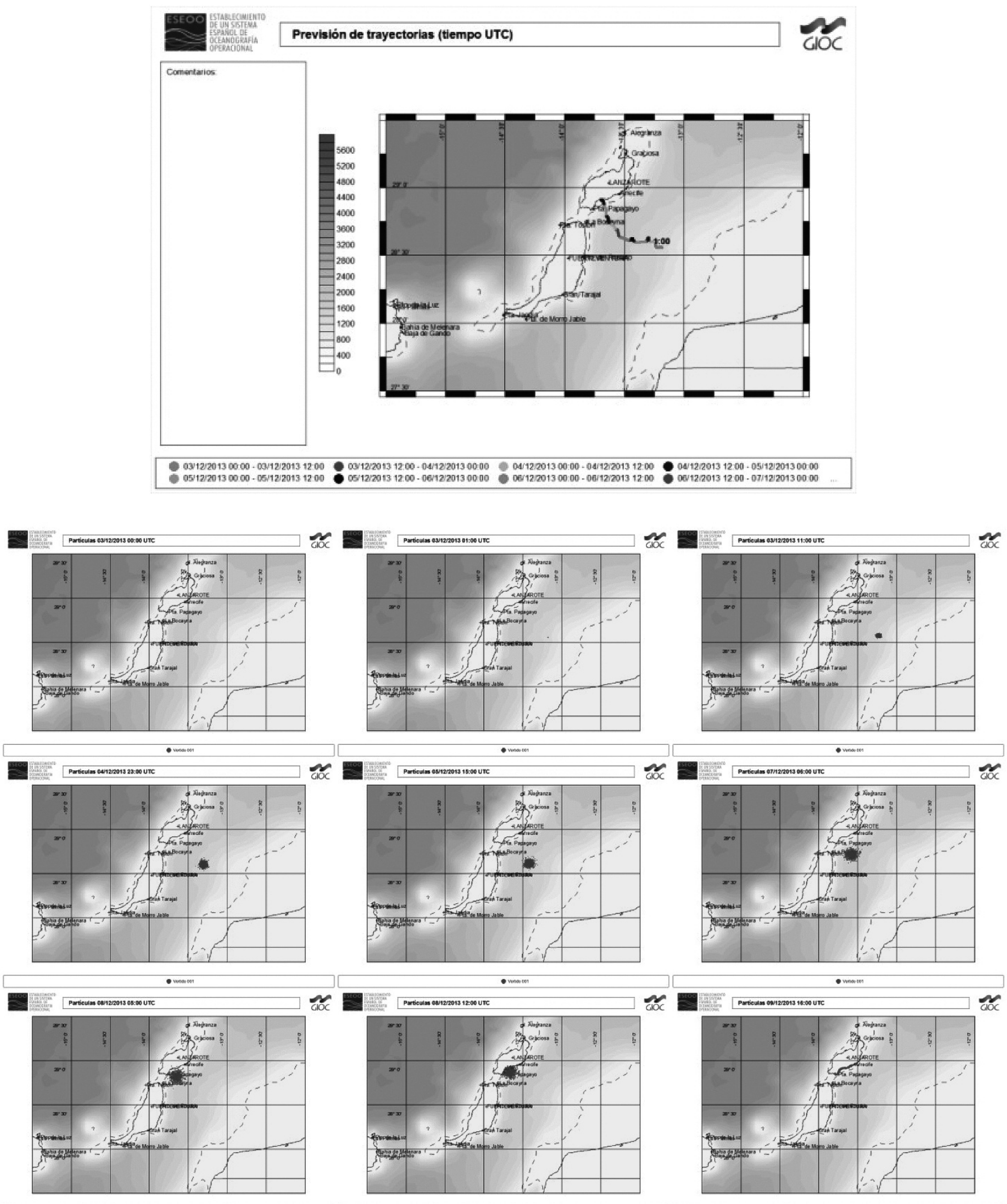
Source: Consemar, 2014

Table 2

SONDEO EXPLORATORIO	CARACTERISTICAS		COORDENADAS		DISTANCIA MÍNIMA (Km)	
	Tipo de Sondeo	Profundidad (M)	LAT	LONG	Lanzarote	Fuerteventura
SANDÍA 1	Somero/Desviado	870	28.560060°	13.185873°	56.0	62.2

