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NAVAL PROPULSION SYSTEM BASED ON A ROTARY MOVEMENT

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Abstract

This work presents the theoretical and experimental study of a new propulsion system based on a rotary movement that applied to a specific case is rendering hopeful results.

We consider our research to be of some application in the naval industry. Our presentation is based on the experiments and tests carried out with a scale model boat in which have been installed three scale model prototypes of our propulsion system working synchronously. The obtained results show that the amount of gained impulse is considerable and to be kept in mind. Following tests and experiments showed also an improvement in the manoeuvrability of the ship. In this work we present the ship model and the theoretical and practical research carried out.

Keywords: Propulsion system; rotary movement; centrifugal forces.

INTRODUCTION

The centrifugal force term comes from two Latin words, from Latin "Centrum" centre and "Fugger" to flee, means get away from the centre, and that explains the being of a force that tends to get any body away from the circle's centre. Let see how this concept can be interpreted.

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Centrifugal force as reaction of the centripetal force:

When the circular movement of the bodies is observed, we only pay attention to the force which gets over the moving body. In our example, in one of the two cases examined, the force of a stretched (deformed) elastic body acts upon a small ball on circular movement.

By the Newton's Third Law, the elastic body action over the sphere will get an equal reaction and opposed to it.

As we know, while the sphere is rotating, a force acts upon it: the centripetal force. Over the elastic body acts an equal force but in opposed way to the first one mentioned, which is called centrifugal force. Then, the centrifugal and centripetal forces act upon different bodies, and, thus, can not balance each other. Figure one shows: (F) the centripetal force applied on the sphere; (Q) the centrifugal force applied to the elastic body and by it upon the small ball's rotation centre, for example, the hand.

Knowing that if a body gets a force over any other body, both will get deformed. So, in the case of the rotary small ball and the elastic body both will get deformed.

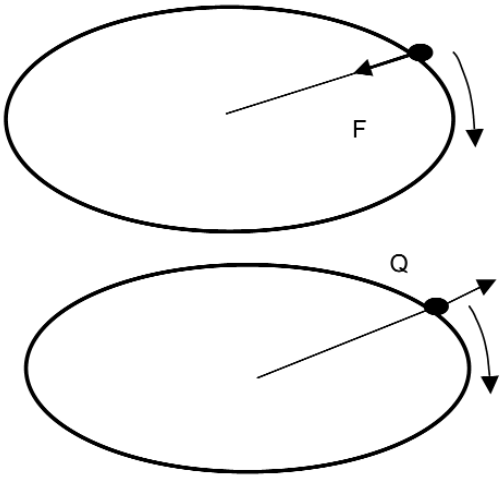

Figure 1. Centrifugal and centripetal forces.

This is referred to every case of the circular movement of the bodies. Thus, for example, when a trolley moves on a bend the rails are deformed and they exert a force over the wheels. These, at the same time, get deformed and press over the rails.

Not to confuse the centrifugal force concept with the one used on the forces of inertia, the real centrifugal force will be called unidirectional gravitational vector, and labelled F_d.

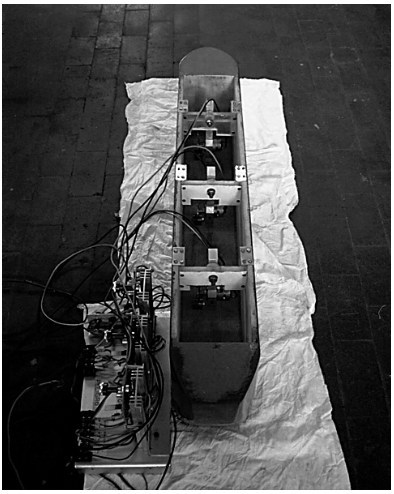

Figure 2.Ship model's photo.

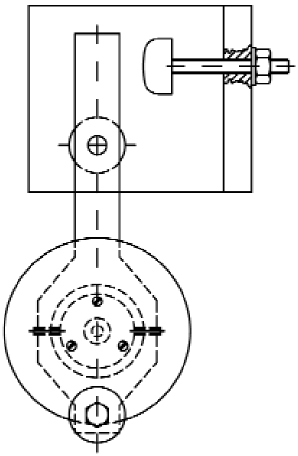

Figure 3. The pendulous system.

LABS MODEL

Figure 2 shows our lab model which consists in a rectangular wooden case and its dimensions are 930x180x240 mm, its total mass is 17.36 kg.

The propulsion for this ship is obtained through the pendulous system represented in figure 3. This system consists in a pendulum with a hole drilled in the centre. The device to be attached in the centre of the pendulum consists in an assembly of a rotating wheel a shaft crossing the pendulum from forward to aft through the drilled hole and a driving small electrical engine fast to the shaft and moving the wheel. This wheel has a mass placed in its outer border. Once the electrical engine is started consequently the rotary wheel will rotate and the whole assembly will star moving from side to side heating against the kinetic brake. Thus, getting some impulse.

Figure 4 shows several sides of the prototypes installed on board the model ship.

Inside each complete pendulum system we have a mass m=121.5 g, situated almost in the periphery of the rotary disk with a radius r=35.8 mm, which rotates with an angular velocity of rotation

$$\omega = \frac{30\,turns}{10\,\sec onds} = 18.85\,{rad}/{s}$$

The rotary wheel releases a useful force on the pendulum during a half turn, while on the other half accumulates the energy. The only energy need is the one for the driving electrical motor.

The test model ship does not possess a propeller no any other known system of propulsion. Our scale model has three complete pendulum and rotary wheel systems in it. These three assemblies work in sequence, in such a way that one of them is always delivering a useful propulsion force. It is clearly seen that the smoothness of the propulsion is in consonance with the number of pendulum systems fit on board the model.

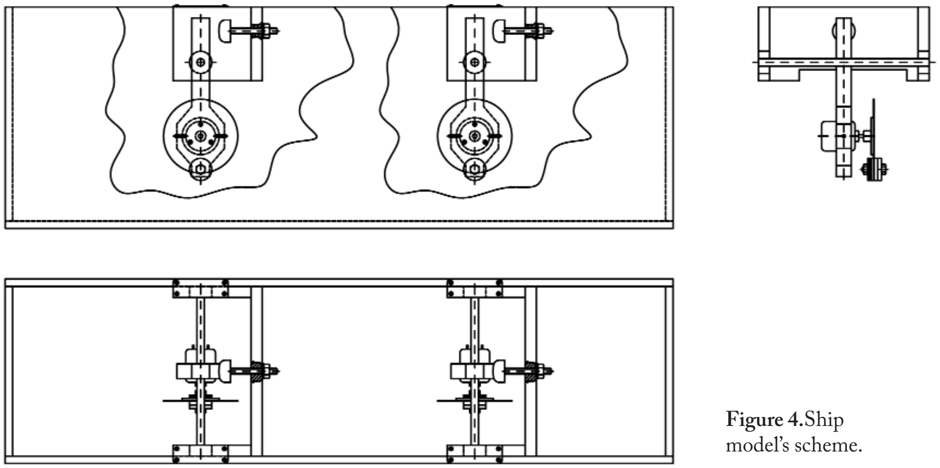

Figure 4. Ship model's scheme.

To calculate the advance of the ship we carried out a dynamic study of what happens inside the pendulous system. For it we take any position and we examine the forces involved.

$$\Sigma\tau_A = I_A.\alpha = I_A.\frac{d^2\theta}{dt^2} \qquad (1)$$

Being:

$\Sigma\tau_A$: The sum of moments respect to A

θ : The angle that displaces itself the pendulum,

α : The angular acceleration of the pendulum.

The equation results:

$$F_d \cdot d - M_d \cdot g \cdot \overline{OA} \cdot \sin\theta - (M_b + M_m) \cdot g \cdot b \cdot \sin\theta - m \cdot g\,(r \cdot \sin(\varphi - \theta) + \overline{OA} \cdot \sin\theta) - F_{Coriolis} =$$

$$= \left[\frac{1}{2} M_d \cdot r^2 + M_d \cdot \overline{OA}^2 + M_m \cdot \overline{OA}^2 + I_{bar}^A + m \cdot a^2\right] \frac{d^2\theta}{dt^2} \qquad (2)$$

Being:

$b = \overline{AJ}$

$\varphi = \omega \cdot t\, \varphi$

$F_d = m \cdot \omega^2 \cdot r$

$d = \overline{OA} \cdot \sin\varphi$

$$d = \overline{OA} \cdot \sin\varphi$$

$$a = \left[\overline{OA}^2 + r^2 - 2\overline{OA} \cdot r \cdot \cos\varphi\right]^{1/2}$$

$$F_{Coriolis} = 2m \cdot v \cdot \frac{d\theta}{dt} = 2m \cdot \omega \cdot r \frac{d\theta}{dt}$$

Resolving this differential equation we can calculate $\theta = \theta_t$, deducing the highest value of θ (θ_{max}) and the angle β at which the accumulation of energy is maximum and is delivered to the kinetic brake. Once has been reached the θ_{max} elevation, the energy transmitted to the kinetic brake is due to the pounding movement of the pendulum system.

We see now what happens with the first collision and in others subsequent. For it, we will apply the principle of conservation of the quantity of movement according to the horizontal axis x, so the speed of the boat can be calculated through:

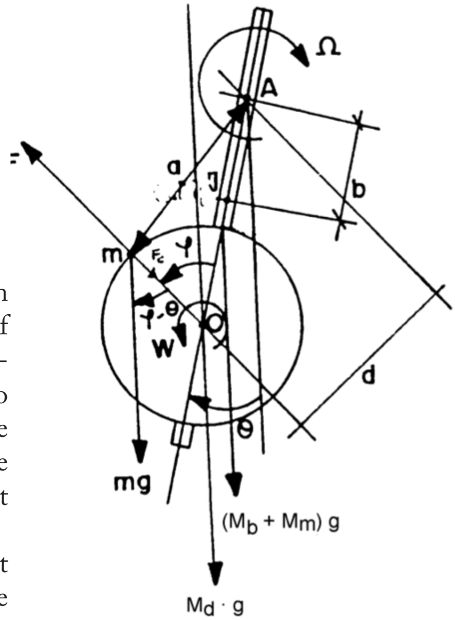

Figure 5. Pendulous system forces.

$$\dot{x} = \frac{(\dot{\theta}_0 + \dot{\theta}_1) \cdot \left[M_b + M_m \cdot \overline{AJ} + M_d \cdot \overline{AO} + m \cdot \overline{AO} - m \cdot r \cdot \sin\beta\right]}{M_T} \quad (3)$$

Being, $\dot{\theta}_0$ the angular velocity on arriving to the collision; and $\dot{\theta}_1$ to bounce; and considering a collision inelastic with a coefficient of restitution e that relates the relative velocities later and before the collision. This will be the velocity of the model after the collision. With that velocity $\dot{x} = v_0$ after the collision and with a friction force $F_r = \mu \cdot M_T \cdot g$ it will be produced a deceleration $a = \mu \cdot g$ and an advance by collision of $\Delta x = \frac{v_0^2}{2\mu \cdot g}$ during the interval of time $\Delta t = \frac{v_0}{2\mu \cdot g}$. So the new differential equation considering the friction will be the one below.

$$\begin{aligned} &F_d \cdot d - M_d \cdot g \cdot \overline{OA} \cdot \sin\theta - (M_b + M_m) \cdot g \cdot b \cdot \sin\theta - m \cdot g \cdot (r \cdot \sin(\varphi - \theta) + \overline{OA} \cdot \sin\theta) - \\ &- F_{Coriolis} \cdot d - (M_b + M_m) \cdot \overline{AJ} \cdot \cos\theta \cdot \ddot{x} - M_d \cdot \overline{AO} \cdot \cos\theta \cdot \ddot{x} - \\ &- m \cdot \left[\overline{AO} \cdot \cos\theta - r \cdot \cos(\omega t - \theta)\right] \cdot \ddot{x} = \left[\frac{1}{2} M_d \cdot r^2 + M_d \cdot \overline{OA}^2 + M_m \cdot \overline{OA}^2 + I_{bar}^A + m \cdot a^2\right] \cdot \frac{d^2\theta}{dt^2} \end{aligned} \quad (4)$$

THEORETICAL VERSUS EXPERIMENTAL RESULTS

The data pertaining to the pendulous system and to the ship are the following:

$OA = 85\ mm$	$m = 121.5\ g$	$M_d = 139.13\ g$
$e = 0.7$	$r = 35.8\ mm$	$\omega = 18.85\ rad/s$
$M_b = 319.28\ g$	$\mu = 3.5 \cdot 10^{-3}$	$M_m = 178.9\ g$
$b = AJ = 47.1\ mm$	$M_T = 17.36\ kg$	

Substituting in the differential equations, we will have:

$$\begin{aligned} &0.13137 \cdot \sin(18.85t) - 0.4485 \cdot \sin\theta - 0.04227 \cdot \sin(18.85t - \theta) = \\ &= [0.00473945 - 0.00074639 \cdot \cos(18.85t)]\ddot{\theta} + 0.0139386 \cdot \sin(18.85t) \cdot \dot{\theta} \end{aligned} \tag{5}$$

$$\begin{aligned} &0.13137 \cdot \sin(18.85t) - 0.4485 \cdot \sin\theta - 0.04227 \cdot \sin(18.85t - \theta) - 0.001596 \cdot \cos\theta + \\ &+ 0.0001479 \cdot \cos(18.85t - \theta) = [0.00473945 - 0.00074639 \cdot \cos(18.85t)] \cdot \ddot{\theta} + \\ &+ 0.0139386 \cdot \sin(18.85t) \cdot \dot{\theta} \end{aligned} \tag{6}$$

Resolving these differential equations by finite differences, by means of a calculator program and substituting in the expressions of $\dot{x}$ and Δx we will obtain $\dot{x} = 7.1\ cm/s$ and $\Delta x = 0.21\ cm$

These results agree very well with them observed experimentally.

WATER VEHICLES

It is understood that the same principles used for a canoe can be used for a transatlantic ship; the only difference seems to be matter of proportional size. The principles of this propulsion system can also be applied to a road vehicle. And it is clearly seen that propellers are not needed for ship propulsion no even for manoeuvring and steering the ship (Fig. 6).

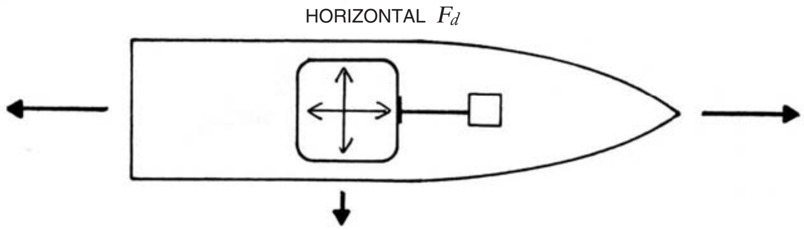

Figure 6. Ship.

This propulsion system could also have applications in underwater crafts, such as submarines, bathyscaphes, submarine investigation vehicles, submarine specialised system to get wires, pipes etc. The directional movement capability of he F_d vector make it very appropriate to be used in all kind of sceneries such as underwater, planets surface, and air (Fig. 7).

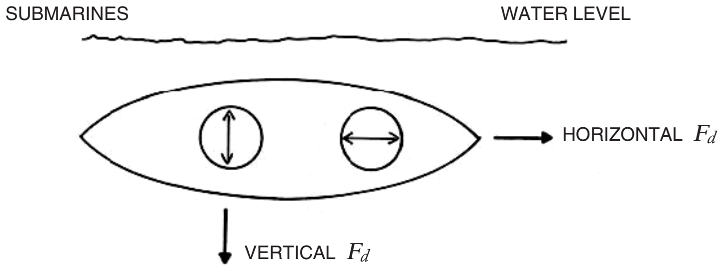

Figure 7. Underwater ships.

CONCLUSIONS

As our propulsion system is based on intermittent impulses, a continuous and smooth movement can be achieved by the synchronization of several autonomous pendulum propulsion systems.

No propellers no any other known propulsion device is required to move a ship through the water.

Vectors can push not only in the aft –fwd direction, but also in any other, so facilitating the steering and berthing of the vessel.

Propellers and wheels will not be needed for propulsion and steering purposes.

Further developments of this system will allow higher speeds on vessels and a better ratio engine power/weight.

REFERENCES

De la Llana, I.; Vila, J. and Kolb, A. (2000): Behaviour of the Kolb-Vila propulsion system mounted in a ship model, *Proceedings of the 2nd International Congress on Maritime Technological Innovations and Research*, 8-11 November, Cadiz, Spain, pp. 248-254.

De la Llana, I., Vila, J. and Kolb, A. (2001): The study and applications of a propelling system based in a rotative movement, *Proceedings of the 1st International Congress on Maritime Transport*, 21-23 November, Barcelona, Spain, pp. 249-262.

Kolb, A. and Vila, J. (1997): Gravitational unidirectional vectors. *Cienciatel* 1, 1-4.

Kolb, A. and Vila, J. (1999): Vorrichtung und Verfahrem zum Erzeugen einer gerichteten Kraft aus einer Drehbewegung. Germany patent number 19712542.

Vila, J. and Kolb, A. (1998): Demostración de la existencia del vector unidireccional gravitatorio. *Cienciatel* 2, 1-4.

Vila, J.; Kolb, A. and De la Llana, I. (1998): Comprobación teórico práctica del vector unidireccional gravitatorio. *Cienciatel* 3, 7-12.

Vila, J.; Kolb, A. and De la Llana, I. (1998) Can the propeller from a ship disappear? *Proceedings of the Second International Conference on Marine Industry (vol. 2)*, 28-02 October, Varna, Bulgaria, pp. 57-65.

Vila, J.; Kolb, A. and de la Llana, I. (1999) Naval application to the Kolb-Vila propulsion system, *Proceedings of the 1st International Congress on Maritime Technological Innovations and Research*, 21-23 April, Barcelona, Spain, pp. 227-242.

SISTEMA DE PROPULSIÓN NAVAL BASADO EN UN MOVIMIENTO ROTATORIO

INTRODUCCIÓN

Algunas veces, al explicar el movimiento circular, se utiliza el término fuerza centrífuga. Este término se deriva de dos palabras latinas, cuyo significado es *alejarse del centro*, lo que implica la existencia de una fuerza que tiende a alejar el cuerpo del centro del círculo.

Al examinar el movimiento circular de los cuerpos, prestamos atención solamente a la fuerza que actúa sobre un cuerpo en movimiento. Así, por ejemplo, si tenemos una bolita unida a un muelle (o un hilo) realizando un movimiento circular, sobre la bolita actúa una fuerza: la fuerza centrípeta. Sobre el muelle actúa otra fuerza igual pero de sentido opuesto a la primera, que es la llamada fuerza centrífuga. Luego vemos que las fuerzas centrífuga y centrípeta actúan sobre cuerpos diferentes y, por tanto, no pueden equilibrarse mutuamente. En la figura 1 se aclara esto: (F) es la fuerza centrípeta aplicada a la esfera; (Q) es la fuerza centrífuga aplicada al cordel y a través de éste sobre el centro de rotación de la bolita, por ejemplo en la mano. Para evitar confundir el concepto de fuerza centrífuga con el utilizado en las fuerzas de inercia, a la fuerza centrífuga real la llamaremos *Vector Unidireccional Gravitatorio*, también conocido como F_d.

MODELO DE LABORATORIO

Nuestro modelo de laboratorio, figura 3, consiste en un pequeño buque de forma rectangular de dimensiones 930x180x240 *mm*, y de masa total 17,36 *kg*. La propulsión de este buque se consigue a través de tres sistemas pendulares de la figura 4. Dentro de cada uno tenemos una masa m =121,5 g situada casi en la periferia de un disco de radio r =35,8 *mm*, el cual gira con una velocidad angular de rotación ω =18,85 rad/s. La energía que se utiliza es la energía eléctrica que necesita el motor para girar. Los tres sistemas están desfasados en cuanto al impulso para conseguir que cuando un péndulo esté chocando con el freno cinético, los otros estén preparados para hacerlo; consiguiendo así un impulso más continuo.