Source: Authors

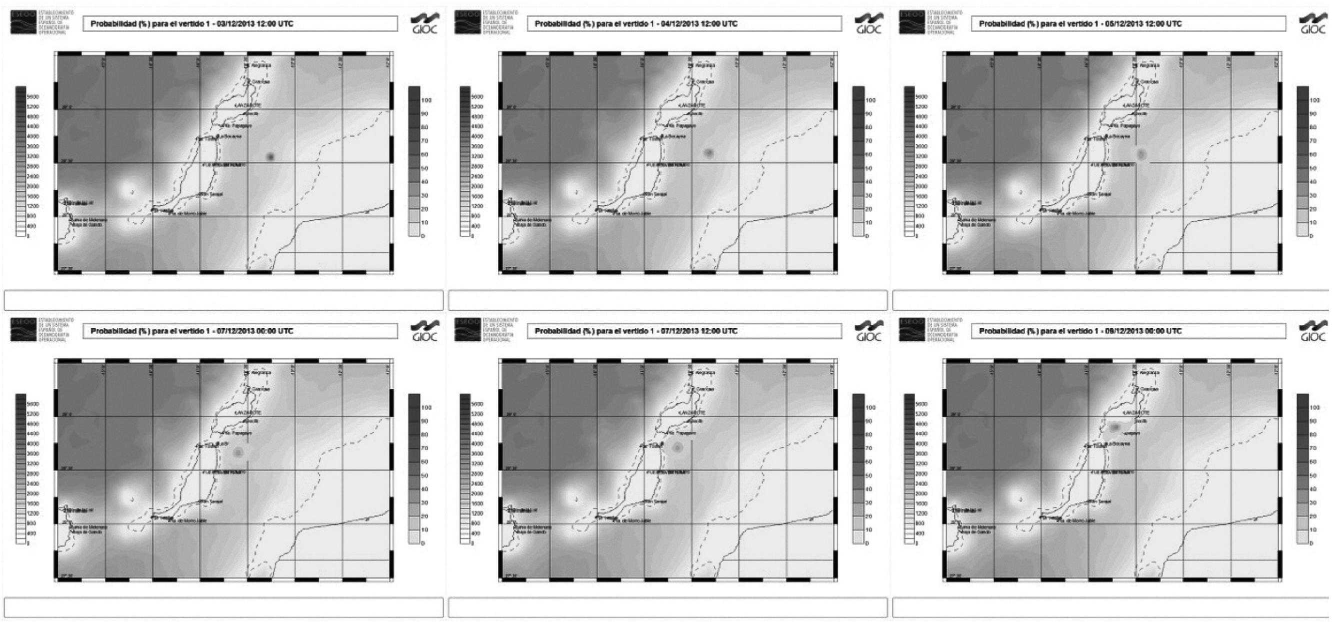
Figure 2



Source: Authors

According to the evolution sequence, from the research area Sandia 1, the oil spill reaches the south coast of Lanzarote in approximately 96 hours.

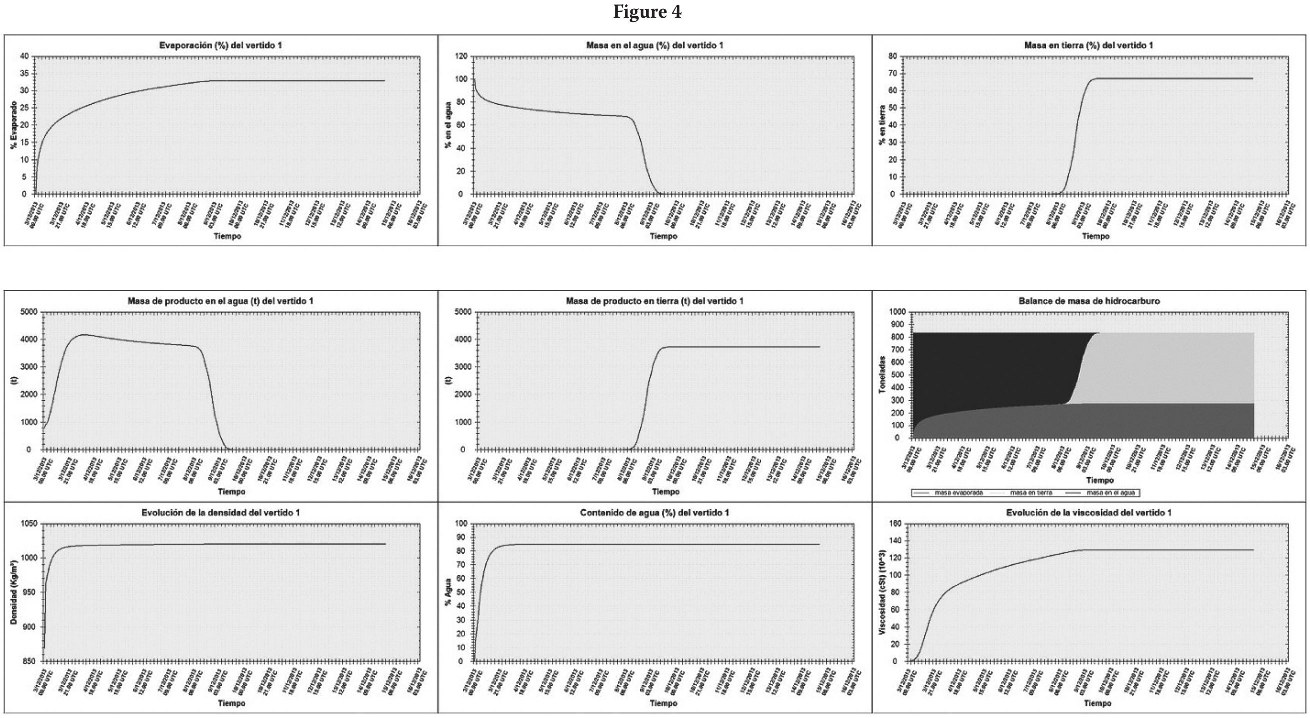
Figure 3



Source: Authors

In the previous sequence we can see the places where the drift particles will reach the coast.

Figure 4



Source: Authors

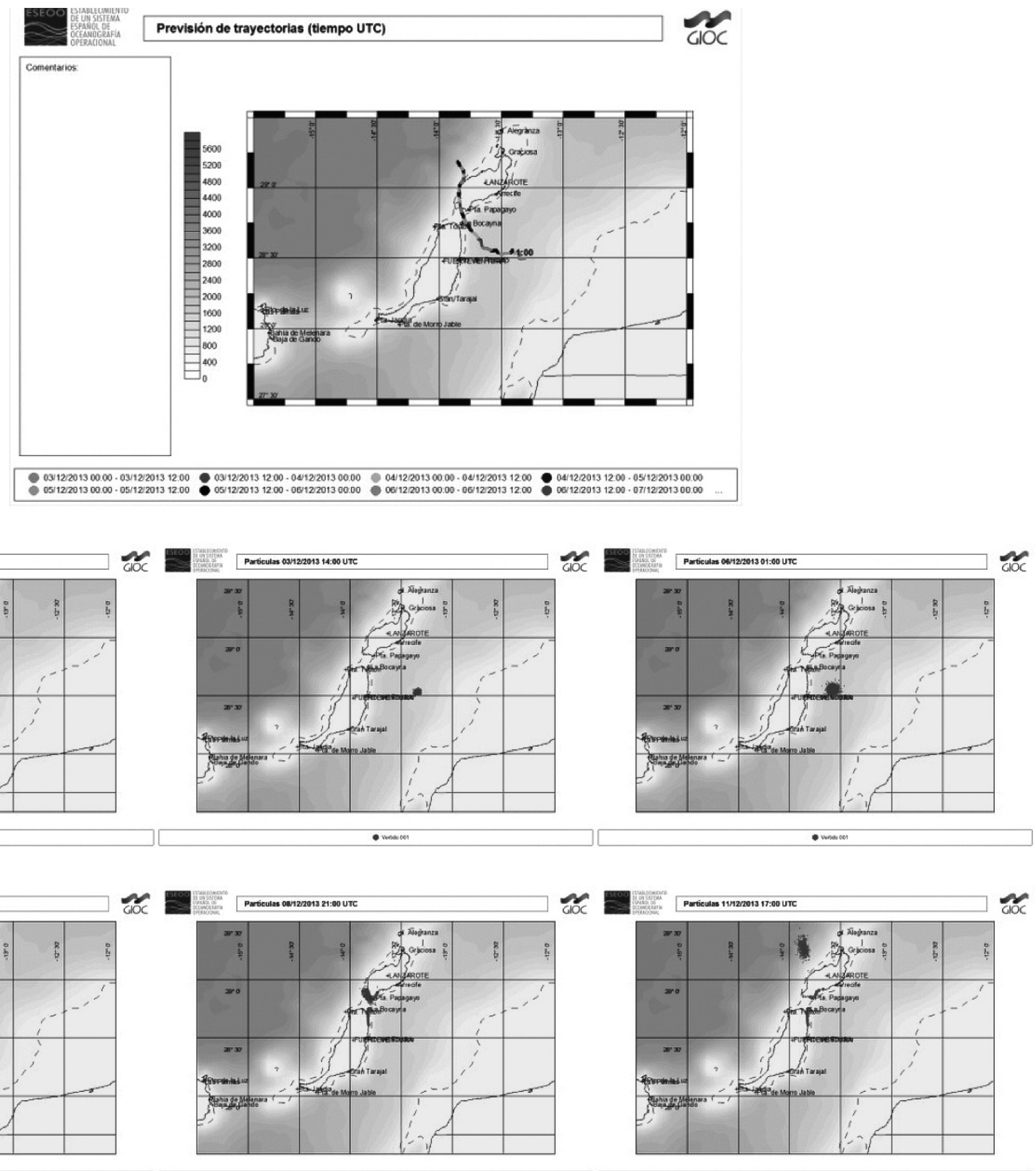
The maximum evaporation of this hydrocarbon is of about 30%, which is produced in the first 48 hours. However, oil density plus its content in water, increase very quickly. This indicates that the emulsion process occurs rapidly too. Therefore, we expect the same in the rest of oil spills like the ones we see in the following prospection areas. As we can see, the volume multiplies allowing extension to increase as well.

Table 3.