El buque no posee hélice ni ningún otro sistema conocido para su propulsión. Si lo colocamos flotando en el agua y ponemos nuestro sistema a funcionar, el buque es impulsado y se mueve por el agua.

Para calcular el avance del buque realizamos un estudio dinámico de lo que sucede dentro del sistema pendular, para ello tenemos una posición cualquiera y examinamos qué es lo que ocurre, figura 5. Resulta la ecuación:

$$F_d \cdot d - M_d \cdot g \cdot \overline{OA} \cdot \sin\theta - (M_b + M_m) \cdot g \cdot b \cdot \sin\theta - m \cdot g(r \cdot \sin(\varphi - \theta) + \overline{OA} \cdot \sin\theta) - F_{Coriolis} =$$
$$= \left[\frac{1}{2} M_d \cdot r^2 + M_d \cdot \overline{OA}^2 + M_m \cdot \overline{OA}^2 + I_{bar}^A + m \cdot a^2\right] \frac{d^2\theta}{dt^2}$$

Resolviendo esta ecuación diferencial podemos calcular $\theta = \theta_t$, deduciendo el valor máximo de θ (θ_{max}). Una vez llegado al θ_{max} de elevación, la energía transmitida al freno cinético es debida a la caída del conjunto. La velocidad con la que se moverá todo el sistema después del choque será:

$$\dot{x} = \frac{(\dot{\theta}_0 + \dot{\theta}_1) \cdot \left[M_b + M_m \cdot \overline{AJ} + M_d \cdot \overline{AO} + m \cdot \overline{AO} - m \cdot r \cdot \sin\beta\right]}{M_T}$$

Siendo $\dot{\theta}_0$ la velocidad angular al llegar al choque y $\dot{\theta}_1$ al rebotar, y considerando un choque inelástico de restitución que relaciona las velocidades relativas después y antes del choque. Con esta velocidad $\dot{x} = v_0$ tras el choque y con una fuerza de rozamiento $F_r = \mu \cdot M_T \cdot g$, se producirá una deceleración $a = \mu \cdot g$, y un avance por choque de $\Delta x = \frac{v_0^2}{2\mu \cdot g}$ durante el intervalo de tiempo de $\Delta t = \frac{v_0}{2\mu \cdot g}$, y entonces habrá que considerar la ecuación diferencial:

$$F_d \cdot d - M_d \cdot g \cdot \overline{OA} \cdot \sin\theta - (M_b + M_m) \cdot g \cdot b \cdot \sin\theta - m \cdot g \cdot (r \cdot \sin(\varphi - \theta) + \overline{OA} \cdot \sin\theta) -$$
$$- F_{Coriolis} \cdot d - (M_b + M_m) \cdot \overline{AJ} \cdot \cos\theta \cdot \ddot{x} - M_d \cdot \overline{AO} \cdot \cos\theta \cdot \ddot{x} -$$
$$- m \cdot \left[\overline{AO} \cdot \cos\theta - r \cdot \cos(\omega t - \theta)\right] \cdot \ddot{x} = \left[\frac{1}{2} M_d \cdot r^2 + M_d \cdot \overline{OA}^2 + M_m \cdot \overline{OA}^2 + I_{bar}^A + m \cdot a^2\right] \cdot \frac{d^2\theta}{dt^2}$$

RESULTADOS EXPERIMENTALES Y COMPARACIÓN CON LOS TEÓRICOS

Introduciendo los datos correspondientes al sistema pendular y al buque, tendremos:

$$0.13137 \cdot \sin(18.85t) - 0.4485 \cdot \sin\theta - 0.04227 \cdot \sin(18.85t - \theta) =$$
$$= \left[0.00473945 - 0.00074639 \cdot \cos(18.85t)\right] \ddot{\theta} + 0.0139386 \cdot \sin(18.85t) \cdot \dot{\theta}$$

$$0.13137 \cdot \sin(18.85t) - 0.4485 \cdot \sin\theta - 0.04227 \cdot \sin(18.85t - \theta) - 0.001596 \cdot \cos\theta +$$
$$+ 0.0001479 \cdot \cos(18.85t - \theta) = \left[0.00473945 - 0.00074639 \cdot \cos(18.85t)\right] \cdot \ddot{\theta} +$$
$$+ 0.0139386 \cdot \sin(18.85t) \cdot \dot{\theta}$$

Resolviendo estas ecuaciones diferenciales por diferencias finitas, mediante un programa por ordenador y sustituyendo en las expresiones $\dot{x}$ y Δx, obtendremos $\dot{x} = 7.1\ cm/s$ y $\Delta x = 0.21\ cm$. Estos resultados concuerdan muy bien con los observados experimentalmente.

VEHÍCULOS ACUÁTICOS

Se puede aplicar tanto a una canoa como a un trasatlántico, la única diferencia sería la sofisticación de la utilización del vector en un trasatlántico que no sería rentable en una canoa; el principio es el mismo. Además, el vector, para empuje de proa o popa, se puede variar para que empuje también de estribor a babor, lo que facilitaría las maniobras de atraque del buque. No se precisa hélice para la propulsión del buque.

En el caso de naves para funcionar bajo la superficie del agua: submarinos, batiscafos, vehículos de investigación submarina, sistemas especializados submarinos para tender cables, tuberías, etc., esta aplicación de los vectores F_d será más versátil. El vector F_d permite una extremada complejidad de traslaciones dentro de una esfera donde el vehículo estaría en punto central.

CONCLUSIONES

Dado que nuestro sistema funciona a impulsos, sincronizando varios motores se puede conseguir un impulso *cuasi-continuo*.

Las pruebas realizadas muestran que con nuestro sistema el modelo de laboratorio es impulsado sin necesitar hélices u otro propulsor conocido.

Los vectores empujan de proa a popa o viceversa pudiéndose variar para que actúen de babor a estribor, facilitando las maniobras del buque.

Basándonos en el mismo principio físico de este modelo podríamos conseguir obtener velocidades mayores que con los sistemas actuales y mejorar ostensiblemente la relación peso-potencia. Además se pudiera conseguirla desaparición de la hélice y del timón.

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PREDICTION OF TOTAL RESISTANCE COEFFICIENTS USING NEURAL NETWORKS

I. Ortigosa[1], R. López[1] and J. García[1]

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Abstract

The Holtrop & Mennen method is widely used at the initial design stage of ships for estimating the resistance of the ship (Holtrop and Mennen, 1982). The Holtrop & Mennen method provide a prediction of the total resistance's components. In this work we present a neural network model which performs the same task as the Holtrop & Mennem's method, for two of the total resistance's components. A multilayer perceptron has been therefore trained to learn the relationship between the input (length-displacement ratio, prismatic coefficient, longitudinal position of the centre of buoyancy, after body form and Froude number) and the target variables (form factor and wave-making and wave-breaking resistance per unit weight of displacement). The network architecture with best generalization properties was obtained through an exhaustive validation analysis (Bishop, 1995). The results of this model have been compared against those provided by the Holtrop & Mennen method, and it was found that the quality of the prediction is improved over the entire range of data. The neural network provides an accurate estimation of two total resistance's components with Froude number and hull geometry coefficients as variables.

Key words: Total Resistance's components, Neural Networks, Holtrop & Mennen Method.

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INTRODUCTION

Prediction of resistance of the ship at the initial design stage is of a great value for evaluating the ship's performance and for estimating the required propulsive power. Essential inputs include the basic hull dimensions and the boat velocity.

The model developed by Holtrop and Mennen at 1982 (Holtrop and Mennen, 1982), is a numerical description of the ship's resistance, subdivided into components of different origin. Each component was expressed as a function of the speed and hull form parameters.

Neural networks have proved to be a very useful tool to data modeling tasks. They can be defined as biologically inspired computational models consisting of a network architecture composed of artificial neurons. One of the most commonly used neural networks is the multilayer perceptron, which is a class of universal approximator (Bishop, 1995).

In this work we present a neural networks approach to two resistance's components prediction. Here a multilayer perceptron has been trained with generated data and experimental data to provide an estimation of the form coefficient and the wave's coefficient as functions of hull geometry coefficients and the Froude number.

THE HOLTROP AND MENNEN'S METHOD

Holtrop and Mennen did a statistical evaluation of model test results, selected from the archive of the Netherlands Ship Model Basin. The evaluation was carried out using multiple regression analysis methods. The objective of this study was to develop a numerical description of the ship's resistance.

Type of ship	L/B	B/T	C_p	F_n max
Tankers, Bulkcarriers	$5.1 < \frac{L}{B} < 7.1$	$2.4 < \frac{B}{T} < 3.2$	$0.73 < C_p < 0.85$	0.24
General cargo	$5.3 < \frac{L}{B} < 8.0$	$2.4 < \frac{B}{T} < 4.0$	$0.58 < C_p < 0.72$	0.30
Fishing vessels, tugs	$3.9 < \frac{L}{B} < 6.3$	$2.1 < \frac{B}{T} < 3.0$	$0.55 < C_p < 0.65$	0.38
Containers ships, frigates	$6 < \frac{L}{B} < 9.5$	$3.0 < \frac{B}{T} < 4.0$	$0.55 < C_p < 0.67$	0.45
Various	$6.0 < \frac{L}{B} < 7.3$	$3.2 < \frac{B}{T} < 4.0$	$0.56 < C_p < 0.75$	0.30

Table 1. Parameter range for different ship types.

The total resistance of a ship is generally subdivided into components of different origin. The evaluation of each component was performed by applying multiple regression analysis to the results of 1707 resistance measurements, carried out with 147 ship models and the results of 82 trial measurements made on board 46 new ships. A survey of the parameter ranges and ship types is given in Table 1.

The total resistance of a ship has been subdivided into:

$$R_{Total} = R_F \cdot (1+k) + R_{APP} + R_W + R_B + R_{TR} + R_A \quad (1)$$

R_F, Frictional resistance of a ship according to the ITTC-1957 friction formula.
$1+k$, Form factor describing the viscous resistance of the hull form in relation to R_f.
R_{APP}, Resistance of appendages.
R_W, Wave-making and wave-breaking resistance.
R_B, Additional pressure resistance of bulbous bow near the water surface.
R_{TR}, Additional pressure resistance of immersed transom stern.
R_A, Model-ship correlation resistance.

The viscous resistance, $R_F \cdot (1+k)$, represents approximately the 63% of the total resistance, and the wave-making and wave-breaking resistance represents approximately the 27% of the total resistance, for Froude number around 0.30. So we have been working in these components.

$$(1+k) = c_{13} \cdot \left\{ 0.93 + c_{12} \cdot \left(\frac{B}{L_R} \right)^{0.92497} \cdot (0.95 - C_P)^{-0.521448} \cdot (1 - C_P + 0.0225 \cdot lcb)^{0.6906} \right\} \quad (2)$$

$$\frac{L_R}{L} = 1 - C_P + \frac{0.06 \cdot C_P \cdot lcb}{4 \cdot C_P - 1} \quad (3)$$

$$c_{12} = \begin{cases} \left(\frac{T}{L} \right)^{0.2228446} \rightarrow \frac{T}{L} > 0.05 \\ 48.20 \cdot \left(\frac{T}{L} - 0.02 \right)^{2.078} + 0.479948 \rightarrow 0.02 < \frac{T}{L} < 0.05 \\ 0.479948 \rightarrow \frac{T}{L} < 0.02 \end{cases} \quad (4)$$

$$c_{13} = 1 + 0.003 \cdot C_{stern} \quad (5)$$

The C_{sterm} coefficient indicate the afterbody form. For V-shaped sections $C_{sterm}=-10$, for normal sections shape $C_{sterm}=0$, and for U-shaped sections with Hogner stern $C_{sterm}=10$.

And *lcb* is the longitudinal position of the centre of buoyancy forward of 0.51 as a percentage of L.

$$R_W = c_1 \cdot c_2 \cdot c_5 \cdot \nabla \cdot \rho \cdot g \cdot \exp\left\{ m_1 \cdot F_n^d + m_2 \cdot \cos(\lambda \cdot F_n^{-2}) \right\} \tag{6}$$

$$c_1 = 2223105 \cdot c_7^{3.78613} \cdot \left(\frac{T}{B}\right)^{1.07961} \cdot (90 - i_E)^{-1.37565} \tag{7}$$

$$i_E = 1 + 89 \cdot \exp\left\{ -\left(\frac{L}{B}\right)^{0.80856} \cdot (1 - C_{WP})^{0.30484} \cdot (1 - C_P - 0.0225 \cdot lcb)^{0.6367} \cdot \left(\frac{L_R}{B}\right)^{0.34574} \cdot \left(100 \cdot \frac{\nabla}{L^3}\right)^{0.16302} \right\} \tag{8}$$

$$\lambda = \begin{cases} 1.446 \cdot C_P - 0.03 \cdot \frac{L}{B} \rightarrow \frac{L}{B} < 12 \\ 1.446 \cdot C_P - 0.36 \rightarrow \frac{L}{B} > 12 \end{cases} \tag{9}$$

$$m_1 = 0.0140407 \cdot \frac{L}{T} - 1.75254 \cdot \frac{\nabla^{1/3}}{L} - 4.79323 \cdot \frac{B}{L} - c_{16} \tag{10}$$

$$c_{16} = \begin{cases} 8.07981 \cdot C_P - 13.8673 \cdot C_P^2 + 6.984388 \cdot C_P^3 \rightarrow C_P < 0.8 \\ 1.73014 - 0.7067 \cdot C_P \rightarrow C_P > 0.80 \end{cases} \tag{11}$$

$$m_2 = c_{15} \cdot C_P^2 \cdot \exp\left(-0.1 \cdot F_n^{-2}\right) \tag{12}$$

$$c_{15} = \begin{cases} -1.69385 \rightarrow \dfrac{L^3}{\nabla} < 512 \\ 0.0 \rightarrow \dfrac{L^3}{\nabla} > 1727 \\ -1.69385 + \dfrac{\left(L/\nabla^{1/3} - 8.0 \right)}{2.36} \rightarrow 512 < \dfrac{L^3}{\nabla} < 1727 \end{cases} \qquad (13)$$

$$d = -0.9 \qquad (14)$$

$$c_3 = \frac{0.56 \cdot A_{BT}^{1.5}}{B \cdot T \cdot \left(0.31 \cdot \sqrt{A_{BT}} + T_F - h_B \right)} \qquad (15)$$

In order to make the resistance prediction valid for ships and models of different size, the resistance components have to be expressed as dimensionless quantities depending on their respective scaling parameter. The form factor is a dimensionless quantity and the dimensionless quantity of the wave-making and wave-breaking resistance is the wave coefficient.

$$C_W = \frac{R_W}{\nabla \cdot \rho \cdot g} \qquad (16)$$

A possible validation technique for the Holtrop and Mennen's model is to perform a linear regression analysis between the predicted and their corresponding experimental values (Beaver et al., 1994, ITTC-Quality Manual 1999). This analysis leads to a line y=a+b·x with a correlation coefficient R^2. A perfect prediction would give a=0, b=1 and R^2=1. Figure 1 and 2 illustrates a graphical output provided by this validation analysis. The predicted form factor and the wave coefficient are plotted versus the experimental ones as open circles. A solid line indicates the best linear fit.

The values of the linear regression parameters here are, a_k=–0.37; b_k=1.120; R^2=0.636 for the form factor and a_W=769; b_w=3.862; R^2=0.886 for the wave's coefficient.

The Holtrop and Mennen's method seems to track the experimental coefficients approximately well, and the R^2 values are acceptable. However, these results could be improved.

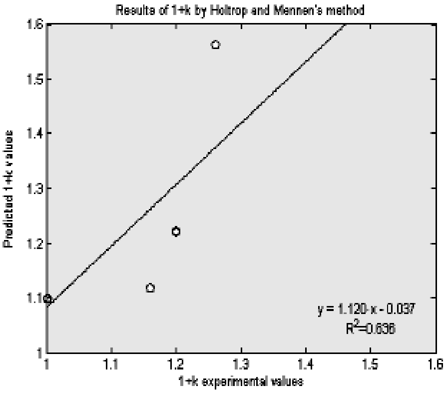

Figure 1. Form factor's linear regression analysis for the Holtrop and Mennen's method.

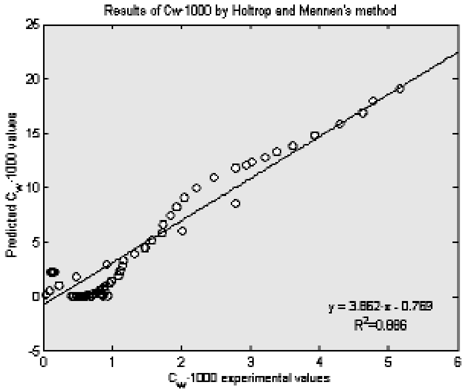

Figure 2. Wave coefficient linear regression analysis for the Holtrop and Mennen's method.

NEURAL NETWORK APROACH

In this section an empirical model for the form factor and the wave coefficient as functions of hull geometry coefficients and the Froude number is constructed by means of a neural network. The problem is solved with the Flood library (Lopez, 2007).

To training the neural network are necessary data. The calculation is based in the Holtrop and Mennen's method and the original data are not available, so the network has been trained with data generated using the Holtrop and Mennen's method.

The range of the variables considered at the experimental data are:

$$F_n < 0.45; 6.0 < \frac{L}{B} < 9.5$$

$$0.55 < C_P < 0.85; 2.1 < \frac{B}{T} < 4.0$$

To generated the data, has been varied the input data considering the influence of each one in the total resistance. In the most influential variables, the variations have been shorten.

The form factor and the wave coefficient have been calculated with a C++ program, using the Holtrop an Mennen's method for all the possible combinations of the input variables.

A multilayer perceptron is thus trained to learn the relationship between the input (C_p, C_{sterm}, L/B, B/T and F_n) and the target variables (1+k and C_W). In that way, the 20664 generated data are divided into a training and a validation subsets, containing the 82% and the 18% of the samples respectively.

Here a multilayer perceptron with a sigmoid hidden layer and two linear output layer is used (Lopez, 2007). The objective functional chosen is the mean squared

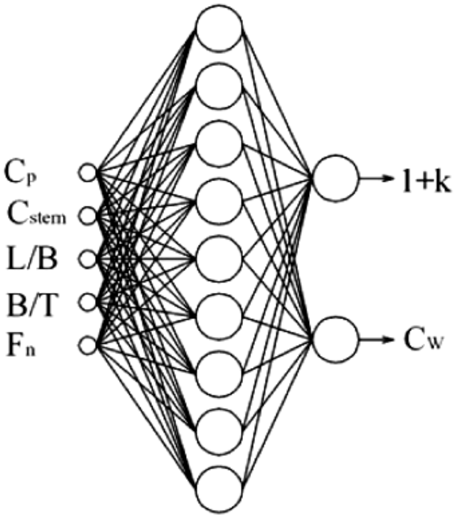

Figure 3. Network architecture for the form factor and wave's coefficient prediction problem.

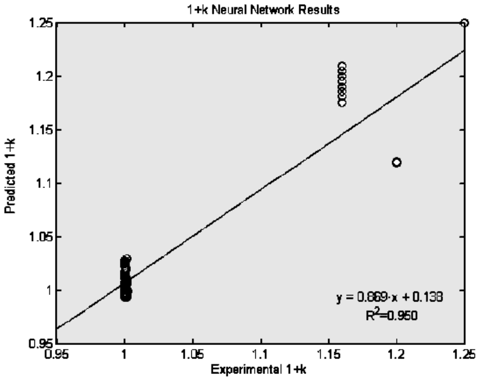

Figure 4. Form factor linear regression analysis for the neural network.

error between the outputs from the neural network and the target values in the data set (Lopez, 2007). The selected training algorithm is a quasi- Newton method with BGFS train direction and Brent optimal train rate (Bishop, 1995).