SONDEO EXPLORATORIO	CARACTERISTICAS		COORDENADAS		DISTANCIA MÍNIMA (Km)	
	Tipo de Sondeo	**Profundidad (M)**	**LAT**	**LONG**	**Lanzarote**	**Fuerteventura**
CHIRIMOYA 1	Somero/Desviado	1093	28.495663°	−13.311121°	55.7	50.5

Source: Authors

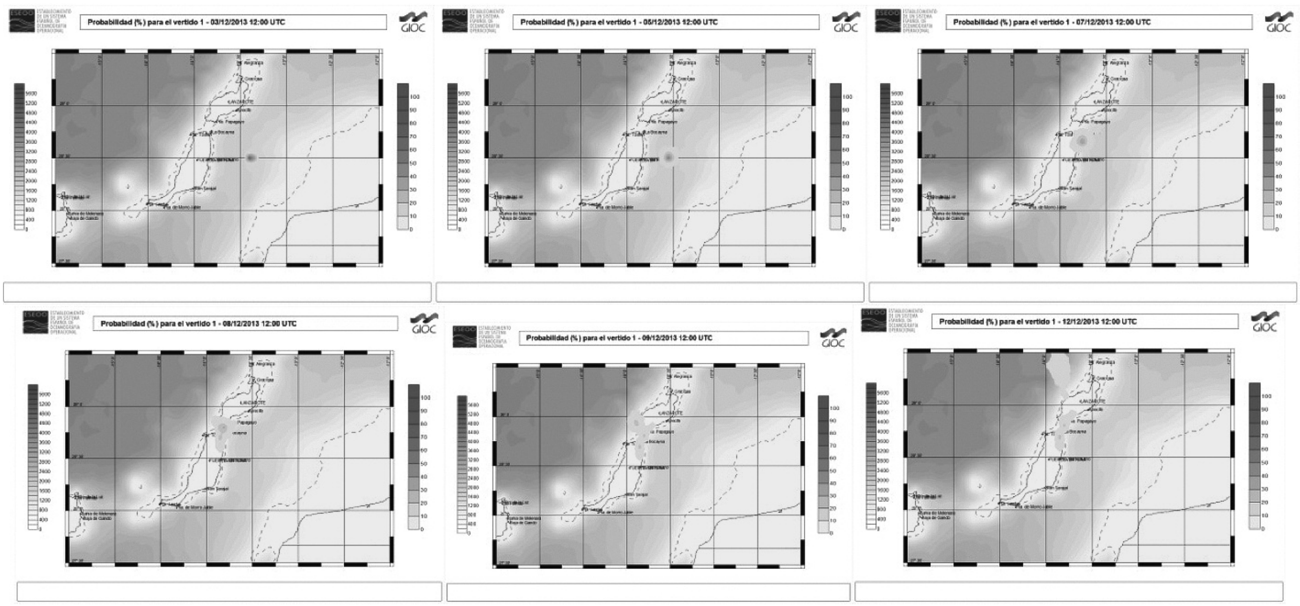
Figure 5.



Source: Authors

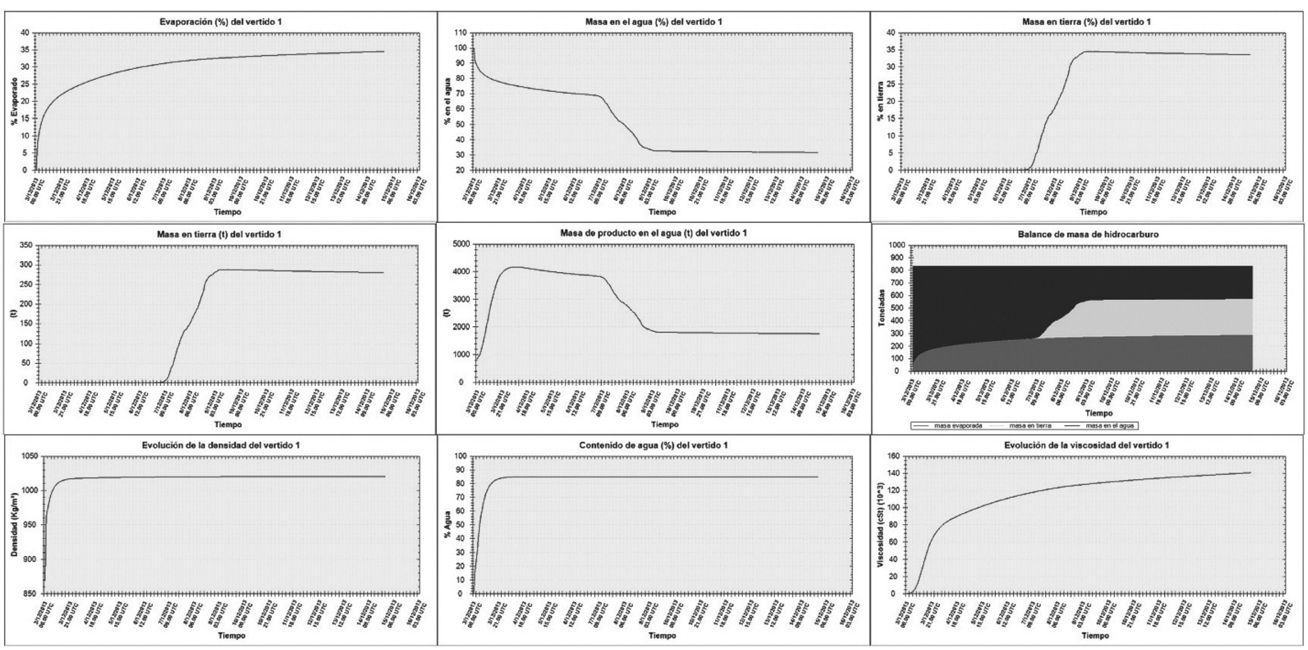
Southern Lanzarote, concretely Playa Blanca, is directly affected in this oil spill. Also Corralejo and Lobos in Fuerteventura are affected since this spill does not stop and reaches the western side of both islands, crossing the so called strait of La Bocaina, which separates them.

Figure 6.



Source: Authors

Figure 7.



Source: Authors

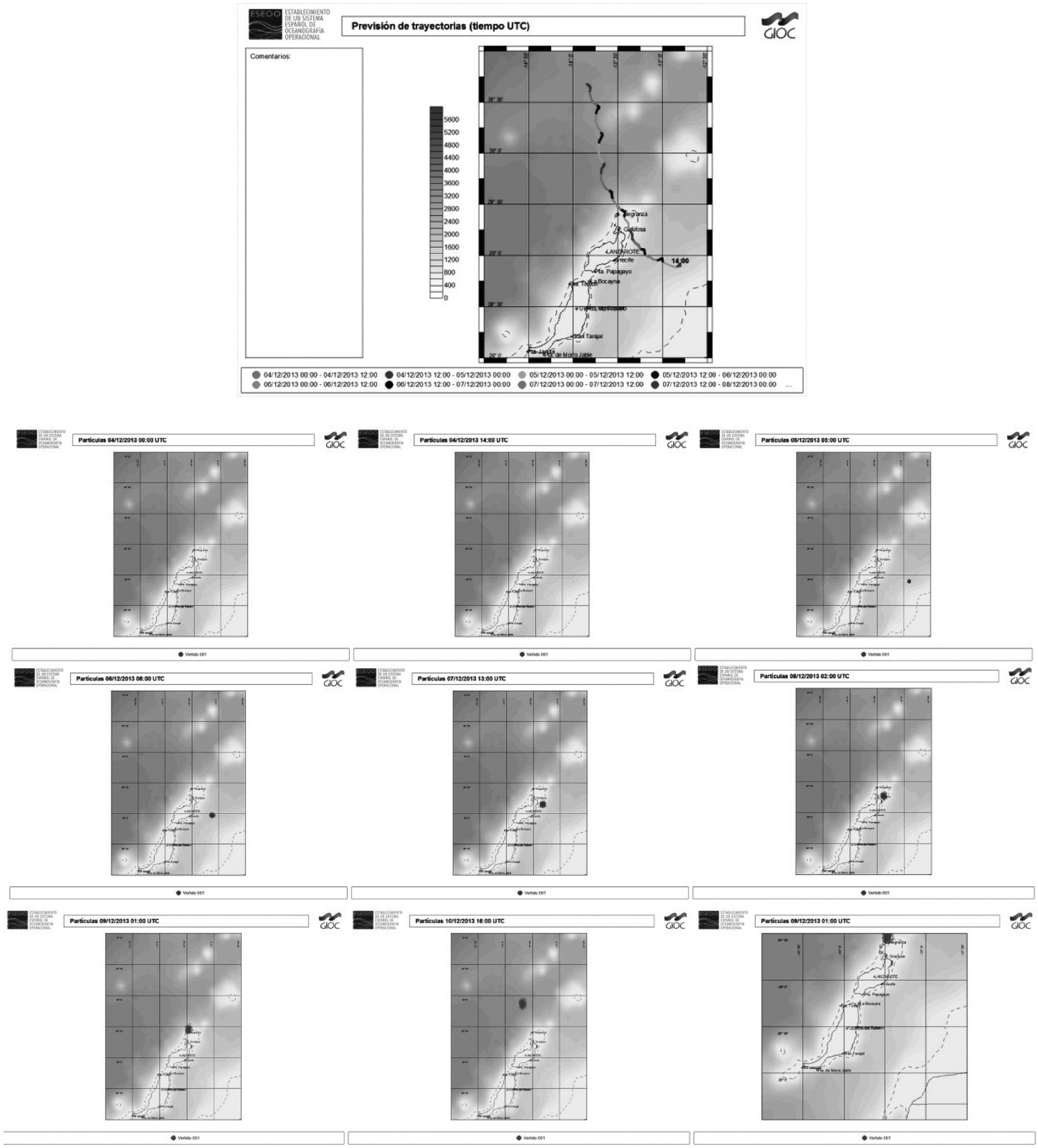
The election of an Arabian Light for simulations is due to the fact of being a reference crude, provided by Repsol Company in the study on environmental impact "Sondeos exploratorios marinos en Canarias" (Exploratory Research in Canary Waters). As we prove in all cases, it is a crude oil which transforms in certain meteorological conditions very quickly. It also increases remarkably the amount of product present in water and thus, the volume that will reach the coast.