The neural network must have 5 inputs (C_p ,C_{sterm} , L/B, B/T and F_n) and two output (1+k and C_W). Here different numbers of neurons in the hidden layer were tested, and the network architecture providing best generalization properties for the validation data set was adopted. The optimal number of neurons in the hidden layer turned out to be 9.

This neural network can be denoted as a 5:9:2 multilayer perceptron, and it is depicted in Figure 3.

Once the optimal network architecture has been found and the generalization properties of the neural network validated, the multilayer perceptron is trained with the experimental data founded in the bibliography (Beaver et al.,1994, ITTC-Quality Manual, 1999), in order to use all the experiments available and to compare the neural network results against the Holtrop and Mennen's method ones.

Figures 4 and 5 shows the linear regression analysis between the experimental and the predicted coefficients provided by the neural network after being trained with the entire experimental data set.

The values of the linear regression parameters here are, a_k=0.138; b_k=0.869; R^2=0.950.

Comparing Figures 1 and 4 we can see that the multilayer perceptron provides better results than the Holtrop and Menne's method.

The values of the linear regression parameters here are a_W=0,016; b_W=0.992; R^2=0.998 for the wave coefficient.

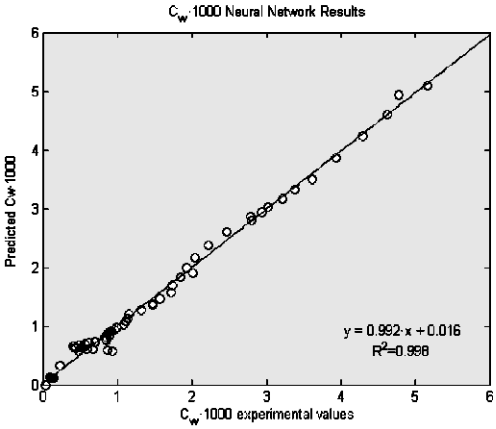

Figure 5. Wave coefficient linear regression analysis for the neural network.sion analysis for the neural network.

Comparing figures 2 and 5 we can see that the multilayer perceptron provides better results than the Holtrop and Menne's method. Indeed, all the linear regression parameters for the neural network are better than those for the Holtrop and Mennen's method.

CONCLUSIONS

The Neural Networks results are compared against those provided by the Holtrop and Mennen's method for estimating the form factor and the wave's coefficient, and it is found that the quality of the prediction with the neural network is improved over the entire range of data. The Neural Network can be improved, training it with more experimental data.

REFERENCES

Beaver, W.; Day, W. and Chwg-Wen Lin. (1994): Resistance and propulsion characteristics of the MarC Guardian tanker design. MARINEX International, Advanced double-hull Technical Symposium.

Bishop, C. (1995): *Neural Networks for Pattern Recognitio.* Oxford University Press.

Holtrop, J. and Mennen, G.G.J. (1982): An approximate power prediction. International Shipbuilding Progress 29, 166-170.

ITTC-Quality Manual (1999): Resistance Uncertainly Analysis, Example for Resistace test. ITTC 22.

Lopez, R. (2007): Flood: An open Source Neural Networks C++ Library [online]. International Center for Numerical Methods in Engineering (CIMNE), Universidad Politécnica de Cataluña. Available from: www.cimne.com/flood.

PREDICCIÓN DE LOS COEFICIENTES DE RESISTENCIA TOTALES USANDO REDES NEURONALES

Resumen

En las fases iniciales de diseño de un barco es de gran valor evaluar el comportamiento del barco para estimar la potencia propulsora necesaria. El modelo desarrollado por Holtrop y Menne en 1982, es una descripción numérica de la resistencia del barco, la cual se subdivide en componentes de origen diferente. Cada componente está expresada en función de los parámetros de forma del casco y de la velocidad.

Se ha demostrado que las redes neuronales son una herramienta muy útil para la modelización de datos. Las redes neuronales se pueden definir como un modelo computacional inspirado en el modelo biológico, que consiste en una arquitectura de red compuesta por neuronas artificiales. Una de las más usadas es el perceptrón multicapa, que es una clase de aproximador universal. En el siguiente trabajo se presenta una red neuronal para el cálculo de dos de las componentes de la resistencia. El perceptrón multicapa ha sido entrenado con datos generados y con datos experimentales, a fin de obtener una estimación del factor de forma y del coeficiente por formación de olas en función de los coeficientes de forma del casco y de la velocidad. La arquitectura de red óptima se ha obtenido mediante un análisis exhaustivo de validación.

EL MÉTODO DE HOLTROP Y MENNEN

El modelo subdivide la resistencia total de un barco en componentes de diferente origen. La evaluación de cada una de las componentes se realizó aplicando múltiples análisis de regresión a 1707 datos experimentales. La resistencia total se expresa como:

$$R_{Total} = R_F \cdot (1+k) + R_{APP} + R_W + R_B + R_{TR} + R_A \quad (1)$$

La resistencia viscosa, , representa aproximadamente el 63% de la resistencia total, y la resistencia por formación de olas representa aproximadamente el 27% de la resistencia total, para números de Froude alrededor de 0.30. El trabajo se ha centrado en estas componentes, ya que son las más significativas.

Los coeficientes que se calculan con la red neuronal son el factor de forma más uno, $(1+k)$ y el coeficiente a dimensional de la resistencia por formación de olas:

$$C_W = \frac{R_W}{\nabla \cdot \rho \cdot g} \tag{2}$$

Validamos el modelo de Holtrop y Mennen realizando una línea de regresión entre valores experimentales que se han encontrado en la bibliografía (Beaver et al.,1994, ITTC-Quality Manual, 1999), y los predichos por el modelo. Esta relación da lugar a una línea de la forma y=a+b·x con un coeficiente de correlación R^2 y una predicción perfecta daría los valores a=0, b=1 y R^2=1. Los valores de los parámetros de la regresión lineal para el factor de forma, (1+*k*) y para el coeficiente por formación de olas, C_W , son respectivamente a_k=–0.037; b_k=1.120; R^2=0.636 y a_W=0.769; b_w=3.862; R^2=0.886.

Como se puede comprobar el método de Holtrop y Mennen da unos buenos resultados, pero éstos se pueden mejorar.

APROXIMACIÓN CON RED NEURONAL

En esta sección se desarrolla un modelo empírico para el factor de forma y para el coeficiente por formación de olas en función de los coeficientes de forma del casco y del número de Froude, utilizando una red neuronal. El problema se ha resuelto utilizando la librería Flood (López, 2007).

Al no disponer de los datos originales con los que se desarrolló el modelo se han generado unos datos basados en el modelode Holtrop y Mennen. Las variables de entrada se han ido variando dentro del rango de validez del método

$$F_n < 0.45; 6.0 < \frac{L}{B} < 9.5 \text{ , } 0.55 < C_P < 0.85; 2.1 < \frac{B}{T} < 4.0$$

considerando la influencia de cada una de ellas en la resistencia total.

El factor de forma y el coeficiente por formación de olas se han calculado con un programa C++ utilizando las fórmulas de Holtrop y Mennen, para cada una de las combinaciones de las variables de entrada.

Se ha entrenado un perceptrón multicapa a fin de obtener la relación entre las variables de entrada (C_p ,C_{sterm} , L/B, B/T y F_n) y las variables de salida (1+*k* y C_W). El entrenamiento se ha realizado con el 82% de los 20664 datos generados y se ha validado con 12% restante de los datos.

Se ha utilizado un perceptrón multicapa con una capa oculta de neuronas sigmoidales y dos neuronas lineales de salida. El objetivo funcional utilizado es la media cuadrada del error entre las salidas de la red neuronal y los valores de salida de los datos.

La red neuronal ha de tener cinco entradas (C_p ,C_{sterm} , L/B, B/T y F_n) y dos salidas (1+*k* y C_W). Se han probado diferentes arquitecturas de red variando el número de neuronas en la capa oculta, y se ha seleccionado la arquitectura que da mejores propiedades de validación. Para este problema y esta configuración el número óptimo de neuronas en la capa oculta es nueve.

Una vez se ha obtenido la arquitectura óptima de la red y se ha validado, el perceptrón multicapa se ha entrenado con datos experimentales encontrados en la bibliografía (Beaver et al.,1994, ITTC-Quality Manual, 1999), a fin de utilizar todos los datos disponibles y para comparar los resultados de la red neuronal para estos datos con los que da el método de Holtrop y Mennen.

Se ha realizado un análisis de regresión lineal entre los datos experimentales y los coeficientes obtenidos con la red neuronal. Los parámetros de la regresión lineal obtenidos para cada uno de los coeficientes son a_k=0.138; b_k=0.869; R^2=0.950, para el factor de forma y a_W=0,016; b_W=0.992; R^2=0.998, para el coeficiente por formación de olas.

Comparando los parámetros de la regresión lineal obtenidos con la red neuronal y los obtenidos con el método de Holtrop y Mennen, observamos que los de la red neuronal se aproximan más a los parámetros de una regresión perfecta.

CONCLUSIÓN

Los factores de forma y los coeficientes de formación de ola, dados por la red neuronal se han comparado con los dados por el método de Holtrop y Mennen y se ha comprobado que la predicción con la red neuronal, dentro del rango de datos, es mejor que la dada por el método de Holtrop y Mennen.

Un factor favorable en la red neuronal, es que se puede mejorar entrenándola con más datos experimentales.

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BALLAST AND UNBALLAST OPERATIONS IN OIL TANKERS: PLANKTONIC ORGANISMS THAT CAN TRAVEL WITH THE BALLAST WATER

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ABSTRACT

At the beginning of the 20th century, the presence of non autochthonous species in ballast water was admitted. However, it was not until the decade of the 70s that it was considered a problem, for more non autochthonous species all over the world were introduced and watched during the decade of 80s. Canada and Australia, two of the countries which suffered from this kind of problem, exposed their worries to the Marine Environment Protection Commitee (MEPC) at the end of that decade.

In February 2004 the IMO adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments, which would be compulsory to fulfilling the approved standards between 2009 and 2016. Such standards comprise the year of construction of dead weight tank ship and the capacity of their ballast tanks.

Between July and December 2002, tests were carried out in an oceanic station (28° 30′ N and 16° 06′ W), with vertical tows of 50 meters long until surface, to register taxons present of the mesozooplanktonic community. The findings show average values of 313.06 density ind./m^3. With regard to the percentage composi-

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tion by taxonomic groups and for the same bathymetry, it stands out the community of copepods with an average value of 64.33%, followed by eggs of invertebrates and fish (18.32%), and appendicularians (5.86%). On the other hand, the remaining groups under study did not surpass the 2% of stocking.

Keywords: Ballast, unballasts, oil tankers, mesozooplakcton, exotic species.

INTRODUCTION

Nowadays, the widespread globalization in our planet, in which the distances are shorter and the communication among regions is faster, affects not only the social and cultural environment, but also the biological one.

In general, the carrier (bulk carriers, ore carries and tankers between others) need big volumes of ballast water when the ship sails without cargo (with ballast). The water warps before undertaking the voyage with the empty ship, which is an essential element for the navigation because it improves the ship stability. Moreover, without the load weight, her gravity centre can remain above the waterline and makes them list. This causes a reshuffle of around ten thousand million tons of dead weight water every year between several parts of the world.

When the ballast tanks are segregated and they only carry sea water and the ship travels without load, with ballast water weight one allochthonous organisms generally of small size, can load as “stowaways”, belonging to the planktonic community. The ballast water sockets are situated in the ship helmet bottom.

Around 3,000 species of animals and plants are estimated to travel in this way every day (IMO, 1998). Besides, the ship displacement speed is another factor that favours the prosperity of these organisms, because many would not survive in the darkness of the ballast tanks for a long period of time.

There are a lot of cases of these unexpected ones, and sometimes undesired, stowaways along the story. Three hundred and sixty seven marine organisms of the Japanese fauna were detected in a bay in Oregon (EEUU) four years after some boats coming from this country released the water from dead weight in this bay (UNESCO). A planktonic algae that reproduces very easily, *Odontella sinensis*, invaded the North Sea in 1903. The dinoflagellata, *Pfiesteria piscicida*, of which twenty-four different forms exist, was discovered in 1988 in North Carolina, after having being introduced in the ballast waters. Some of these organisms produce a series of innocuous toxins for the human being, but they are responsible for injuries and a high death rate of fish (pitches).

Not only are there planktonic beings: the European green crab (*Carcinus maenas*) is a crustacean of approximately eight centimetres of length (in adult state), voracious enough and practically omnivorous, that has been introduced by the ballast waters in Hawaii, both coasts of United States, Panama, Madagascar, the Red Sea, India, Australia and Tasmania (HIDRITEC).

It is also necessary to consider that the invading species not only affect marine ecosystems. For example, in the short stretch of the Guadalquivir an exotic species has been located, the Chinese mitten crab (*Eriocheir sinensis*). He probably arrived in larval state in the water of dead weight of some cargo ship that drained into the port of Seville; he was in the estuary of the Guadalquivir between 1997 and 2002 (Cuesta et, 2006); from March 2005 until June 2006 more than 240 units have been capturated (Ortega and Ceballos, 2006). This crab is a catadromous species, that is to say, he combines freshwater ecosystems and salted ones, depending on age; the adults are reproduced in salted water and the young ones go to sweet waters where they stay for three to five years (Díaz Muñoz, 2006). This species has been introduced in other European, western coasts, in the Baltic Sea and also in the western coasts of North America (IMO, 2004).

In the United Nations Conference on Environment and Development (UNCED) celebrated in Rio de Janeiro in 1992, a complete chapter of the Program 21 was devoted to the Protection of the oceans as well as of the seas. Later, between 1993 and 1997, the International Maritime Organization (IMO) dictated directives to prevent the transfer of aquatic organisms and pathogenic unwanted agents proceeding from the ballast waters and sediment unloading of the ships. The problem is, however, that, unlike the spillages of hydrocarbons and other forms of polluting the sea originated by the maritime traffic, the marine species and exotic organisms are very difficult to eliminate. The resolution A.868 (20), approved on November 27, 1997 as annexe of the agreement MARPOL, is concerned with "Directives for the Control and Management of Ballast Waters in ships, in order to reduce the transfer of harmful aquatic organisms and pathogenic agents". The main objective of this resolution is to achieve that the whole world fleet sterilizes the waters of ballast as soon as possible. It also demands the governments to stimulate urgent averages to apply such directives and to spread them in the shipping sector.

On February 13, 2004 the IMO adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments. Nevertheless, the compulsory nature of the fulfillment of the approved standards will change between 2009 and 2016, depending on the year of construction of the craft and of the capacity of its ballast tanks.

Therefore, the vessels should be equipped with a plan of management of the specific ballast water, included in the documentation regarding their operations.

OBJECT AND METHOD OF THE BALLAST AND UNBALLAST IN OIL TANKERS

The operations of ballast and unballast are carried out to keep, at every moment, the best conditions of a ship stability, efforts and navigability; in order to achieve this, the ballast tanks with which the ship is equipped are used (Fig. 1).

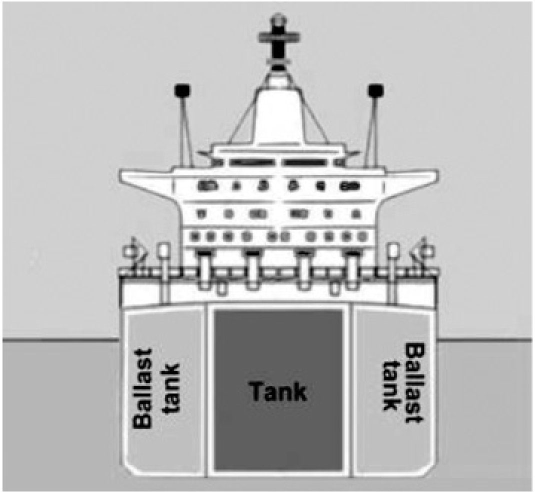


Figure 1. Scheme of the position of the tanks of ballast tanks in oil tankers.

Generally, tankers have twenty tanks of load, apart from their size, ten lateral (five to port and five starboard) and ten headquarters, whose capacity is double than that of the lateral ones (Fig. 2); they are classified in terms of their load capacity:

—ULCC (*Ultra Large Crude Carrier*), more than 300.000 tons.
—VLCC (*Very Large Crude Carrier*), more than 200.000 tons.
—Suezmax (ships capable of fitting through the Canal de Suez), between 125.000 and 200.000 tons.
—Aframax (*American Freight Rate Association*), between 80.000 and 125.000 tons.
—Panamax (ships capable of fitting through the Panama Canal), between 50.000 and 79.000 tons.

An oil tanker of 60.000 tons takes approximately 25.000 tons of ballast water in a trip with swell; since $1m^3$ of water of the sea weighs 1.020 kg, 25.000 tons equal approximately 24.509.804 m^3.

In Spain, when oil tankers need to realize operations of ballast, they have to comply with the directives exposed in the chapter II-1 of the International Agreement SINGLE, Rules 22. Likewise, the operations have to respond to the Booklet of Stability, taking into consideration the own conditions of stability of the ship in question, to the ISGOTT, and to the recommendations of the Spanish Administration (January 15, 2002).

When the vessel must sail in ballast, the situation of the same specified in the Notebook of Information about Stability that is kept in the Captain's power will adopt one. The tanks in which dead weight is introduced, if possible, will get one full to the 100 percent of their capacity. Moreover, it would avoid moving dead weights in the sea, above all in the run tanks of false bottom.

In deballasting operations the seawater contained in slops and other tanks must be pumped ashore once a check list of ship – tanks operations is done be the vessel's officer and the terminal segregated. The operations must take in to account the stresses on the yeses'.

With regard to the water contained in the tanks of ballast segregated, it will disburden bearing in mind the following considerations:

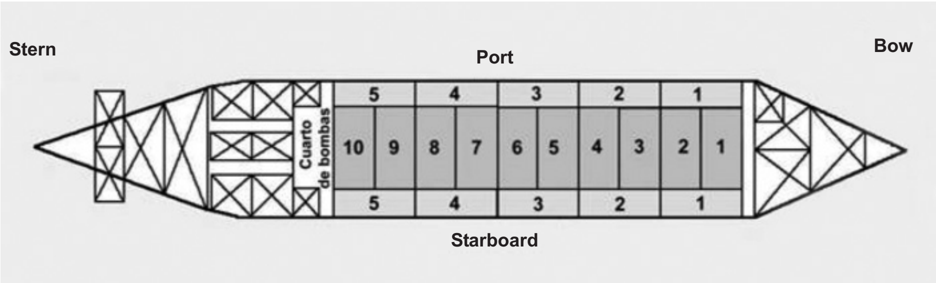


Figure 2. Central and lateral tanks distribution.

— Before beginning the operations of unballasts of the tanks of ballast segregated to the sea, some will verify that traces of hydrocarbons do not exist in the water contained in the indexed tanks, by means of the capture of samples and measurement of the gas concentration of hydrocarbons. The records of the realized operations will take form of a document.
— To support the ship with enough trim by the stern, but in no case superior to 4.0 meters, so that the tanks of continuous ballasts of double fund could remain dry.
— A lot of care must be taken so as not to exceed the soaked maximum allowed for mooring.
— To support the ship with a fret that allows manoeuvring at any time, in an emergency, for example, to stop moor.
— Combine it with the load operations so that excessive efforts in the ship helmet structure avoid one.
— In the moment of starting the operations of unballasts of the tanks of ballast segregated to the sea, in the ships where the above mentioned operation is feasible, a visual inspection of the water contained in the same ones must be carried out, or, if it is not feasible, from the water exhaust to the sea, stopping the operations if indications of pollution were observed.

As for the management of the ballast water, the Dirección General de la Marina Mercante (DGMM), has established that given the implications that the current skill of change of ballast during the navigation has for the safety and stability, it is not considered to be prudent to demand to the ships of Spanish flag the fulfillment of the A.868 Resolution: consults on the Plan of Management of the Ballast Water for ships (Ref. 04/JV, of January 15, 2002).

If the ships travel to foreign ports, the Plan of Management of the Ballast Water for ships can be demanded by the Authorities of the Governing State of the Port, and in this case, the following considerations should be born in mind:

— When the Port authorities consider fit to deballast a versel that has ballasted in a port in which the water is known to be contaminated, the deballasting has to be done offshove, in depths of move than 2.000 meters overflowing the ship`s tank.

— In this case, it will be sent to the Consignee the confirmation of the change of ballast, leaving witness of it in the Logbook.
— To avoid possible claims of pollution of the water of the port, the Captain will warn the Person in charge of the Terminus that he is going to unballast the ballast contained in the segregated ballast tanks, if he decides to send a person who recognizes the cleanliness of the water contained in them, leaving written witness of the request in the Logbook of the ship.

The Protocol of 1978 (MARPOL 73/78) introduces a series of modifications in the Annexe I of the Agreement. For example, it prescribes ballast tanks separated for all the new ships-tanks of dead weight equal or superior to 20.000 tons, whereas in the original Agreement, the above mentioned tanks were prescribed only for the new ships-tanks of dead weight equal or superior to 70.000 tons. The Protocol also arranges that the tanks of separated ballast are placed in such a way that they help to protect the tanks of load in case of boarding or launching. Besides, following the Rule 20 of the Annexe I of the International Agreement to anticipate the pollution by the ships (1973), in their form modified by the Protocol of 1978 (MARPOL 73/78), the operations of ballast-unballast of the oil tankers of brute arching equal or superior to 150 tons, will have to record in the Book Record of Hydrocarbons (Part II).

The management of that spoils of unballasts in a refinery is a professional speciality, for the pipeline bayout in a refinery is complex, the handling of ballast water must be done with extreme caution. Every refinery must have two water systems:

In them, terminals of clearance he must have poured installed teams to be the water about unballasts of the oil ones, avoiding that of hydrocarbons the being given back to the sea.

In the own refinery, because the volume of unballasts water is only surpassed in quantity by that of the own crude.

PLANKTONIC COMMUNITY IN AN OCEANIC ZONE

The quantity and diversity of beings that constitute the planktonic community depends on a lot of factors: the latitude, the season of the year, and the bathymetric level amongst others.

Since the ballast water is taken from the low part of the hull of a nose, and since the change of ballasts, it is known the existence of the distribution in spots that the zooplankton experiences in the natural way (Steele and Frost, 1977).

The material studied in this piece of research comes from the tows fullfilled from July to December 2002, on a station placed in the North-East of the island of Tenerife, Canary Islands (28° 30’ N and 16° 06’ W), to 5 miles of the coast with a depth of probe of 1.200 m (Fig. 3). The anchorage of ships is habitual in the zones nearby.

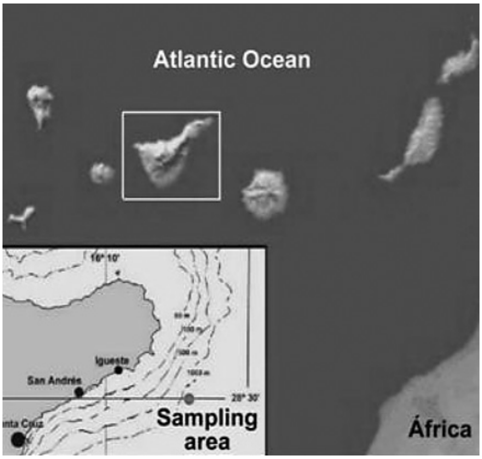


Figure 3. Situation of the sampling station.

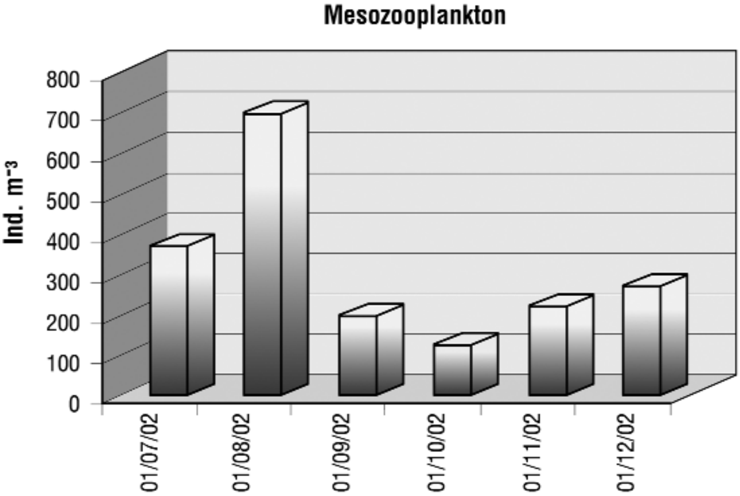
Vertical tows of 50 metre of length samplings were carried out until surface. The samples one harvested with a Juday-Bogorov net of 56 cm in diameter (0.246 m^2) and 250 μ mesh, obtaining a volume of filtered water of 12.3 m^3. Given the available net mesh light the collected units belong, by his size, to the mesozooplankton (0.2 – 20 mm.)

The samples were preserved with formalin at 4% on board, previously buffered with sodium borate (borax), labeled and stored for his posterior study in the laboratory.

Table 1 shows the results of the counts conducted with indication of ind.m^{-3} and its percentage in each one of the considered taxonomical groups. In Fig 4, one population averages indicate the density data.

TAXA	DATE (d/m/y)											
	30/07/02		27/08/02		24/09/02		29/10/02		28/11/02		27/12/02	
	Ind.m^{-3}	%	Ind.m^{-3}	%	Ind.m^{-3}	%	Ind.m^{-3}	%	Ind.m^{-3}	%	Ind.m^{-3}	%
Copepods	136,26	37,18	476,43	68,32	152,20	77,74	103,09	81,49	133,66	60,71	163,58	60,53
Cladocers	–	–	1,95	0,28	0,65	0,33	0,33	0,26	–	–	–	–
Ostracods	0,98	0,27	3,58	0,51	3,58	1,83	6,18	4,88	5,85	2,66	1,63	0,60
Mysidacea	–	–	–	–	–	–	–	–	0,33	0,15	0,33	0,12
Euphausiids	–	–	–	–	–	–		–	–	–	–	–
Amphipods	0,65	0,18	1,63	0,23	–	–	0,33	0,26	0,33	0,15	0,33	0,12
Crustacea Larvae	9,43	2,57	9,76	1,40	2,28	1,16	0,98	0,77	0,33	0,15	0,98	0,36
Chaetognaths	11,71	3,19	20,81	2,98	8,13	4,15	0,98	0,77	3,90	1,77	5,85	2,17
Appendicularians	13,33	3,64	66,34	9,49	7,48	3,82	6,50	5,14	1,95	0,89	32,85	12,15
Pteropods	4,55	1,24	2,93	0,42	0,65	0,33	0,33	0,26	7,15	3,25	1,30	0,48
Siphonophores	9,43	2,57	17,89	2,56	0,98	0,50	0,98	0,77	4,23	1,92	5,85	2,17
Salps	11,38	3,11	0,98	0,14	–	–	–	–	–	–	–	–
Doliolids	3,90	1,06	9,11	1,30	1,30	0,66	0,33	0,26	1,63	0,74	1,30	0,48
Hydromedusae	5,53	1,51	6,83	0,98	0,98	0,50	0,33	0,26	0,33	0,15	1,63	0,60
Eggs	154,15	42,06	61,14	8,74	16,26	8,31	6,18	4,88	59,84	27,18	50,73	18,77
Fish Larvae	–	–	1,30	0,19	–	–	–	–	–	–	–	–
Polychaetes	3,90	1,06	6,83	0,98	1,30	0,66	–	–	0,65	0,30	2,60	0,96
Polychaetes Larvae	–	–	–	–	–	–	–	–	–	–	0,33	0,12
Mollusca Larvae	–	–	0,65	0,09	–	–	–	–	–	–	0,33	0,12
Echinodermata Larvae	1,30	0,35	10,73	1,53	–	–	–	–	–	–	0,65	0,24
Total	**366,5**	---	**699,19**	---	**195,77**	---	**126,5**	---	**220,16**	---	**270,24**	---

Table 1. Density of population (ind.m^{-3}) and percentage (%) of the mesozooplancton taxonomic groups collected in tows 50 - 0 m.



	30/07/02	27/08/02	24/09/02	29/10/02	28/11/02	27/12/02
Ind. –3	366,5	669,19	195,77	126,5	220,16	270,24

Figure 4. Half population densities.

The found half densities for the sampling period he was 313.06 ind.m^{-3}. The values of maximum (699.19 ind.m^{-3}) and minimum (126.5 ind.m^{-3}) density were registered during the months of August and October.

TREATMENTS FOR THE STERILIZATION OF THE SEA WATER

Out of the different treatments known to sterilize the sea water, three of them can be basically distinguished:

— Chemical
— Mechanics
— Physical

Within the physical methods, the ultraviolet radiation is one of the most used and effective, although it has the disadvantage that it is the treatment of mechanical type that must be used in ideal conditions. The treatment with heat is another physical method; in this case the energy of the boilers inseeld/makes use? of increasing the temperature of the water, causing the death of the organisms. Nevertheless, a relatively complicated design is necessary and it is less effective than the treatment with ultraviolet radiation. A treatment for ultrasound also exists although it is still in an experimental phase.

Amongst the mechanical methods, the treatment for filtration eliminates any solid one or organism whose size overcomes the pore of the filter, but it allows stepping in of small organisms/,for example, small organisms to go through (virus, bacteria). Something slightly similar happens with the method of centrifugation; when the water centrifuges in a hydrociclon the particles and organisms with a bigger density than the water are dragged to the external part of the device and, thus, they are easily eliminated. However, the particles and organisms that have a similar or minor density to that of the sea water escape, and therefore they cannot be eliminated.

As for the chemical treatments, there are disinfectant products and biocides, generally oxidizers of the organic matter (as the chlorine that is used to make consumption water drinkable); a great disadvantage is that the waters treated this way preserve certain biocide character that can later affect other species. Also, on certain occasions, they give place to organochloride compounds of toxic and carcinogenic nature. Therefore, other substances are being investigated with limited biocide effects that do not put in danger other species, as well as the use of copper and other metals that are toxic for the microorganisms, though it can transport the problem of which certain metals, which in some cases are accumulative, enter the trophies chains. Nevertheless, these systems are not completely effective if not all the zones have been covered of the ballast tank and have left dead spaces without treating.

In the chemical measurements other possibilities as the treatment with ozone, electrolysis or variations in the acidity grade of the water have been proposed, but they have been discarded because of their high cost and because they can bring new, environmental problems.

Therefore, the management of the ballast waters worldwide needs an effective and economic method, but taking a lot of care not to damage the ecosystem of the zone or region where the unballast is realized, because, otherwise “prevention will be better than cure”.

CONCLUSIONS

Although nowadays oil tankers of new construction tend to have segregated tanks for the transport of the load and of the water of ballast, this separation in the tanks does not p revent that multiple organisms are moved every day from one zone to another around the planet, with the consequent problem of the introduction of exotic species in an ecosystem.

In the period recollected/analysed, an average density in the mesozooplankton of 313.06 ind.m-3 has been found, in spite of the fact that the sampling reported upon has been carried out in the North-East of the island of Tenerife (Canary Islands), which is a zone considered like oligotrophic, in comparison with the density that other zones and other latitudes can have, and that is the reason why an oil tanker that sucks 24.000.000 m^3 of ballast water can gather, approximately, 7.512 million organisms belonging to this one community.

REFERENCES

Cuesta, J.A. et al, 2006: The decapod crustacean community of the Guadalquivir Estuary (SW Spain): seasonal and inter-year changes in community structure. *Hydrobiologia*, 557: 85–95.

Díaz Muñoz, M., 2006: Especies exóticas invasoras de la Península Ibérica. Fichas de especies. Crustáceos: *Eriocheir sinensis*. InvasIber. Available 15/05/06 from URL: http://hidra.udg.es/invasiber/fitxa_detalls.php?taxonomic=5&id_fitxa=94.

HIDRITEC, Tecnología y gestión de recursos hídricos. Documentación: Aguas de lastres. Available 9/05/07 from URL: http://www.hidritec.com/doc-lastre1.htm.

Horwood, J.W. & R.M. Driver, 1976: A note on a theorical subsampling distribution of macroplakton. *J. Cons. Int. Explor. Mer*, 36 (3): 274-276IMO, 1998.

IMO. La OMI al día: Veinticinco años del MARPOL. Available 10/05/06 from URL: http://www.imo.org/includes/blast_bindoc.asp?doc_id=1053&format=PDF.

2004. International Convention for the Control and Management of Ships' Ballast Water and Sediments. Available 19/05/07 from URL: http://www.imo.org/Conventions/mainframe.asp?topic_id=867.

Novi, C., 2001: Protagonismo de la Organización Marítima Internacional en la lucha contra la contaminación del mar. Versión internet -con adaptaciones técnicas- de la publicación efectuada por Ultramarine Foundation, Amsterdam 2001 (86 pp). O.R. Ortiz-Troncoso, editor. ISBN: 90-75024-03-7 NUGI: 825-Marine environment- Marine pollution. Available 4/05/06 from URL: http://www.xs4all.nl/~oro/ultramarine/fidalmar2001/04-protagonismo.html.

Ortega Alegre, F & G. Ceballos, 2006: Control de Especies Exóticas Invasoras: Actuaciones. Junta de Andalucía. Medio Ambiente, 54. Available 14/05/06 from URL: http://www.juntadeandalucia.es/medioambiente/contenidoExterno/Pub_revistama/revista_ma54/ma54_32.html.

Steele, J. H. & B. W. Frost, 1977: The structure of plankton communities. *Trans. R. Soc. London*, 280: 485-534.

UNESCO: Manual de Educación de Medio Ambiente. Los mares. La amenaza de las bioinvasiones. Available 9/05/07 from URL: http://www.unescoeh.org/ext/manual/html/mares2.html.

OPERANCIONES DE LASTRES Y DESLASTRE EN BUQUES PETROLEROS: ORGANISMOS PLANCTÓNICOS QUE PUEDEN VIAJAR EN EL AGUA DE LASTRE

RESUMEN

A principios del siglo XX se reconoció la presencia de especies no autóctonas en el agua de lastre, pero no fue hasta la década de los 70 cuando realmente se vio como un problema. Durante la década de los 80, se introdujeron y observaron cada vez más especies no autóctonas en todo el mundo, y a finales de dicha década, Canadá y Australia, dos de los países que sufrían problemas de éste tipo, expusieron sus preocupaciones al Comité de Protección del Medio Marino (CPMM).

En febrero de 2004 la OMI adoptó el Convenio Internacional para el Control y Gestión del Agua de Lastre y Sedimentos de Embarcaciones, y será obligatorio cumplir los estándares aprobados entre 2009 y 2016, según el año de construcción del buque y la capacidad de sus tanques de lastres.

Durante el periodo julio - diciembre de 2002, se realizaron, en una estación oceánica (28° 30´ N y 16° 06´ W), muestreos verticales, de 50 metros hasta superficie, para registrar los taxones presentes de la comunidad mesozooplanctónica, encontrando valores medio de densidad de 313,06 ejem./m^3. Con referencia a la composición porcentual por grupos taxonómicos y para la misma batimetría, destacó la dominancia de los copépodos con un valor medio de 64,33%, seguido de huevos de invertebrados y peces (18,32%,) y apendiculariáceos (5,86%) mientras que el resto de grupos estudiados no superó el 2% de media.

Palabras clave: Lastre, deslastre, petroleros, mesozooplancton, especies alóctonas.

METODOLOGÍA

Los buques cargueros, necesitan grandes volúmenes de agua de lastre cuando el buque navega sin cargamento (en lastre). El agua se bombea antes de emprender el viaje con el buque vacío, y es un elemento imprescindible para la navegación ya que mejora la estabilidad del buque. Esto ocasiona un trasiego de unos diez mil millones de toneladas de agua de lastre cada año entre diversas partes del mundo. Con ese agua de lastre se pueden embarcar organismos alóctonos, generalmente de pequeño tamaño, pertenecientes a la comunidad planctónica.

Se estima en unas 3.000 especies los animales y plantas que diariamente viajan de ésta forma (OMI, 1998). Además, la rapidez de desplazamientos de los buques actualmente, es otro factor que favorece la prosperidad de estos organismos, ya que muchos no sobrevivirían un largo periodo de tiempo en la oscuridad de los tanques de lastre. La Organización Marítima Internacional (OMI) dictó, entre 1993 y 1997, directrices para impedir la transferencia de organismos acuáticos y agentes patógenos indeseados procedentes de las aguas de lastre y descargas de sedimentos de los buques, pero el problema es que, a diferencia de los derrames de hidrocarburos y otras formas de contaminación del mar originadas por el tráfico marítimo, las especies marinas y organismos exóticos son muy difíciles de eliminar. La resolución A.868(20), aprobada el 27 de noviembre de 1997 como anexo del convenio MARPOL, lleva por título "Directrices para el control y la gestión de las aguas de lastre de los buques a fin de reducir al mínimo la transferencia de organismos acuáticos perjudiciales y agentes patógenos", y su objetivo es lograr que toda la flota mundial esterilice las aguas de lastre en el menor plazo posible.

El material estudiado en este trabajo procede de los arrastres realizados desde julio a diciembre de 2002, en una estación situada en el noreste de la isla de Tenerife (28° 30´ N y 16° 06´ W), a 5 millas de la costa con una profundidad de sonda de 1200 m (Fig. 3). En zonas próximas, es habitual el fondeo de buques.

Se realizaron muestreos verticales de 50 metros hasta superficie. Las muestras se recolectaron con una red Juday-Bogorov de 56 cm de diámetro de boca (0,246 m^2) y malla de 250 μ, obteniéndose un volumen de agua filtrada de 12,3 m^3. Dada la luz de malla de la red disponible, los ejemplares recolectados pertenecen, por su tamaño, al mesozooplancton (0,2 – 20 mm).

Las muestras fueron fijadas a bordo con formol al 4%, previamente neutralizado con tetraborato de sodio (bórax), etiquetadas y almacenadas para su posterior estudio en el laboratorio.

A continuación, se procedió a la subdivisión de las muestras hasta el nivel 4 de fraccionamiento (16 submuestras) con un subdivisor Folsom, realizándose el recuento total de 4 de las submuestras sobre placas de recuento del tipo Bogorov bajo microscopía estereoscópica. Los datos obtenidos fueron sometidos al cálculo dado por HORWOOD & DRIVER (1976) expresando los resultados en número de ejemplares por m^3 y porcentaje. Los resultados obtenidos se expresan teniendo en cuenta a los 19 grupos taxonómicos encontrados, incluidos dentro del holoplancton o plancton permanente (copépodos, cladóceros, ostrácodos, misidáceos, eufausiáceos, anfípodos, quetognatos, sifonóforos, hidromedusas, pterópodos, poliquetos, apendiculariáceos, sálpidos y doliólidos) y meroplancton o plancton estacional (huevos de invertebrados y peces, y larvas de crustáceos, poliquetos, moluscos, equinodermos y peces).

CONCLUSIONES

Aunque actualmente se tienda a que los petroleros de nueva construcción tengan tanques segregados para el transporte de la carga y del agua de lastre, ésta separación en los tanques no impide que múltiples organismos sean trasladados diariamente de una zona a otra del planeta, con el consiguiente problema de la introducción de especies alóctonas en un ecosistema.

En el periodo de tiempo muestreado, se ha encontrado una densidad media en el mesozooplancton de 313,06 ejem./m^3, a pesar de que dicho muestreo se ha realizado en el noreste de la isla de Tenerife, zona considerada como oligotrófica, en comparación con la densidad que puede encontrarse en otras zonas y otras latitudes, por lo que si un petrolero succiona 24.000.000 m^3 de agua para lastre, puede recoger unos 7.512 millones de organismos pertenecientes a ésta comunidad.