Table4

SONDEO EXPLORATORIO	CARACTERISTICAS		COORDENADAS		DISTANCIA MÍNIMA (Km)	
	Tipo de Sondeo	Profundidad (M)	LAT	LONG	Lanzarote	Fuerteventura
CEBOLL A 1	Somero/Vertical	1148	28.966079°	–12.764071°	67.8	104.5

Source: Authors

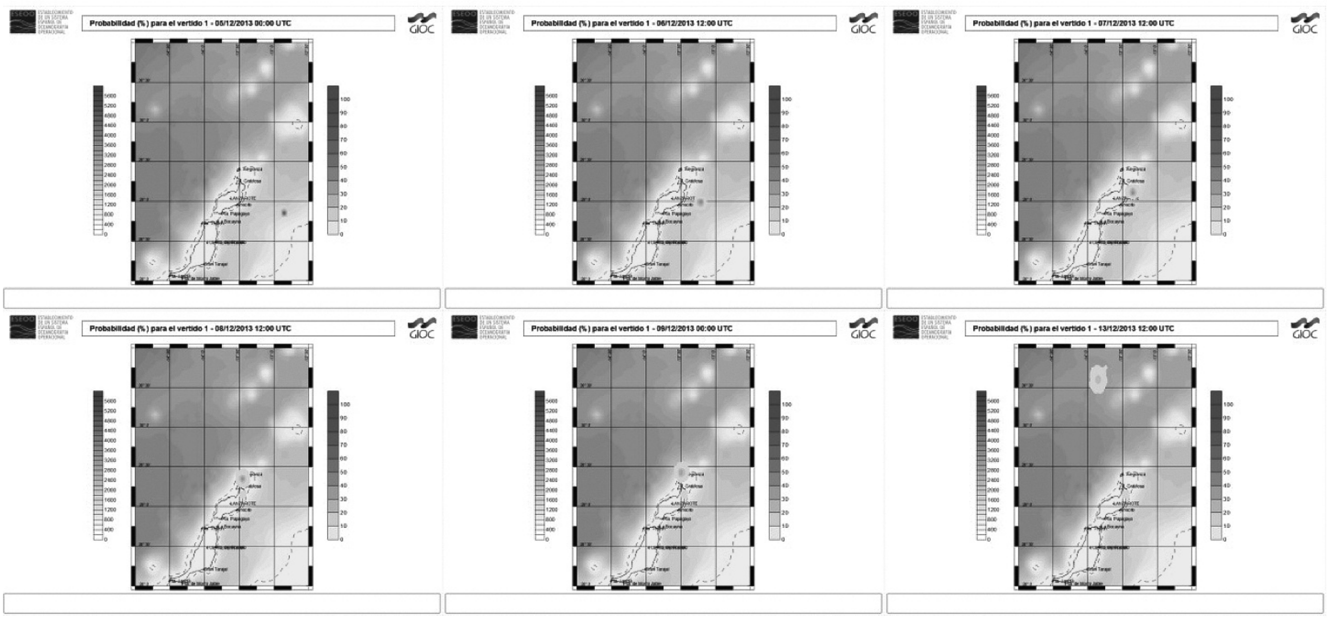
Figure 8.



Source: Authors

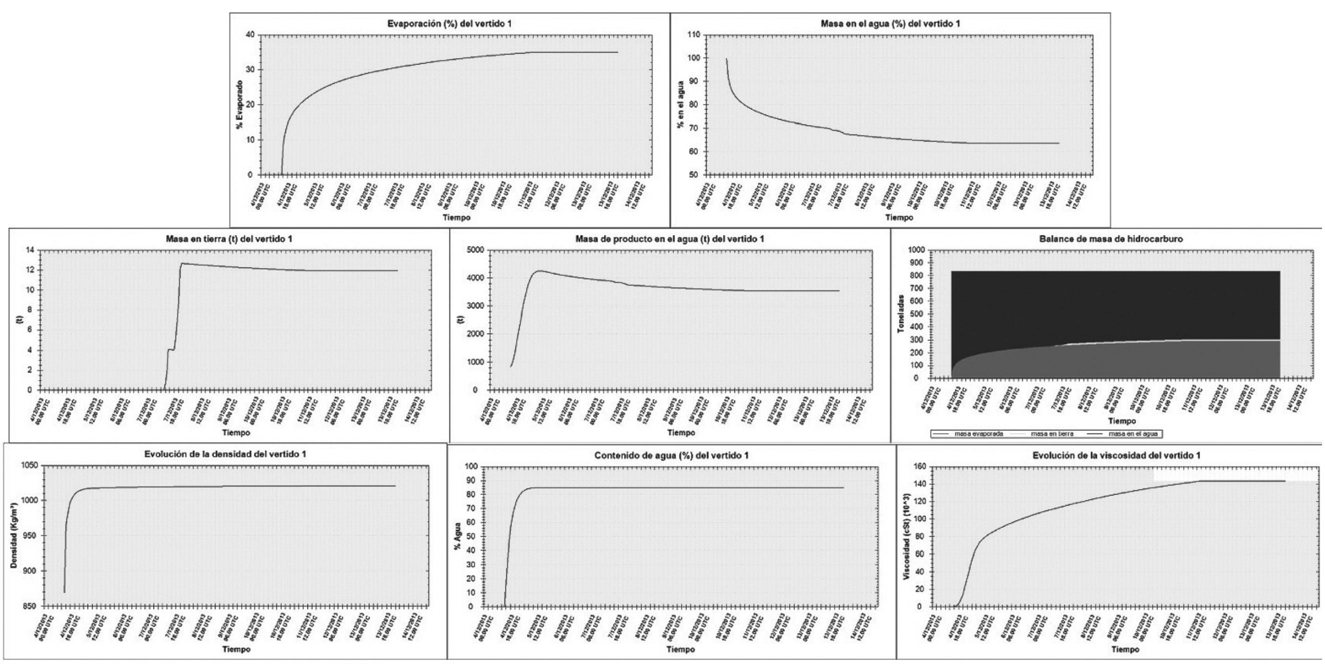
This will obviously influence the cleaning and recuperation of the coastal area in a quite negative way. We can confirm that, with the weather conditions present during the days this study was carried out, the island mostly affected is Lanzarote. The reason for this is spill direction changing to SW-SSW, something observed in seasonal simulations to NW in this decisive case.