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RULE- AND ROLE-RETREAT: AN EMPIRICAL STUDY OF PROCEDURES AND RESILIENCE

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ABSTRACT:

To manage complex and dynamic socio-technical systems places demands on teams to deal with a range of more and less foreseeable situations. Three groups of participants with different maritime experiences were studied using the same simulation of a ship to better understand the role of generic competencies (e.g. information management, communication and coordination, decision making, and effect control) play in such high-demand situations. Groups with moderate maritime experience were able to balance contextual knowledge with use of generic competencies to successfully manage unexpected and escalating situations. Novices, lacking contextual knowledge, performed less well. Groups with the most maritime expertise remained committed to presumed procedures and roles and did not perform as well as the other two groups. The results suggest that training to operate complex socio-technical systems safely and effectively should go beyond procedures and include development of generic competencies. This could provide operators with better tools to enhance organizational resilience in unexpected and escalating situations.

Keywords: resilience, procedures, emergency management, training, simulation

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INTRODUCTION

Procedures & resilience

Teams managing complex and dynamic systems have to be able to deal with a range of more and less foreseeable situations. In unexpected and escalating situations demands on such abilities can increase rapidly, for example when an operational problem of unknown origin becomes more serious or more intense. A fire aboard a ship could be a relevant example, such as the blaze on the *Scandinavian Star*, a passenger ferry on the route between Oslo and Copenhagen, on 7 April 1990, in which 158 people died when fire broke out and could not be contained until the next day (NOU, 1991). Unexpected and escalating situations create a range of cognitive and coordinative demands. As the tempo of operations rises and becomes more (if not entirely) event-driven, there is more to consider, communicate and coordinate, i.e. more information to process, distribute and act upon (e.g. Woods, Patterson & Roth, 2002). Goals can multiply, diversify and compete more steeply, and risk can increase dramatically.

A common regime in many operational worlds for absorbing those increased demands is proceduralization - the matching of situational symptoms with prepared scripts of coordinated action. Proceduralization is meant not only to help teams accomplish the sorts of actions necessary to further diagnose the situation, reduce uncertainty in it, and deal with its effects. It also supports the prioritization of certain work in the face of time pressure and resource constraints. Proceduralization can also be indivisibly connected with role assignments that govern who does what in dealing with the problem, and who double-checks or follows up the accomplishment or effect of specified actions. Proceduralization has provided operators in complex socio-technical systems with solutions on how to resolve normal and emergency situations and thus increased the reliability of operational activities. In the aviation industry in particular, proceduralization has been regarded as the most important system component to achieve increased operational safety and this has inspired maritime, nuclear and chemical industry as well as recently medicine. Shipping has relatively unthinkingly adopted this practice without reflection on the consequences, often perceived by seafarers as "counteracting the use of common sense, experience, and professional knowledge epitomized in the concept of seamanship" (Knudsen, 2009). Over time proceduralization has become more than an answer of how to increase safety in modern socio-technical systems, it may have become *the* answer.

Scientific management gave the original impetus to the development of procedures as ways of specifying action (see Taylor, 1947). It assumed that order and stability in operational systems can be achieved rationally, mechanistically, and that control is implemented vertically. These strategies persist. For instance, shortly after a fatal shootdown of two US Black Hawk helicopters over Northern Iraq by US fighter jets "higher headquarters in Europe dispatched a sweeping set of rules in documents several inches thick to 'absolutely guarantee' that whatever caused this tragedy would never happen again" (Snook, 2000, p.201). In the maritime regulatory domain, one sees the direct influence of singular accidents in new rules, often to the point where a ship can be identified by name. In many operational worlds, the strong influence of information-processing models on human factors has reinforced the idea of procedures as IF-THEN rule following, where procedural prompts serve as input signals to the human information processor (Wright & McCarthy, 2003). Procedures, however, are inevitably incomplete specifications of action. They contain abstract descriptions of objects and actions that relate only loosely to particular objects and actions that are encountered in the actual situation, and a procedure often requires a whole set of cognitive and coordinative tasks to be executed that the procedure itself cannot specify or call for (Suchman, 1987). Therefore it will remain difficult to construct global and prescriptive rules intended to guarantee certain outcomes of human behavior in complex socio-technical systems. Consequently, an over-reliance on procedures for safe operation may add additional layers of complexity rather than guide action and become part of the problem rather than the solution on to how to resolve a situation. One example is the fatal accident of Swissair 111 that crashed into the Atlantic ocean after that the presence of smoke in the cockpit was responded to promptly by the crew by adhering to the relevant checklist (Transportation Safety Board of Canada, 2003). However, while following established procedures for this situation (aiming at finding the source of the smoke rather than extinguishing any fire or putting the aircraft on safe ground), the fire engulfed the aircraft. In this case following the procedures turned out to be the problem rather than the solution (see Burian & Barshi, 2003).

The literature has recognized the limits and costs of a procedural approach to management of high-demand situations (e.g. Vicente, 1999, ; Snook, 2000, ; Burian & Barshi, 2003, ; Dismukes, Berman & Loukopoulos, 2007), but it has remained relatively mute on the mechanisms that translate that cost into real performance losses. Whereas the literature has shed light on the difficulty of processes of sensemaking in demanding situations that lie beyond procedural reach (Weick, 1993) it has not developed a detailed understanding of those aspects of performance that enhance or debilitate a team's adaptive capacity; its ability to migrate into a different regime for handling high demands. These are situations where novel behaviors can emerge, new and different resources are brought to bear, a regime where the stretched capacities of its constituent members actually open up opportunities for novel initiatives, interactions or role adoptions.

The ability to adapt is one of the key aspects of making a team work as a resilient organization, where resilience is defined as the ability to recognize, absorb and adapt to disruptions that fall outside a system's design base (Woods, 2006). The design base incorporates soft and hard aspects that went into putting the system together (e.g., equipment, people, training, and indeed procedures). The question is whether we can expect this kind of resilience from operators, experts as they may be, who are trained to follow the rules, adhere to checklists, and who have perhaps been professionally indoctrinated to believe that there is a procedure for every occasion.

In this paper we report on a series of empirical studies in which we explored the basis for the kind of adaptive capacity that could enhance organizational resilience in high-demand situations. Previous micro-world experiments (see Dörner, 1996) have illuminated the importance of generic competencies in handling dynamically escalating situations. Based on previous research on team decision making and human behavior, when handling unexpected and escalating events, as well as case studies from various domains, Bergström, Dahlström and Petersen (2008) suggested a theoretical framework to describe such generic competencies. The framework contains the four categories information management, communication and coordination, decision making, and finally effect control.

Here we ask the question whether a gap in such generic competencies can lead to over-proceduralization, over- reliance in role behavior and real operational losses. Without generic competencies to lean on, an increase in demands could actually accelerate rule- and role-retreat: a fall-back into, and an increasing rigidity of, rehearsed roles and rules (procedures). Possession, articulation and rehearsal of generic competencies, in contrast, could enhance a team's resilience in the face of accumulating demands.

The M/S Antwerpen simulation

The M/S Antwerpen simulation is part of a two-day emergency management training course developed at the University of Bamberg in Germany (Strohschneider & Gerdes, 2004). The course consists of first one simulator session, followed by instructions, extensive debriefings and theoretical training on emergency management, and concludes the following day with a second simulation session. However, apart from its training purposes, the simulation can be used as a research tool for providing data on group action and interaction in escalating events.

The simulation is designed for a group of five to seven participants who act as the ship's officers. Each participant takes on a specified role, namely: captain, chief officer, chief and main engineer, chief steward, ship's doctor and navigation officer. Initially each participant is provided with general information which describes the features of the ship as well role specific information. The information emphasizes the conditions for the simulation with extreme clarity, e.g. stresses not to make assumptions about the ship or its status but rather use the information that is available. It is the participants' task to safely navigate the ship through a stormy night in the North Atlantic. Due to the adverse conditions, and because the ship has been poorly maintained, the crew is forced to deal with a number of passenger-related problems and technical failures that towards the end of the simulation result in a state of emergency.

To sail the ship and handle these events, the participants have a wide variety of options and actions available to them. They have control over the technical facilities of the ship, including maintenance and repairs. Furthermore, they are presented with an abundance of information regarding the ship provide by regular printer outputs. By filling out order sheets they direct the crew and give various orders relating to the passengers (including, e.g. sending misbehaving passengers to their cabins, closing or evacuating sections of the ship, and using life boats and rafts to abandon the ship). Participants are not provided with a prescribed list of possible responses. Instead they have to plan and execute actions as a team and deal with the possible consequences and side-effects of their actions. The participants, therefore, find themselves in a dynamically developing situation, one that has a high level of uncertainty. Moreover, they have to deal with all this under the threat of all the conceivable emergencies that come with navigating a poorly maintained ship in bad weather.

The effect of different levels of procedural-experience

In this study, three different types of groups participated in the M/S Antwerpen training program. Each type of group differed in their familiarity with maritime operations. We were interested in the effects of the different levels of knowledge, experience and availability of procedures on concepts regarding team interaction and management of unexpected and escalating situations. Each type of group was represented by three groups of participants which were observed during the M/S Antwerpen training program.

The first type of participants was made up of novices in maritime settings, namely civil aviation student pilots. This type of group had minimal knowledge of maritime concepts, operations, and procedures. The second type of group consisted of maritime students with limited experience of maritime operations. These participants had some professional experience, however, being students, they did not have years of practical firsthand experience with the procedures and practices on large ships. The third group consisted of experienced seafarers, who had multiple years of experience on large ships. This type of group possessed practical expertise in regards to maritime concepts as well as with normal and emergency procedures onboard such ships.

Our main point of interest was whether the availability of procedures would enhance or impair the groups' use of generic competencies and therefore their ability to be resilient. When observing the three groups in order to assess their generic competencies, we categorised statements made and strategies chosen into the four categories information management, communication and coordination, decision making, and effect control (see Bergström, Dahlström & Petersen, 2008).

Regarding the teams' information management-strategies we specifically recorded whether or not the participants: openly stated their personal and group's goals, whether or not these goals were discussed, and whether or not decisions were based upon them. The simulation ensures that the groups are required to find a way to manage the continuous printer outputs. Therefore strategies for receiving and distributing incoming information to the group or its individual members were examined. We were also interested in how the groups would establish strategies, like prioritize incoming information based on the team goals, to cope with the data overload problem.

Secondly we focused our attention on the category communication and coordination; mainly how team members dealt with workload and role definition. We were interested to see to what extent participants shared their tasks and workload (flexible structure), or whether they rigidly remained within the work constraints of their prearranged roles (robust structure). How the groups dealt with the idle time during the simulation was a further area of interest. Idle time refers to the periods during the simulation in which there is hardly any work to do for the group. Idle time, intentionally produced by the simulation, provided the groups with the opportunity to think ahead, reflecting upon team processes, and construct team strategies accordingly, instead of just waiting for the next crisis to come along.

Thirdly we observed and recorded the decision making process, specifically at where the decision making process took place (distributed, hierarchical, etc.). We were interested in observing whether or not group goals were used to build up shared mental models and shared expectations of the problems at hand, and also in how team members shared information about decisions made.

Finally we examined the groups' overall capabilities to step back and on a meta-level analyze, discuss, and adjust their approach and team functioning during the simulation.

It seems that the different levels of (procedural) experience described above give rise to different ways of managing emergencies, in particular unexpected and escalating situations. In analyzing the performance of the groups, we distinguished between the two perspectives of "process" and "outcome". Outcome relates to the quantitative results of the simulation; primarily numbers of injuries and casualties, and damage to the ship. As a performance measure, however, the outcome of the simulation is dependent on the interaction between the participants and the facilitators of the simulation and therefore renders it a less reliable measure of performance. "Process" refers to qualitative aspects of how the group managed situations encountered in the simulator sessions, e.g. the generic competencies outlined above, in relation to accepted and recommended practices for emergency management. Reporting of results are mainly focused on "process".

RESULTS: DESCRIPTIONS OF THE THREE TYPES OF GROUPS' PERFORMANCES DURING THE M/S ANTWERPEN SIMULATION

Group type 1: Civil aviation student pilots

The first type of group, in general, performed poorly in the first simulator session in regards to both process and outcome. Most of these groups lost the ship and barely saved any passengers on their first trips. This began directly with the group getting immersed in the simulation, literally just starting and going wherever events would take them, without any clearly communicated goal or strategy, thus becoming locked in the dynamics of events almost immediately. This was manifested in the group's performance; they soon became overwhelmed by the amount of information they received. At no time did they discuss whether their initial approach of handling the information (printouts that soon formed piles and stacks of paper) was successful or even functional. Actions were almost exclusively reactive, i.e. in response to emerging problems, and normally based on urgency, not priority. Tasks were not shared in the group outside their original role descriptions, which led to a very high workload for some participants while others had few tasks to perform. The group did not monitor, discuss or change the group processes in any way, even when the workload was recognized within the group as becoming impossible to manage.

In the second session this type of groups did better regarding the outcome of the simulation: all groups still lost the ship, however this time they managed to save the majority of the passengers and crew. On a process level, the improvements were even more evident. The group showed great improvements in competencies. Although this improvement is somehow expected due to the participants' experience from the first trip and the subsequent theoretical training on emergency management, it was surprising how these groups were able to successfully transfer this to improved behavior in the second session. Tasks were explicitly distributed and redistributed to manage workload within the group. A role with low workload took the role of moderator, who then was in charge of monitoring the group's processes and dynamics. This meant that the captain was able to maintain an overview of the current situation and focus on issues of priority (rather than of urgency). Measures to ensure effective information sharing were taken, such as attempts at establishing routines for regular briefings and other forms of presenting the current situation of the ship, personnel, and problems to establish a shared mental model of the situation (use of blueprints, whiteboard, log notes etc.). They also followed up on more orders to ensure that they were carried out as intended (i.e. "effect control") and were much more cautious when making assumptions about a situation when there were gaps in their knowledge. The groups took more precautions in regards to various threats and were more proactive during this trip, for example by checking that rescue equipment was operative. The differences between the two sessions, in terms of team processes and generic competencies, are outlined in table 1.

	Session one	Session two
Information handling	▪ No explicit goals ▪ No prioritizing of incoming information ▪ Information overload	▪ Clearer formulation of goals ▪ Captain able to prioritize tasks
Communication and coordination	▪ No assignment of tasks outside role descriptions ▪ Robust rather than flexible environment	▪ Distribution and redistribution of some tasks ▪ Not overruling the predefined roles ▪ Moderator responsible for monitoring group processes and dynamics
Decision-making	▪ No sharing of goals ▪ No sharing of expectations ▪ Little sharing about decisions made	▪ Regular briefings to share information about the latest decisions made ▪ Using blueprints, whiteboards to share information ▪ Clearer orders
Effect control	▪ No following-up on decisions made ▪ No reflections about, or updates of, the tasks assigned to each role	▪ Redistribution of tasks based on the situation ▪ Follow-ups on decisions made and orders given

Table 1. Summary of the established processes to manage the simulation in the groups of type one.

Overall these groups, being student pilots, were hampered by a lack of understanding of maritime concepts which made it challenging for them to extrapolate from available knowledge in order to invent creative solutions for solving the problems they faced. Nevertheless, clever alternatives were devised for a number of problems, e.g. as the general alarm was defective an effective notification was devised for passengers to tell them that they should go to the life boats.

Group type 2: Maritime students

During the first trip, the second type of group performed, in regards to final outcome, moderately better then the first group, however, most groups still lost the ship and the majority of the passengers and the crew. These groups devised creative solutions which were difficult for the first type of group to come up with, since a basic understanding of ships is required to be able to devise such solutions. An example of this was when a group of this second type used a stream anchor to maneuver the ship after a breakdown of the steering engine. However, despite their creative problem solving capabilities, in comparison with the first type of group this type of group only performed marginally better in regards to aspects of process. Similarly to the previous groups, almost all of the second groups' actions were reactive; discussions and action were prompted exclusively by the information that came out of the printer. There was hardly any analysis of the occurred events, revision of current situation and strategies, or discussions on which potential tasks and risks may be ahead of them. There were also no structural solutions to deal with the information overflow.

After reflecting on the first trip and receiving the theoretical training, these groups performed very well in the second trip; saving the ship and its passengers. They were still applying their creative problem solving skills, but proactive thinking was added to that. They questioned their initial approaches to problems, and what became apparent during their second trips was their anticipation of potential problems. Examples of improved effect control were evident in the groups' continuous verification of the results of all their actions. There were numerous examples of proactive actions and planning in regards to potential threats to the safety of the ship. During a large fire all these groups sent people to higher decks, anticipating the spread of the fire. Their ability to foresee contingencies and consequences lead them to react quickly and forcefully. They prioritized effectively and responded in this way to every event that threatened safety. They were able to rank actions, given the situation, and defer the least important of them until a normal status of operation was

	Session one	Session two
Information handling	■ Everyone's responsibility to handle incoming information ■ No explicit goal formulations	■ Clear goals ■ Prioritizing and ranking potential threats
Communication and coordination	■ No assignment of tasks outside role descriptions ■ Robust rather than flexible environment	■ Resisting confirmation bias ■ Clear roles, but flexible distribution of tasks
Decision-making	■ Creative solutions to maritime-related problems ■ No discussions about potential tasks and risks	■ Creative solutions to maritime-related problems ■ Formulation of potential problems guided a distributed decision making processes ■ Quick reactions to contingencies
Effect control	■ Hardly any analysis of occurred events ■ No revision of current situations or strategies	■ Continuous verification of the results of actions ■ Dynamically adjusting strategies

Table 2. Summary of the established processes to manage the simulation in the groups of type two.

regained. They were also reluctant to make any sort of assumptions which could not be sustained by facts. They were also able to dynamically adjust their strategies, given the conditions encountered. An example of this was their discovery, prior to any emergency situation, that the instructions did not include specific references to muster stations and the resulting creation of an alternative approach to evacuation. The differences between the two sessions, in terms of team processes and generic competencies, are outlined in table 2.

These groups performed better than the first type of groups mainly because they had contextual knowledge that supported a more effective use of generic competencies. They devised creative solutions based on extrapolations of their nautical knowledge, e.g. reducing roll angle by course change and using auxiliary engines proactively.

Group type 3: Experienced seafarers

This type of group consisted of participants with first hand practical experience in direct relation to their roles in the simulation (the captain, chief officer and chief engineer all had experience in these respective professional roles). In the first trip a steep hierarchy of command was quickly established among the participants. This hierarchy seemed comparable to that of real vessels, with the captain being clearly in charge of everything. This hierarchical role division and task distribution worked effectively during this session as it provided structure to both normal tasks and unclear situations. All group members reported to the captain, which resulted in the captain being in control of all goals and problems, and he gave orders accordingly. He then relied on his crew to execute the given orders. The captain and the rest of the group relied heavily on many types of procedures that they would also apply in real-life situations, and these proved useful on most occasions. These procedures, drawn from practical experience, led to the participants checking a number of parameters. This also proved useful as it supported a structured plan for management of emergencies. However, the group did not fully integrate and act on information given to them even though this issue was heavily emphasized in the instructions they had received. This was manifested on many occasions, including a fire where a captain ordered the crew to go to their muster stations and only then it was discovered that these were not specified in the simulation. The participants were however unable to solve this problem by inventing an alternative to the concept of muster stations; instead there were repeated questions about them in the group as well as complaints to the facilitators about the lack of them. Overall the procedures, often unspoken and simply assumed, did not always work as anticipated, because the scenario of the simulation did not match entirely with their expectations based on their previous experiences. As a result the group was not able to advance much beyond their silent consensus on how things "should be". There were also expectations on the behavior of the crew in the simulation which did not prove valid. The amount of expectations and inability to break out of them resulted in unanticipated failures and losses. The hierarchical team structure worked smoothly initially. It did however start to erode as soon as the workload increased; the captain became buried in information and tasks. For example, during a large fire the captain was in charge of both the fire fighting and evacuation of passengers. In practice, this meant that only one of these two tasks could be adequately managed. The final outcome was moderately successful because, based on his experience, the captain decided at an early stage of the emergency that they were not going to be able to fight the fire effectively and therefore he decided to evacuate.

Surprisingly, after the relatively good first trip (keeping in mind the flaws of relying solely on procedures mentioned above) and subsequent training, this group showed only marginal improvement in the second session after receiving the training that the other types of groups received. The group preserved their reliance on roles and procedures that proved less than ideal during the first trip. In many aspects the mistakes during the second session were identical to those committed during the first session. The serial approach to problems used in the first session, which was ineffective at times when the captain was preoccupied, again in the second session lead to standstills until the captain was free to approach the next problem. With the exception of maintenance of machinery, practically no action was executed in parallel. An example of this was seen as the group was attempting to investigate potential water penetration at a time when a bomb threat was received, resulting in a switch of full focus to the bomb threat and a return to the potential water penetration only when the bomb threat had been investigated. By not approaching these two problems in parallel, for which there were more than enough resources available, the lower decks could have been flooded before both problems had been addressed. The group members stayed precisely within the boundaries of their roles and task descriptions (relying on other "roles" to do "their own" tasks). In one case it took a "hero", one of the most experienced group members, a chief engineer, to break out of this structure. During an emergency he stepped out of the hierarchy to suggest to the captain that he should take charge of the evacuation as long as the captain was preoccupied with fire fighting. Due to this initiative, the evacuation was taken care of effectively and again the outcome was relatively successful (although not nearly as successful regarding process as session two for the type 2 groups). The differences between the two sessions, in terms of team processes and generic competencies, are outlined in table 3.

DISCUSSION

Group type 1 & 2 vs. type 3: The limiting effect of procedural experience

Overall, the third type of group did relatively well in terms of group process and outcome. Despite that they did not perform optimally under increasing stress they did have a clear solution to the information flow problem and a clear distribution of

	Session one	Session two
Information handling	▪ All group members reporting to the captain ▪ The captain in control of possible goals	▪ All group members reporting to the captain ▪ The captain in control of possible goals
Communication and coordination	▪ Steep hierarchy ▪ Robust rather than flexible environment	▪ Steep hierarchy ▪ Robust rather than flexible environment
Decision-making	▪ Decisions made by the captain ▪ Reliance on perceived procedures ▪ Not acting on the information given ▪ No information sharing except for reporting to the captain ▪ Tasks not performed in parallel	▪ Decisions made by the captain ▪ The Captain overloaded with tasks ▪ Reliance on perceived procedures ▪ No information sharing except for reporting to the captain ▪ Tasks not performed in parallel
Effect control	▪ Unable to revise the belief in perceived roles and procedures ▪ No revision of roles and tasks ▪ Few follow-ups on orders given	▪ Unable to revise the belief in perceived roles and procedures ▪ Few revisions of roles and tasks ▪ Few follow-ups on orders given

Table 3. Summary of the established processes to manage the simulation in the groups of type three.

tasks, as well as a systematic approach to most of the situations encountered. However, as soon as events developed beyond the "design base" of their procedures, the work structure started to disintegrate rapidly. This did not occur in the other two types of groups – ones that were not as reliant on presupposed procedures. These two groups used the generic competencies and the knowledge they gained from their experiences in the simulation as well as from the training in-between the two scenarios. Furthermore, in contrast to the other two types of groups, the third type of group very rigidly held onto their original hierarchical group structure, even when this proved ineffective. The other groups were able to manage a more dynamic group structure in order to deal with unexpected situations and the different phases of escalation.

Although procedures may prove effective to some degree, as shown by the relative success of the third group during their first trip, as soon as the specific conditions for a procedure did not precisely apply, control was lost and competence degraded. As not all scenarios or situations can be foreseen, relying on procedural knowledge or procedures may not always be enough. However, trained crews tend to react to emergency events with the use of pre-prescribed procedures even when these do not match the problem. In other words, for someone equipped with a hammer all problems will look like nails, and this is where the danger lies. In particular in emergency situations individuals and groups need to be able to review their situation and assess whether their "standard" approach is appropriate (exemplified by the fatal accident of Swissair 111, outlined above).

Relying on procedural knowledge can limit alternatives and may prevent potentially powerful non-presupposed solutions from being considered. This may mean that not even reviewing or reframing of a situation may occur. In short, relying on procedural knowledge can severely limit crews' options to be resilient.

Moreover, armed with the knowledge that they have a procedure for every scenario, the experienced participants (group type 3) felt more secure than the inexperienced groups (group type 1 and 2). This sense of security seemed to cause overconfidence. In the simulation this was manifested by the following: giving non-specific orders, not following up on orders and making unfounded assumptions in many situations. This may be a functional approach in extremely stable and reliable conditions. However, this was not the case in the simulation and is rarely the case in the transportation industry, where crew composition and operational conditions may change frequently and equipment often is used at or close to the limits prescribed by the manufacturer.

Despite long periods of operation during which nothing dangerous ever happens, it is important that operators go to work and are prepared to expect the unexpected (Dekker, 2006). In the simulation sessions, in particular during the second trip, group types 1 and 2 showed caution regarding their situation; institutionalizing effect control, proactively checking the status of equipment (e.g. technical and rescue equipment) and simply contemplating what might go wrong next. Multiple groups of type 1, for example, checked whether all the life-boats were in good condition, whereas the experienced seafarers assumed that they were, based on the claim that such matters are regularly tested (even though they admitted that there has been a number of accidents at sea where rescue equipment has been defective). This summarizes exactly the issues that the experienced crews faced (group type 3); they assumed that things were as they should have been, that situations would proceed as expected or as ordered, and all of this would occur in accordance with procedures. Experience makes people expect certain things regarding quality of equipment, action sequences performed by crews, crew reactions in emergencies, passenger reactions and behavior etc. Procedures create reliability, i.e. expected events. Procedures are in place to fight foreseeable problems, whereas caution, forethought and inspection can give rise to resilience, to the ability to adapt to unexpected and escalating events (see McDonald, 2006).

A point of criticism may be that the experienced crew did not do as well as the other type of groups during the simulation because the simulation did not exactly mirror real world conditions. This is however to some degree the main point that the participants of the simulation were meant to take home; in an emergency situation not everything will go according to plan, e.g. not everybody will report back and not all orders will be carried out (Dahlström, van Winsen, Dekker, & Nyce, 2008). But under those circumstances groups need to find and mobilize resources and competences that will enable them to remain functioning. When procedures limit options they need to be able to find alternative ways to solve problems.

Group 1 vs. group 2: Difference between generic competencies, domain knowledge and procedural knowledge

If relying entirely on procedures is not appropriate, we can argue that having only generic competencies without having any domain specific knowledge (group type 1) may have the same effect. Maritime knowledge should facilitate the generation of solutions to the problems encountered in the simulation. The student pilots (group type 1) were not likely to come up with alternative solutions for navigation at sea. The second group type did have knowledge of maritime concepts in addition to the general competencies learned during the training phase of the program; even when the steering engine broke down they explored actions in order to make the bow of the ship turn into the wind, thereby reducing the dangerous roll angle of the ship. However they were not limited to following established procedures, even when there were explicit procedures available. To argue that even in a simulation appropriate contextual and domain competence "counts" seems self-evident. But this is not the point we wish to make here. What we believe this simulations suggests is that the role generic competencies can play for safety needs to be reconsidered for unexpected and escalating situations.

On a process level, it proved easier for groups with a certain level of domain knowledge (group type 2), as compared to groups with only generic competencies (group type 1), to cooperate. The reason for this lies in the more appropriate match between their common knowledge and the situation. The type 1 groups improved their generic competencies between the two trips and therefore performed more effectively during the second trip. Despite this improvement, it proved harder for these groups to apply their skills in an unfamiliar setting. Moreover, for participants without previous domain-specific knowledge, it proved impossible to step out of their roles, in order to assist or even overrule other roles. The reason for this lays in the role-specific information being the only information on which to base their behavior. With no alternative knowledge to use in these unfamiliar settings they remain "too loyal" to these roles.

There is a fine line that distinguishes the second group's (theoretical) domain knowledge, which enabled them to come up with more creative solutions, from the first group who lacked maritime concepts, and the third group's procedural experience which seemed to limit them to following procedures. The student pilots had no tools with which to deal with a maritime emergency, they had to rely solely on generic knowledge and competencies. The experienced crews relied on tools and procedures they normally used. The maritime students on the other hand were able to look into the toolbox and select an appropriate (but not necessarily prescribed) tool for the situation.

CONCLUSIONS

If operators are to be able to resolve normal and emergency situations, they do need to be trained in established procedures. Many industries, including the maritime, have tended to equate training and education with the acquisition of procedural knowledge. This has led to a regime of control, a discourse, in which every conceivable variation away from normal operation can be "anticipated" or controlled additively by the creation of new or more procedures and rules—a trend that may be larger than the safety-critical situations studied for this paper (see Foucault, 1977). However, the intractability of human action and design compromises inherent in any complex socio-technical system can lead to operational situations which require action and response that extends beyond any set of established procedures no matter how elaborate or detailed. Observations of emergencies in these ship simulations suggest that procedural knowledge or guidance can lead operators in unexpected and escalating situations to act in ways that are irrelevant or detrimental given the situation at hand. The issue here is not whether procedural knowledge be part of any operator's training. It is to suggest that operator training should not be limited to this. Apart from being reliable in the sense of following predetermined procedures, an organization also has to be able to "recognize and adapt to handle unanticipated perturbations that call into question the model of competence, and demand a shift of processes, strategies and coordination" (Woods, 2006, p.22). McDonald (2006) suggests that being able to successfully resolve this apparent contradiction is a characteristic of a resilient organization. While unanticipated, it is industry's strong commitment to and investment in safety and procedure that has left operators less able to respond to unexpected and escalating situations. Next to the training of procedures, operator training needs to stress as well the development of generic competencies that add up to resilience in the face of unexpected and escalating situations. This would provide operators with the tools they need to manage situations that go beyond what can be anticipated. Only then can the kinds of counterproductive rule- and role-retreat behavior observed in these shipboard simulations (and often reported in accident reports) be avoided.

REFERENCES

Bergström, J.; Dahlström, N. and Petersen, K. (2008): Securing Organizational Resilience in Escalating Situations: Development of skills for crisis and disaster management, *Proceedings of the third Resilience Engineering Symposium,* 28-30 October, Antibes-Juans Les Pins, France, pp.11-17 .

Burian, B. and Barshi, I. (2003): *Emergency and Abnormal Situations: A Review of ASRS Reports*. the 12th International Symposium on Aviation Psychology, Dayton, OH, Wright State University Press.

Dekker, S. (2006): *The field guide to understanding human error*. Aldershot: Ashgate Publishing Company.

Dismukes, R. K., Berman, B. A. and Loukopoulos, L. D. (2007): *The limits of expertise: Rethinking pilot error and the causes of airline accidents*. Aldershot: Ashgate Publishing Company.

Dörner, D. (1996): *The Logic of Faliure*. New York: Metropolitan Books.

Foucault, M. (1977): *Discipline and punish: The birth of the prison (A. Sheridan, Trans.)*. New York: Vintage (Original work published 1975).

Knudsen, F. (2009): Paperwork at the service of safety? Workers' reluctance against written procedures exemplified by the concept of 'seamanship'. *Safety Science*, *47*, 295-303.

McDonald, N. (2006): Organisational Resilience and Industrial Risk. In E. Hollnagel, D. Woods and N. Leveson (Ed) *Resilience Engineering, Concepts and Precepts,* pp. 155-180. Aldershot, Ashgate Publishing Company.

NOU (1991): *A Scandinavian Star: Ulykken 7 april 1990 Hovedrapport*, Oslo

Snook, S. A. (2000): *Friendly Fire, The accidental shootdown of U.S. Black Hawks over northern Iraq*. Princeton: Princeton University Press.

Strohschneider, S. and Gerdes, J. (2004): MS: ANTWERPEN: Emergency management training for low-risk environments. *SIMULATION & GAMING* 35 (3), 394-413.

Suchman, L. A. (1987): *Plans and situated actions: The problem of human-machine communication*. Cambridge, UK: Cambridge University Press.

Taylor, F. W. (1947): *Scientific Management*. New York: Harper & Brothers Publishers.

Transportation Safety Board of Canada (2003), *Aviation Investigation Report: In-flight fire leading to collision with water, Swissair Transport Limited, McDonnell Douglas MD-11 HB-IWF, Peggy's Cove, Nova Scotia 5 nm SW, 2 September 1998, (Report number A98H0003)*, Catinau, QC

Weick, K. (1993): The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster. *Administrative Science Quarterly*, *38*(4), 628-652.

Vicente, K. (1999): *Cognitive work analysis: Toward safe, productive, and healthy computer-based work*. Mahwah, NJ: Lawrence Erlbaum Associates.

Woods, D. D. (2006): Essential Characteristics of Resilience. In E. Hollnagel, D. D. Woods and N. Leveson (Ed) *Resilience Engineering - Concepts and Precepts,* pp. 21-34. Aldershot, Ashgate Publishing Company.

Woods, D. D.; Patterson, E. S. and Roth, E. M. (2002): Can we ever escape from data overload? A cognitive systems diagnosis. *Cognition, Technology & Work* 14, 22-36.

Wright, P. C. and McCarthy, J. (2003): Analysis of procedure following as concerned work. In E. Hollnagel (Ed) *Handbook of cognitive task design,* pp. 679-700. Mahwah, NJ, Lawrence Erlbaum Associates.

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MARITIME ARCHIVES ADMINISTRATION IN NIGERIA: A BLUEPRINT

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Abstract

Maritime archives are warehouses of past water based activities which have been recorded in various forms and are considered to be valuable for both present and future references. They are storage of valuable marine related records and documents that speaks about the hardware and software of water transportation of a country from the earliest date to the last date of all the records kept. Maritime archives therefore reveals about the historical endowment of a country's water transport from crude to sophisticated infrastructure, boat, yacht and ship building and repair evolution and developmental stages, education and training, shipping trade and policies, people, etc.

This Paper proposes principles or blueprint for maritime archives administration in Nigeria that will guide decision making process regarding the establishment, structure, staffing and functions as well as funding of maritime archives in the country by using deductive reasoning out of general archives literature and personal interviews with maritime administrators on their perception about maritime archival services and their expectations on what should be collected and kept in ideal maritime archives.

The Paper observes that maritime archives materials can be collected from the national archives, States history and culture bureaus, archives of the old regional formations, research centres of tertiary institutions, palaces of Emirs, Obas, Obis and other traditional chiefs as well as museums and libraries overseas.

The paper therefore recommends that maritime archivists must have industry knowledge and cognate work experience while funding can be done through cost sharing between major institutional stakeholders.

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The paper concludes that sustainability of maritime archives lies in a comprehensive document policy for electronic data that stipulates the retention policy as it affects back-up by all maritime organisations in the country and duration or age within which to transfer documents to central collation domain at the maritime archives.

The views expressed in this Paper are entirely those of the Author and do not necessarily reflect the official position of the Nigerian Maritime Administration and Safety Agency.

Keywors: Maritime archives; blueprint; sustainability archives

INTRODUCTION

Maritime is a broad based water related activities while maritime archives are warehouses of such past activities which have been recorded in various forms and are considered to be valuable for both present and future references. Consequently, archives are historical domain; and, maritime archives are storage of valuable marine related records and documents that speaks about the hardware and software of water transportation of a country from the earliest date to the last date of all the records kept.

Although maritime archives may contain pictorial and nongraphical information about different water resources and their utilization and development, the records and documents are generally concerning water transport and transportation system. Maritime archives therefore reveals about the historical endowment of a country's water transport from crude to sophisticated infrastructure, boat, yacht and ship building and repair evolution and developmental stages, education and training, shipping trade and policies, people, etc.

This Paper proposes principles for maritime archives administration. It sets a blueprint that would guide decision making process regarding the establishment, structure, staffing and functions as well as how to fund maritime archives in Nigeria using deductive reasoning based on general archives literature. Interview was employed to get maritime administrators' perception about maritime archival services and to know their expectations on what should be collected and kept in an ideal maritime archives.

This Paper is a pioneering work in Nigeria because local articles on maritime archives were not available. Consequently, the Author relied heavily on articles from internet sources, the National Archives Act, 1992 and the Public Procurement Act, 2007. These sources together with the information gathered from personal interviews resulted in the proposed Blueprint or the principles of maritime archives administration in Nigeria.

The Paper therefore attempts to answer questions on the structure of archives and what kind of maritime archives best suits Nigeria? What calibre of staff should work in maritime archives? What should be their duties? What records and documents should be kept in Nigeria's maritime archives? What are the financial implications?

STRUCTURE OF MARITIME ARCHIVES

Maritime archives are places where maritime public records or historical documents are collected, gathered, kept, preserved and accessed. The nature and number of records and documents may change from time to time depending on the "add and destroy" policy that guides the operations and management of the archives.

The basic function of maritime archives is to educate in the area of history with specific reference to water transport. Maritime archives therefore preserve the collections of materials about yachting, the boats, the waters and people who, at one time or the other, were part of the history within the range of years which the archives management considered valuable to the public.

Usually, what is kept in maritime archives is determined by history, the development processes which a country had passed through and the perception of policy makers as to what is relevant. However, the collections would consist of literary materials, works of arts, transcript of meetings and tapes, letters, laws, edicts, bylaws, manuals, reports, newsletters, photographs, films, video and sound recordings, electronic data files, cartographic records and maps, motion pictures, historic objects including buildings, sites and records of immigration in their original forms and in copies.

Invariably, the structure of maritime archives would be influenced by the number and size of records and documents collected and to some extent, the space available as well as the training and specialization of staff. Maritime archives may therefore consist of Collection, Preservation and Conservation (CPC)[1] section; Appraisal, Description and Arrangement (ADA)[2] section; Access and Information Management (AIM)[3] section; Research, Liaison and Outreach (RLO)[4] section; and Administration, Standard and Training (AST)[5] section. In contrast, the Kenya National Archives and Documentation Service (KNA & DS) has 6 Sections which

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[1] The duties of the CPC Section will be guided strictly by the principles of "add and destroy" (A & D). The A & D principle is the standard policy that determines the type of historic materials and artifacts to search for and collect; their method of preservation and the duration as well as how such items may be replaced either by substitution or destruction.

[2] The ADA Section is responsible for ensuring that the Archives is stored with the prescribed items. It is also its duty to describe each item in a manner that information users will find it easy to understand. The ADA Section must adopt a standard retrieval system so that items can be traced without difficulties.

[3] Access and Information Management (AIM) Section is the real archives in the public eyes because it is responsible for providing access to the items collected in the archives. It manages the utilization of the archives' collections and recommends additional items to be gathered based on enquiries from the public.

[4] The RLO Section is responsible for identifying collectable items through historical research efforts. It liaises with the public to know what they want, how they value what is gathered as well their views on what need to be replaced. The Section also reaches out to volunteers, institutions and bodies where archival items can be obtained.

[5] Budget preparation and implementation, establishment of working policy, quality of service delivery and training of staff, volunteers and inter-archives collaboration are part of the duties of the AST Section.

are divided according to specific and specialised functions namely: Searchroom and Education Service, Microfilming, Conservation, Repository Services, Information Technology and Audiovisual[6].

Maritime archival is an enormous and essential service if the spirit of gathering, describing and providing material and artifacts are sustained. There is no overlap in the functions and responsibility of each of the Sections where their duties are properly described.

It is pertinent to note that due process mechanisms must be applied to all archival procurements[7]. In fact, it is required that procurement entity, like the maritime archives, shall plan its procurement by identifying the goods, works or services required[8] and all bidders shall possess the necessary professional and technical qualifications to carry out particular procurements[9] in order to archive value for money and fitness for purpose[10].

Consequently, where archival procurements are to be undertaking by non-staff, the maritime archives must advertise and solicit for bids in order to enhance openness, fairness and transparency so that confidence can be enhanced in the procurement process by all stakeholders and the general public. The advertisement must also be explicit by indicating the qualifying requirements, the scope and location as well as providing adequate tendering periods[11].