Figure 9.



Source: Authors

Figure 10.

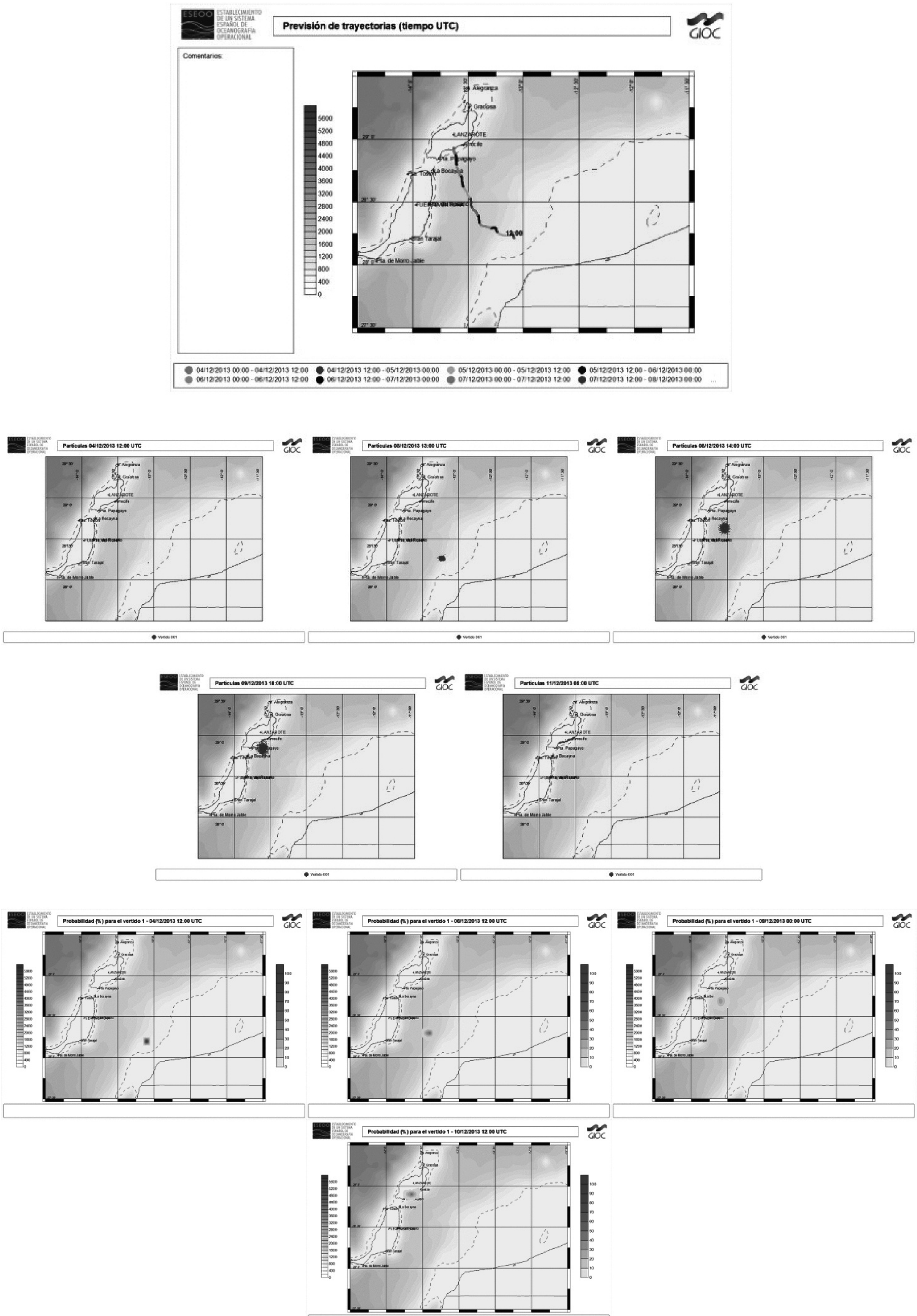


Source: Authors

Table 5.