MARITIME ARCHIVISTS

Every staff working in the maritime archives is an archivist. The staff may have different academic qualifications but every staff should have an additional qualification in maritime or related areas. Although library is part of archives, a qualification in library science does not give an upper hand to someone without training and understanding of the maritime environment. This is because maritime archives do not just gather books, journals, periodicals and other reference materials of general nature. It is a specialised historical service domain which, however, cannot also be equated with museum. Maritime archives are broader than both maritime museum and a library in any maritime body or institution.

Maritime archivists are professionals who assess, collect, organise, preserve, maintain control over and provide access to information determined to have long-

[6] See, www.kenyarchives.go.ke/archives_administration.html.

[7] Kingibe A. B. G (2008): "Circular"; Ref. No. SGF/OP/1/S.3/VII, Office of the Secretary to the Government of the Federation.

[8] See *Public Procurement Act, 2007*, Section 18 (b)

[9] Ibid. Section 16 subsection 6(a(i)).

[10] Ibid. Section 16(1e).

[11] Kingibe A. B. G. (2008): "Circular", Ref. No. SGF/OP/1/S.3/VII, Office of the Secretary to the Government of the Federation, page 2.

term value. Maritime archivists keep records that have enduring value as reliable memories of the past; and, they help people to find and understand the information they need in those records. It is challenging to determine what records have enduring value. Such records must justify the costs of storage and preservation as well as the labour expenses to arrange, describe and provide reference service.

The preferred qualification for maritime archivist is a master's degree in archival studies and records management plus at least a postgraduate diploma in maritime studies. However, persons with master's degree in marine engineering, naval architecture, transportation studies, history, archaeology, library science, arts or science are trainable as maritime archivists if they have cognate work experience in the maritime environment. Such candidates need training in archives interpretation, source studies, records preservation and management, documentation policy, dealing with electronic and digital records as well as archives service management.

Although the structure of maritime archives may differ from one setup to another; and, from one country to another, the duties or functions of the director of the national Archives is spelt out in Section 2(2a–2m) of the National Archives Act of 1992. Some of the functions include giving advice on all matters relating to records and archives, appraisal and selection of permanent preservation, periodical publication and microfilming of archives, research, duplication, lending, training and establishing relationship with foreign or international organisations on all matters relating to records and archives.

STRUCTURE OF MARITIME ARCHIVES FOR NIGERIA

Nigeria is yet to have maritime archives despite her rich water based activities spanning several centuries. With big and small rivers in all the States of the Federation and the Federal Capital Territory (FCT), the public would appreciate to have a one-stop place for maritime heritage.

However, maritime administrators[12] differ in their views and perception about collectible items for the maritime archives and the cut-off age. Whereas some believe that every activity is undertaken in the first instance because it is important in the maritime environment and therefore records and documents about everything should be kept, others opine that there should be criteria for sorting out what is relevant for archival service from what is not. For example, Gunwa (2008) suggests that maritime archives should contain reports, photographs, project studies and draft legal documents filled in alphabetical order with cross index and referencing like a library which can be considered as having a reference value in the future. On the other hand, Olokoba (2008) emphasises on capturing everything in the maritime

[12] See, References for names of selected maritime administrators interviewed about the subject matter of this Paper.

operation because what is not valuable today may be important in future just as Ofodile (2008) also posits that the archives should keep everything about the past in order to assess the present and plan for the future. Edward (2008) however assets that maritime archives should have different categories of information that may be grouped according to headings such as "Accidents", "Registered ships", "Scrap/Dead ships", etc. He adds that the archives should contain information about conventions, instruments of ratifications, IMO Resolutions and proceedings of meetings. He relates archives service to library services.

Alim (2008) perceives maritime archives as a place for collection of discharge book on-board ships, survey records, particulars and activities of ships, agents, chandeliers as well as records and documents of shipping masters and the white paper of every seaman. Balogun (2008) suggests that maritime archives should store milestone of events such as the first Europeans to visit Nigeria, where they went, who they met; the first passenger vessel, who were the passengers, where did they go; the first indigenous vessel acquired, for what purpose and similar epoch making events about the Nigerian maritime. Since maritime archives is to keep records of history for the purposes of education, Olopoenia (2008) recommends that what is kept would be determined by the type of materials institutions within the sector have. He also suggests the National Museum and Archives as sources of materials.

Age of Archival Materials

Generally, maritime administrators suggest a cut-off range of ten to fifteen years for all closed files and documents to be transferred to the archives.
By and large, Section 12 (1a, 1b & 1c) of the National Archives Act declares public archives materials to be "All non-current public records of the age of twenty-five and above which contain evidence of the organisation, function, policies, procedures and transactions of the public office in which they were originally made or received; or evidence of public or private personal property rights or civil rights; or historical or general information".

Notwithstanding the prescribed age cut-off for archival items given in Section 12(1a, 1b & 1c) and the reiteration in part of Section 35(4) of the National Archives Act, the Act also allows for early transfer of records and documents to the archives[13] which invariably respects the wish of the maritime administrators because of the significance and historical interests attached to maritime activities in Nigeria. Furthermore, in this digital age when a lot of government functions using e-mail and electronic documentation have increased dramatically, it becomes necessary to determine for how long the mass information being generated would be held before it is

[13] See, Section 14 and Section 35(4) of the *National Archives Act*; Cap N6, 1992 No 30, Laws of the Federation of Nigeria.

archived. Apparently, the twenty-five year cut-off age for paper documents can not apply to electronic data.

Legality of Maritime Archives

Some maritime administrators also question the legality of establishing maritime archives separate from the National Archives. For example, Dirisu (2008) asserts that all public records not in circulation should be domiciled in the National Archives. However, the provisions of Section 20 (1 & 2) of the National Archives Act unambiguously recognize special circumstances which may warrant the establishment of place of deposit in lieu of the National Archives thereby lending support for the establishment of other categories of archives such as the maritime archives.

Staffing of Maritime Archives

While the qualification of the head archivist is not explicitly stated in the National Archives Act, some administrators feel that any librarian can serve. Gunwa (2008) opines that a librarian/archivist that knows filing and data processing should work in the maritime archives. Balogu (2008) on the other hand differs in his opinion. He suggests someone with information technology background and should also be conversant with the maritime industry. Although Alexander (2008) believes that any staff of NIMASA[14] can be deployed as maritime archivist, he also prefers research officers to work there.

However, the National Archives Act provides that for the purpose of ensuring permanent custody, care and control of archival materials in the country, under circumstances of a different category of public archives, such as the maritime archives, the head shall be appointed in consultation with the Director of the National Archives[15]. Nevertheless, this Author expects that the position would be filled by someone with the requisite academic and professional qualifications that is blended with cognate industry experience.

Funding of Maritime Archives

In terms of the financial implications for establishing and operating maritime archives, Gunwa (2008) notes that space, archivists pay, computer with data software for archiving documents, racking, shelve and box files are the major cost centres in maritime archives. Balogun (2008) however argues that based on the supervisory role of the Federal Ministry of Transportation, financing of maritime archives can be made to be contributed by water related parastatals under the ministry.

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[14] Referring to the Nigerian Maritime Administration and Safety Agency.

[15] See, Section 21(1) of the *National Archives Act*; Cap N6, 1992 No 30, Laws of the Federation of Nigeria.

It is obvious that the costs of establishing and sustaining archives are huge particularly when it involves storing conventional records digitally. In the United States of America (USA) for example, $411.1 million was approved for funding the National Archives and Records Administration (NARA) in 2008 (as against $341.1 million in 2007) out of which $315 million was for operating expenses covering energy, security and staff costs[16]. The sum of $321.291.000 and $316.322.000 were respectively also approved in 2005 and 2004[17] for the Agency's activities. These funding figures show increases on annual basis as a result of expansion, new recruitments and research and publication activities.

It follows therefore that in order to establish, operate and sustain standard maritime archives in Nigeria, there must be consistent funding, strong commitment to archives upgrading in the face of other competing projects, sincere commitment to records retention and link between current records, information management and the archives.

Recommendations and Conclusion

This paper reviewed the principles of general archives and discusses the views of maritime administrators regarding archival materials, legality, funding and staffing of an ideal maritime archives for Nigeria.

Nigeria is endowed with several water based resources such as 210.900 kilometers of maritime waters including the Exclusive Economic Zone (EEZ)[18]; 853 kilometers of coastline and 8.600 kilometers of inland waterways stretching the lengths of Niger and Benue rivers, Niger Delta, Lagos Lagoon, Cross River and other small rivers and creeks[19]. The country also has had continuous inward and outward cargo flows including dry, wet and LNG cargoes that constitute modern trade. There were also trade records on cocoa, timber, rubber, groundnuts, hide and skin, cotton, palm oil and palm kernel during the colonial era. Presently, Nigeria has 8 international seaports, 11 oil terminals, 124 private jetties, about 15 shipyards, various floating production storage of take vessels (FPSO) etc.[20] where various shipping services are undertaken by many maritime service providers.

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16 The National Archives (2007): "Press Release" at www.archives.gov/press/press-releases/2008/nr08-41.html, accessed on 14th July, 2008.

17 The National Archives (2004): "Press Release" at www.archives.gov/press/press-releases/2005/nr05-26.html, accessed on 14th July, 2008.

18 A. V. Amire (2008): *Monitoring, Measurement, and Assessment of Fishing Capacity: The Nigerian Experience*, www.fao.org/docrep/006/y4869e/4849e0c.html, Accessed on 8th July, 2008.

19 Central Intelligence Agency (2007): *Nigeria* www.cia.gov/library/publication/the-world-factbook/geos/ni.html, Accessed on 8th July, 2008.

20 See, David Oladimeji (2008): "Chandelling business 'll stem capital flight"; *New Age* Newspaper, 8th July, 2008, page 24.

This shows enormous opportunities for water based activities in the country for both Nigerians and foreigners. Accordingly, the following recommendations are made in respect of sources of archival materials, staffing and funding of maritime archives.

Sources of Archival Materials

There are various sources of archival materials that can be collected to equip a maritime archive for the country. These sources depend on whether the archival being sought is for traditional maritime activities, colonial era or post independence. The following are identified amongst others:

1. Retired mariners, naval officers and seafarers: Nigeria has had six generations of mariners that traveled round the oceans[21] .
2. Government agencies[22] responsible for maritime activities including government owned shipping lines[23] .
3. Maritime and related training institutions[24] .
4. Associations, individuals and families of traditional shipping operation, search and rescue activities as well as boat building[25].
5. Regional and international maritime cooperation and ratified international conventions.
6. Domesticated maritime conventions[26] and various enactments[27] for the regulation and promotion of maritime activities.

[21] Apart from conducting personal interview with retired mariners to document matters of historical value based on oral tradition, which is within the provisions of the National Archives Act, Section 27 (3 & 4) of the Act also stipulates that where archives are voluntarily deposited by private companies and individuals, public access to them must be based on the conditions given by the archives depositors and written permission. It is therefore expected that this protection would encourage mariners and other experienced maritime personnel to deposit personal archives and grant interview about their private lives.

[22] These include the Federal Ministry of Transportation (FMoT), Nigerian Port Authority (NPA), Nigeria Shippers' Council (NSC), Nigerian Maritime Administration and Safety Agency (NIMASA), Nigerdock Shipyard, National Inland Waterways Authority (NIWA) and National Clearing and Forwarding Agency (NCFA).

[23] The government established the Nigerian National Shipping Line (NNSL) as a national carrier which was liquidated after 3 decades and replaced by the Nigerian Unity Line (NUL) which could not compete in the market and therefore went under.

[24] Maritime and related courses are being run by over thirty universities, polytechnics and specialized training institutions offering diploma, higher national diploma, bachelor, masters and doctorate degrees in the country. There are also some private training institutions apart from centres for artisanship.

[25] Boats are still being built by artisans who learn the art from their parents. There are also search and rescue families in all the places where water based activities are taking place. In fact, water transportation in the rural and coastal areas are generally traditional.

[26] The United Nation Convention on Trade and Development (UNCTAD) was domesticated through the National Shipping Policy Act of 1987.

[27] Example includes the Merchant Shipping Act and the Coastal and Inland (Shipping) Cabotage Act.

7. Records and documents of companies carrying out all manners of maritime activities in the country.
8. Research and publications on Nigeria's maritime sector.
9. Portuguese and British explorations of the Niger[28], slave trade and commodity trade before the amalgamation of the Southern and Northern Protectorates.
10. Colonial maritime policies[29], shipping companies[30], trade and cargo throughput.
11. Colonial maritime training centres and policies in Nigeria and the activities of foreign shipping companies in post-independence.
12. History and Culture Bureaus (HCB) of all the States in the Federation and the FCT where local and state-wide documents about past activities are kept.
13. There are also archives of the old regional formations of the country like the *Arewa House* in Kaduna which store records and documents especially of the former Northern Region. Similarly, research Centres of many universities such as the *Mumbayya* House[31] in Kano have valuable records and documents concerning the past of Nigeria and people.
14. Above all, the National Archives is the major custodian of all records and documents about people and Nigeria.
15. Complementary to the National Archives are the palaces of Emirs, Obas, Obis and other traditional chiefs that maintain records, documents and artifacts of the fabulous indigenous maritime activities during centuries of precolonial days through colonial era and the nation's post-independence times.

Apparently, there are many established sources for collecting maritime archives materials. Furthermore, information about past maritime activities can be gathered through oral tradition since the National Archives Act recognises oral tradition and oral history as one of the sources for archival documentation[32].

Staffing and Duties of Maritime Archivists

Based on our discussion on the nature of maritime archives, it is obvious that staffing must take cognizance of relevant qualification and cognate industry experience. The

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[28] The records of and documentations on Major Daniel Houghton, Mungo Park, Hugh Clapperton, Isaaco, Richard Lander and Thomas Park would be valuable.

[29] It may be necessary to visit British and Portuguese libraries and museums to source for archival in this regard.

[30] These include Elder Dumpsters and Palm Line.

[31] The *Mumbayya* House is a research and documentation centre of the Bayero University, Kano which was established in the Late Mallam Aminu Kano's house as a symbol of respective for his political leadership.

[32] See Section 44 (1, 2 & 3) of the National Archives Act, Cap N6, 1992 No. 30, Laws of the Federation of Nigeria.

job of archivist is quite challenging that quality of staff in terms of relevant educational and professional background should not be compromised. While it may be necessary to employ people without masters degree in archives studies, prospective senior staff of the maritime archives should have at least bachelor degree with postgraduate qualification in maritime studies and 5 years work experience. Employment of the junior cadre should also be guided by the task they are expected to perform.

We can then deduce the general and specific duties of maritime archivists as follows:

1. To promote a broader understanding of maritime history defined by the scope of the maritime archives in terms of period, sequence and size of collections.
2. To identify, collect and preserve original and copies of records and documents relating to the history of water based activities.
3. To provide detail description of all materials in the archives and how to access them.
4. To sort and list separately records and documents of mixed sources or those lacking clear originality and arrangement.
5. To describe, catalogue, index and analyse materials and objects for the benefit of researchers and the public.
6. To organise and/or coordinate educational and public outreach programmes such as tours, workshops, lectures and classes.
7. To liaise with other archives and maritime institutions to design and administer maritime archives plans and policies.
8. To research into topics or items relevant for maritime archives collections.
9. To maintain control over the range of information by adding and substituting records and documents as stipulated by policy.
10. To create and maintain searchable database.
11. To identify and recommend sources of aids and other forms of support for archival activities.
12. To prepare budget for archival activities and ensure compliance to due process in archival spending.
13. To keep financial records of all receipts and expenditure concerning archival activities.
14. To establish archives rules and regulations and make policy recommendation concerning membership registration, fees, working hours, use of parking space, group visits, affiliation, taking pictures, etc.
15. To prepare schedules for archival collection surveys and recommend archival restoration projects.
16. Prepare situational, monthly, quarterly, biannual and annual reports of the activities of the archives.

17. To make periodic review of filing system in maritime institutions in order to recommend transfer of outdated records and documents to the archives.
18. To define and establish retention period for vital historical and/or permanent records and objects.
19. To train library officers and other personnel in maritime institutions on the fundamentals of archival system.

The wide range of duties enumerated above is to be discharged by maritime archivists working in different sections of the archives. This explains why every staff in the maritime archives is an archivist. When these duties are apportioned appropriately to the various Sections of the maritime archives it becomes the functions of the respective Sections.

The performance of those duties also requires maritime archivists to have certain skills in order to function effectively. Maritime archivists need to:

I) Have knowledge of water based activities.
II) Be good with people so as to help them with their research.
III) Have basic knowledge of conservation in order to extend the useful life of maritime artifacts.
IV) Be logical, organised and pay attention to detail and accuracy.
V) Have research skills and ability to understand the content of documents and the context in which they were created.
VI) Be computer literate with ability to work with electronic records and databases.
VII) Have knowledge of records retention systems, organisation and management techniques.
VIII) Have an interest in history, water based activities and records preservation.
IX) Have sound verbal and written communication skills, time management and the ability to operate with little supervision, initiative and flexibility.

Funding of Maritime Archives

To identify, collect, transport to designated location, describe, index, catalogue/arrange, prepare rules and regulations for accessing maritime archival materials across the country and abroad is a very big task. Another big task is to recruit and train competent staff with genuine interest in maritime archives administration. There is also the complex task of sustainable preservation and conservation of the archival materials as well as the building structure and space to keep them apart from the infrastructure to be provided.

Overall, it is difficult to set a figure for establishing maritime archives but the total funding commitment may necessarily require cost sharing between the major institutional stakeholders in the country. The minister of transportation may direct all water based parastatals to contribution 1 percent of their annual gross income to fund the activities of the maritime archives. There should however be take-off grant of at least N2 billion to provide the structure and source for records and documents, recruit staff and provide logistics.

The maritime archives should also be capable of soliciting and receiving archival from individuals, organisations and governments including financial aid that would boost its collections, maintenance and sustainability. Part of the aid may be in kind such as in form of staff training, free participation in exhibitions and access to other archives to copy relevant materials.

Finally, the archives should be able to generate income through its services to the public that would augment income from other sources.

The Future

In a developing country like Nigeria, the future of maritime archives is both bright and dicey. It is bright because with the cabotage regime in place, increased oil and gas activities and the amendment of the National Inland Waterways Authority's Act which now provides wider funding sources for the agency, maritime activities in the country will grow. On the other hand, the future is dicey because organisations are rapidly digitalising their operations without national document policy for electronic data. In the face of viruses, careless deletion of valuable information and lack of policy for back-up and subsequent transfer to archives, most important information would be lost. It is already noted that the twenty-five years cut-off age for paper records and documents transfer to archives is not appropriate for electronic documents.

It is therefore necessary to develop comprehensive document retention and risk management protocols and strong compliance mechanisms that address all electronic documents including e-mails and attachments. It is equally imperative to regulate individual employee document retention behaviour and IT staff behaviour in the back-up of electronic data as well as the rotation of storage media.

There should be a Standing Archives Committee (SAC) in each water based organisation in the country composed of management, IT staff and Research and Statistics officers that would monitor document retention compliance. The SAC must also authenticate that employees properly transfer all data storage devices in their possession when they are redeployed and before leaving the organisation when their service terminates. Payment of staff final disengagement allowance may be tied to the confirmation by the SAC that all documents have been properly and completely handed over.

While the archiving procedure should be periodically reviewed and tested, a computer forensics device should also be installed to assist in document recovery. A third party individual or organisation may also be invited to periodically review and validate that document retention policies are being followed.

Finally, all maritime organisations in the country should be connected to a network with automatic central collation of 3-5 years information at the maritime archives.

REFERENCES

A. V. Amire (2008): *Monitoring, Measurement, and Assessment of Fishing Capacity: The Nigerian Experience*, www.fao.org/docrep/006/y4869e/4849e0c.html, Accessed on 8th July, 2008.

Abdulmumuni Dirisu (2008): Personal interview; at the Legal Services Department, Nigerian Maritime Administration and Safety Agency, Lagos; 4.15pm to 4.37pm on 1st July, 2008.