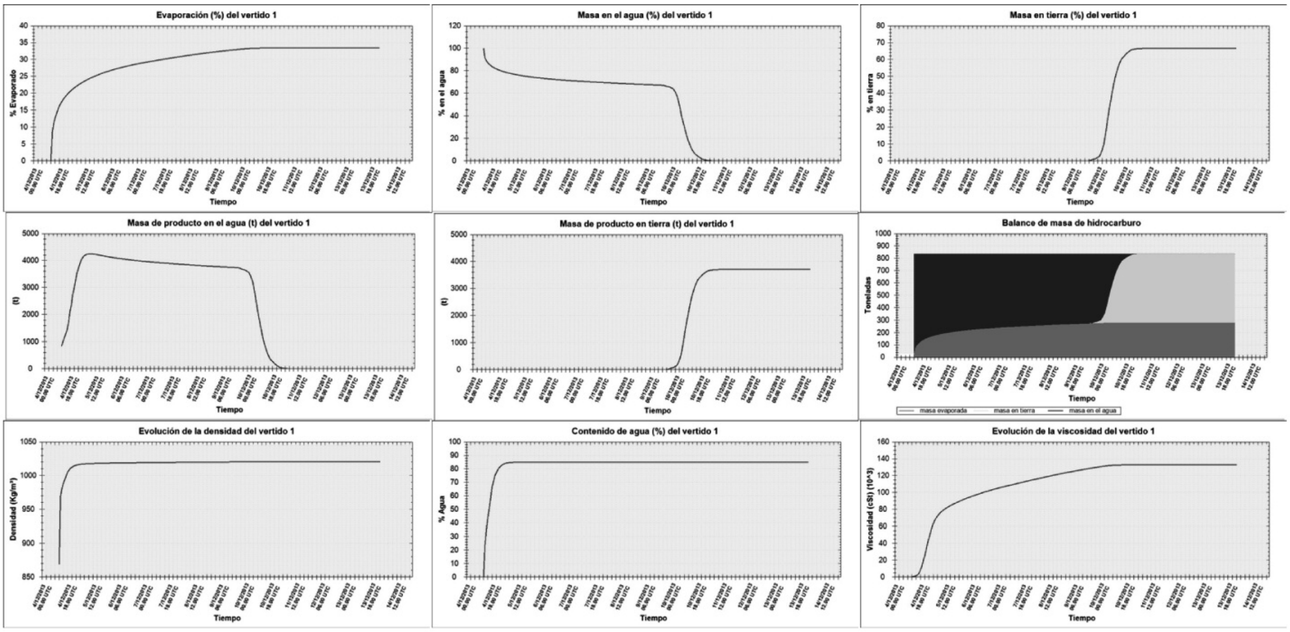
SONDEO EXPLORATORIO	CARACTERISTICAS		COORDENADAS		DISTANCIA MÍNIMA (Km)	
	Tipo de Sondeo	Profundidad (M)	LAT	LONG	Lanzarote	Fuerteventura
CAPE JUBY (Marruecos)	-----	-----	28.213678°	13.082930°	-----	-----

Figure 11.



Source: Authors

Figure 12.



Source: Authors

4. Conclusions

Along the progress of this study we present the results of crucial simulations for a possible Adverse Meteorological Phenomenon during exploratory researches of Repsol and Morocco (CAIRN ENERGY).

The potential spill trajectories have been analyzed using TESEO model to evaluate the final consequences. Real data from National Meteorological Agency and *Puertos del Estado* (State Ports) was used to accomplish the description of wind, water flows and waves in the area. From the viewpoint of impact and drift length probability:

– The eastern coast of Lanzarote has got the highest probability to receive the impact of oil spill, because of explorations SANDIA-1, CHIRIMOYA-1 and CAPE JUBBY.

– Concerning spills produced in areas located in northern latitudes like CEBOLLA-1, even though it seems they do not seriously influence the coast, they directly affect the sea reserve of northern Lanzarote, La Graciosa and the small islands of Chinijo archipelago (Montaña Clara, Roque Oeste, Roque Este and Alegranza).

– In what has to do with minimum times, the spill may reach the coastal areas in approximately 72 hours; although in that period of time the emergency supplies could not stop contamination because of the dominant adverse weather phenomenon.

– Presumably, in Fuerteventura the most affected area could be the North-East (Corralejo and Lobos island), whose land would be infected in the first 96 hours in the case of CHIRIMOYA-1.

From the results of these cases, it can be concluded that a large amount of oil spill stays in the water column. This implies evaporation, as a remarkable process of natural degradation, which reaches values up to 30%. Nevertheless, emulsion occurs very quickly, something that increases notably the spill volume and its viscosity. As a consequence, the coast cleaning and restoration labour becomes more difficult. Eventually, exploratory research in Morocco waters does not exempt the eastern Canary Islands of being affected by oil spill in view of the fact that time to reach the coast multiplies.

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