Alexander, E. V. (2008): Personal interview, at Office of the Director General, Nigerian Maritime Administration and Safety Agency, Lagos, 10.33 am to 10.44 am, on 17th July, 2008.

Alim, D. I. (2008): Personal interview; at the Maritime Safety and Seafarers Standards Department, Nigeria Maritime Administration and Safety Agency, Lagos; 2.15pm to 2.25pm on 1st July, 2008.

Andrej (2007): "Digital Archive Costs Surprising", at http://andrej.mobileduo.com/archives/2007/12/digital_archive.html, accessed on 16th July, 2008.

Appalachian Library (2007): "Archivist", at http://apps.leg.wa.gov/WAC/default, accessed on 24th June, 2008.

Beth Gaudio (2005): "Documents Retention Policies", The National Federation of Independent Business; at http://www.nfib.com/object/IO_21047.html, accessed on 9th July, 2008.

BLS (2008): "General Archives Policy", at http://www.bls.gov/oco/ocos065.htm, accessed on 24th June, 2008.

Central Intelligence Agency (2007): *Nigeria* www.cia.gov/library/publication/the-world-factbook/geos/ni.html, Accessed on 8th July, 2008.

City of Boise (2008): "Duties of Archivist", at www.cityofboise.org/city_clerk/citycode/0123.pdf, accessed on 24th June, 2008.

D. D. Fer (2008): "Records Creation and Control"; Unpublished paper presented at the Training Programme for Archives Staff of the Nigerian Maritime Administration and Safety Agency at Chelsea Hotel, Abuja; 27th - 29th August.

D. D. Fer (2008): "Transfer of Records to National Archives"; Unpublished paper presented at the Training Programme for Archives Staff of the Nigerian Maritime Administration and Safety Agency at Chelsea Hotel, Abuja; 27th - 29th August.

D. D. Fer (2008): "An Overview of the National Archives Act of 1992"; Unpublished paper presented at the Training Programme for Archives Staff of the Nigerian Maritime Administration and Safety Agency at Chelsea Hotel, Abuja; 27th - 29th August.

David Oladimeji (2008): "Chandelling business 'll stem capital flight"; in *New Age* Newspaper, 8th July, 2008, page 24.

Edward, A. O. (2008): Personal interview; at the Maritime Safety and Seafarers Standards Department, Nigeria Maritime Administration and Safety Agency, Lagos; 2.27pm to 3.07pm on 1st July, 2008.

Fatai Balogun (2008): Personal interview, at Office of the Director General, Nigerian Maritime Administration and Safety Agency, Lagos, 10.45 am to 10.56 am, on 17th July, 2008.

Federal Republic of Nigeria (1992): *National Archives Act*; Cap N6, No 30, Laws of the Federation of Nigeria.

Federal Republic of Nigeria (2007): *Public Procurement Act, 2007*, Federal Government Press, Lagos.

Gunwa, J. A. (2008): Personal interview, at the Marine Environmental Protection Department, Nigerian Maritime Administration and Safety Agency, Lagos, 2.03pm to 2.13pm, on 1st July, 2008.

H. A. Lafinhan (2008): "The Economic and Social Utility of Records Management Systems and Services"; Unpublished paper presented at the Training Programme for Archives Staff of the Nigerian Maritime Administration and Safety Agency at Chelsea Hotel, Abuja; 27th - 29th August.

Howard University School of Divinity (2004): "Archival Program", at www.howard.edu/divinity/documents/archives_flier.pdf, accessed on 16th July, 2008.

JKS (2008): "Elements of a Good Documents Retention Policy", at www.lexisnexis.com/applied-discovery/lawlibrary/whitePapers, accessed on 9th July, 2008.

Kenya National Archives and Documentation Service (1998): "Archives Administration" at http://www.kenyarchives.go.ke/archives_administration.html, accessed on 9th July, 2008.

Kingibe A. B. G (2008): "Circular"; Ref. No. SGF/OP/1/S.3/VII, Office of the Secretary to the Government of the Federation, page 2.

Kingibe A. B. G. (2008): "Circular", Ref. No. SGF/OP/1/S.3/VII, Office of the Secretary to the Government of the Federation, page 2.

Lanre Dosunmu (2008): "Automation of Archival Services"; Unpublished paper presented at the Training Programme for Archives Staff of the Nigerian Maritime Administration and Safety Agency at Chelsea Hotel, Abuja; 27th - 29th August.

National Library of Australia (2007): "Policy on Networked Australian Electronic Documents", at http://www.nla.gov.au/policy/elecpol.html, accessed on 9th July, 2008.

Ofodile, P. O. (2008): Personal interview, at the Marine Environmental Protection Department, Nigerian Maritime Administration and Safety Agency, Lagos, 1.45pm to 1.57 pm, on 1st July, 2008.

Olopoenia, A. S. (2008): Personal interview; at the Maritime Safety and Seafarers Standards Department, Nigeria Maritime Administration and Safety Agency, Lagos; 3.37pm to 3.45pm on 1st July, 2008.

Radford (2007): "Library Archivist", at http://www.radford.edu/~pers-web/Admin-positions/Library-Archivist.htm, accessed on 24th June, 2008.

Red Gold Fish (2008): "Job of an Archivists", http://www.redgoldfish.co.uk/view, accessed on 24th June, 2008.

Saliu Olokoba (2008): Personal interview; at the Maritime Safety and Seafarers Standards Department, Nigeria Maritime Administration and Safety Agency, Lagos; 3.15pm to 3.35pm on 1st July, 2008.

Salt Lake City (2002): "Electronic Mail and Electronic Documents Policy", at http://www.ci.slc.ut.us/recorder/pdfs/emailpolicy.pdf, accessed on 9th July, 2008.

State of Washington (2007): "Powers and Duties of State Archivist", at http://www.alis.gov.ab.ca/occinfo/Content/, accessed on 24th June, 2008.

Steven M. Harris (2007): "Policy Needed to Manage Electronic, Paper Documents", *AMNews*, at http://www.ama-assn.or/amednews/2007/02/05/bica0205.htm, accessed on 9th July, 2008.

The Maritime History Archives (2008): "Mandate", http://cache.search.yahoo-ht2.akadns.net/, accessed on 24th June, 2008.

The National Archives (2004): "Press Release" at http://www.archives.gov/press/press-releases/2005/nr05-26.html, accessed on 14th July, 2008.

The National Archives (2007): "Press Release" at http://www.archives.gov/press/press-releases/2008/nr08-41.html, accessed on 14th July, 2008.

The NHPRC (2007): "Archives" at http://www.archives.gov/nhprc/administer/grantee/basic-07.pdf, accessed on 16th July, 2008.

UCLA (2008): "Duties of Archivist", at www.mlgsca.mlanet.org/ac_manual/, accessed on 24th June, 2008.

Umar A. (2008): "Establishing a Record Centre"; Unpublished paper presented at the Training Programme for Archives Staff of the Nigerian Maritime Administration and Safety Agency at Chelsea Hotel, Abuja; 27th - 29th August.

Umar A. (2008): "Processing, Boxing and Stacking of Records"; Unpublished paper presented at the Training Programme for Archives Staff of the Nigerian Maritime Administration and Safety Agency at Chelsea Hotel, Abuja; 27th - 29th August.

Umar A. (2008): "Records Retention and Disposition Schedule"; Unpublished paper presented at the Training Programme for Archives Staff of the Nigerian Maritime Administration and Safety Agency at Chelsea Hotel, Abuja; 27th - 29th August.

Walford Anglican School for Girls (2008): "Duties of Archivist", at www.walford.net.au/uploaded_files/, accessed on 24th June, 2008.

Washington State Archives (2008): "Duties of Archivist", http://www.lib.washington.edu/nwa/Archivist—WashingtonStateArchives.html, accessed on 24th June, 2008.

Wikipedia (2007): "Archives" at, accessed on 24th June, 2008.

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WARSHIP DAMAGE STABILITY CRITERIA CASE STUDY

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ABSTRACT

All navies struggle to achieve a balance between safety and military capability, ensuring that activities in peace time are undertaken with an acceptable level of risk. Despite the need for intrinsic differences in construction, increasingly, the acceptable level of safety for the navies is becoming equivalent to those of merchant vessels under civil law. Navies are resorting to Classification Societies for assistance in this matter. Rules and regulations of the Classification Societies for ships are set within the framework of international law overseen by International Maritime Organization (IMO), particularly the international convention for the safety of life at sea (SOLAS). These "IMO" agreements are not always appropriate for the majority of warships, so that the military mission demand solutions in the design and operation that are not fully compatible with the philosophy of the conventions "IMO" and prescriptive solutions. Separate rules of the Classification Societies of the conventions "IMO", to apply to ships of war, create a vacuum that can lead to confusion. This confusion can be misinterpreted and as a result there can be a drop in safety standards. Stability in case of collision is a critical theme to maintain buoyancy in ships. These aspects are even more critical given the increasing size of the boats and the growing number of passengers and crews onboard. Both experience and performed studies demonstrate that the most dangerous issue for the ships with closed deck is the impact of an accumulation of water on the deck. The studies have clearly shown that the residual freeboard of the ship and the height of the

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waves in a specific sea area influence in a very relevant manner the amount of water that could be accumulated after a clash. The article concludes by presenting a series of comparisons between the criteria used by both, leading to some interesting conclusions as to the current criteria used by the navy. This can be enormously improved with a few minor changes, to maintain the integrity of its basic approach, and increase the similarities with the criterion of "IMO", such as the calculation of water on deck out in the Stockholm Agreement.

Keywords: Damage stability criteria, Stockholm Agreement, Naval Ship Code.

INTRODUCTION

Admitting that there is no equivalent of the "IMO" for warships, the North Atlantic Treaty Organization (NATO) has established a team of specialists in the Naval Ship Classification Association (NSCA) and a partnership for classification of warships. This has been entrusted with the development of new legislation. This team of specialists has been entrusted with the preparation of the Naval Ship Code (NSC) and benchmark of international standards for ships. This will promote greater transparency and consistency in safety standards for vessels of war. The Code aims to fill the void by providing the framework for the armed security that has achieved acceptable levels of security. To accomplish this, the Code will be the link between "IMO" and Classification Societies. It will promote improvements in vessel design and greater consistency and transparency of safety standards. The United Nations Conference on the Law of the Sea (UNCLO), in article twenty-nine defines a warship as a ship belonging to the armed forces of a State and bearing the external distinguishing marks for the nationality of the vessel, is under the command of an officer duly commissioned by the government whose name appears on the list of appropriate services or the equivalent, and manned by an allocation under the discipline of the navies. The "SOLAS", in its third rule "Chapter I-General Provisions", states that its rules do not apply to warships and ships to transport troops. Warships are exempt from most of the laws of the merchant ships, and as such both international and national levels have directed the

SOURCE: www.nato.int

Figure 1. In front a Dutch frigate followed by the Spanish and German frigates.

Naval Forces ships safety independent of the statutory organizations. There are exceptions to this. The vessels may be classified and certified by Classification Societies or flag authorities and there are some aspects of the statutory legislation that warships have to consider.

These include the navigation of ships through international waters, communications with other ships and increasingly support, environmental protection. Moreover, due to a combination of resources restriction and increasing public pressure, most of the navies are resorting to Classification Societies for support. In this way, for example, approximately ninety percent, by tonnage, the fleet of the British Royal Navy is in hull classified either by Lloyd's Register of Shipping (LLR). At this time almost all new buildings are being conducted under the rules of any of the Classification Societies. Problems will arise if the ships engaged on the Classification Societies compare their management of safety against civilian vessels.

Perhaps, to avoid duplication, gaps and shortcomings in safety, it is important for the navies to work together with the Classification Societies in the development of effective and sustainable arrangements. Thus, development of rules for warships Naval Ships Rules by various Classification Societies is the most important contribution to work in this area. The idea of cooperation to make a "SOLAS" goes back to the nineties. In September 1998, Classification Societies of the Member States of the "NATO" met to establish links with their own "NATO". This meeting established the "NSCA", in May 2002, and the cooperation was defined according to the following terms of reference: promote safety standards at sea, promote measures to protect the marine environment, promote and develop common operating standards, undertake "R&D" to support the above and communicate the views of the partnership agreements and the "NATO". The philosophy of the "SOLAS" is applicable to merchant ships, and is not fully transferable to a warship, for example, radar transponders are quite undesirable for the feature to be a stealth warship and that a lifeboat is orange can hardly be regarded as an improvement in optical characteristics of such a vessel. This list would be too long, and serves to demonstrate that the requirements of civil security should be tailored to the needs of the Navy. A warship has requirements for acoustic signature, electromagnetic signature, signature radar, electronic warfare, antisubmarine warfare and it demonstrates that a ship is not civil.

DAMAGE STABILITY CRITERIA ACCORDING TO DESIGN DATA SHEET

The criteria to evaluate adequate damage stability performance according "DDS 079-1" are based on the "Figure 2". A reduction of the righting arm equal to $(0.05 \cdot \cos\theta)$ is included in the righting arm curve to account for unknown unsymmetrical flooding or transverse shift of loose material. Beam wind heeling arm curve is calculated with the same method as used for intact stability calculations, but considering a beam wind velocity of around *32-33 (knots)* as defined in "DDS 079-1"

(Naval Ship Engineering Centre, 1975). The damage stability is considered satisfactory if the static equilibrium angle of heel "θc", point "C" without wind rolling effects does not exceed *15(°)*. The dynamic stability available to counter the heeling forces imparted to the ship by moderately rough seas in combination with beam winds is a measure of adequacy of the stability after damage. The limit angle "θ_1" of the damage righting arm curve is *45(°)* or the angle at which unrestricted flooding into the ship would occur, whichever is less. The angle "θr" is the expected angle of roll into the wind from the point of intersection of the righting arm and heeling arm curves for the assumed wind and sea state. Subject to later verification by experience and model testing, the value of the rolling angle "θr" to be estimated according to "DDS 079-1".

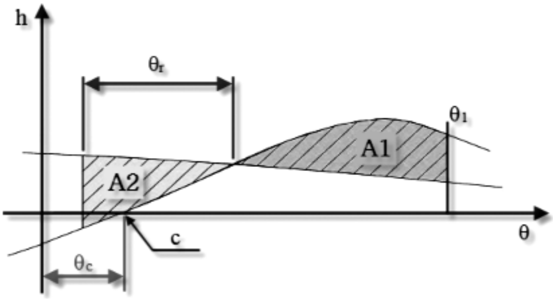

Figure 2. Damage stability criteria.

The criterion is considered fulfilled if the reserve of dynamic stability "A1" is not less than (*1.4·A2*), where "A2" extends "θr" to windward as shown in the "Figure 2". The tendency during recent decades in surface naval ship design was to assess and minimize susceptibility through detailed signature management. Therefore the probability of detection was usually estimated and it was considered as input in simulations scenarios. On the other hand the probability of staying afloat and upright was less frequently taken into account. Most of the simulations assumed a single-hit-kill probability equal to one for small naval ships whereas two hits where considered adequate for the sinking of larger vessels. Thus the defence analysis was actually never treating the vulnerability as a probability. For naval architects it is usually enough to assess the adequacy of its design with respect to vulnerability through the

SOURCE: Surko, S.W. (1994)

Criteria	UK "NES 109"		US Navy "DDS-079"	
Damage length	L_{WL} < 30 m	1-compartment	L_{WL}<100 ft	1-compartment
	30m < L_{WL} < 92m	2 comp of at least 6m	100ft < L_{WL} < 300ft	2 comp of at least 6m
	92 m < L_{WL}	Max {15%L_{WL} or 21 m}	300 ft < L_{WL}	15%L_{WL}
Permeability	Watertight Void	97%	Watertight Void	95%
	Accommodation	95%	Accommodation	95%
	Machinery	85%	Machinery	85% - 95%
	Stores	60%	Stores	60% - 95%
Area "A1"	> 1.4 Area "A2"		> 1.4 Area "A2"	
"GZ" at "C"	60 % of "GZmax"			
Longitudinal "GM"	> 0		—	

Table 1. Current UK & US damage stability criteria for surface warships.

use of damaged stability requirements introduced by the various navies, such as those used by the US Navy and the UK MoD, depicted in "Table 1".

Based on the concept of the damage function used in the theory of defence analysis, the fraction of the target assumed to be damaged within a radius r from the impact point is assumed to follow the well-known log-normal distribution given by the "Equation 1" (Przemieniecki, 1994):

$$\mathrm{d}(r) = 1 - \int_0^r \frac{1}{\sqrt{2\cdot\pi}\cdot\beta\cdot r}\cdot\exp\left[-\frac{\ln^2\left(\frac{r}{\alpha}\right)}{2\cdot\beta^2}\right]\cdot dr \qquad (1)$$

Where "R_{SK}" is the sure kill radius which means that [$d(R_{SK}) = 0.98$], "R_{SS}" is the sure save radius which means [$d(R_{SS}) = 0.02$] and "z_{SS}" constant equal to (*1.45222*).

$$\alpha = \sqrt{R_{SS}\cdot R_{SK}} \quad (2) \qquad \text{and} \qquad \beta = \frac{1}{2\sqrt{2}\cdot z_{SS}}\ln\left(\frac{R_{SS}}{R_{SK}}\right) \quad (3)$$

The damage extent ranges of naval ships may result from test analysis, analysis of data from actual engagements, empirical formulas linking the damage range with the type and the weight of the warhead or from the use of damage lengths defined in current deterministic damage stability regulations for naval ships.

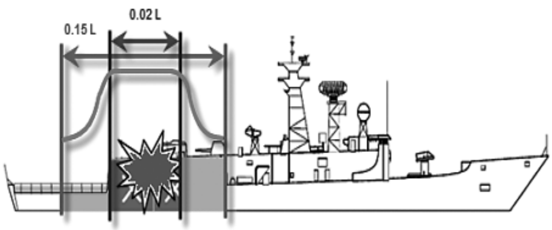

Figure 3. Damage extent on naval ship profile.

In the later case a first approximation of the "R_{SS}" can be taken according to "NES-109" and "DDS-079" and it would be (*0.15·L*), see "Figure 3" (Boulougouris and Papanikolaou, 2004). The "R_{SK}" has been assumed equal to (*0.02·L*).

A more efficient methodology to implement the suggested survivability assessment procedure within a ship design optimization scheme is an approach that considers the probability of survival based on quasi-static survival criteria, like those of the British Royal Navy and the US Navy. They take into account data of real damage incidences of World War II and they have proved to be reliable until today, in so far as they appear satisfactory to not have been changed over a long period of time. The philosophy for transforming these deterministic criteria into a set of rational probabilistic approach criteria will be herein based on an approach similar to the "IMO" Resolution *A.265* for passenger ships. It is well established that in all relevant criteria there is an underlying assumption that the sea conditions at the time of damage are moderate. This constraint could be lifted if there was a requirement for specific survival sea state in case of damage. This would allow the correction of these requirements by consideration of the probability of exceedence of the wave height considered as basis for the current deterministic British Royal Navy and the US Navy criteria.

NEW DAMAGE STABILITY CRITERIA. NAVAL SHIP CODE

The Naval Authority Knowledge Management Office (NAKMO) library is a website, an unclassified version of the Naval Authority System (NAS) library. In addition to navies, Classification Societies through the Naval Ship Classification Association (NSCA) have a standing invitation to attend the meetings of the specialist team as active participants. The specialist team is tasked with the development of a "NSC" that will provide a cost-effective framework for a naval surface ship safety management system based on and benchmarked against "IMO" conventions and resolutions. The Specialist Team has established a Goal Based Approach to the development of the "NSC" and is now developing each chapter in turn. This folder in the "NAS" library contains the latest documents including "NSC" chapters, related guidance and records of meetings. The "NSC" adopts a goal based approach. The basic principle of a goal based approach is that the goals should represent the top tiers of the framework, against which ship is verified both at design and construction stages, and during ship operation. This enables the "NSC" to become prescriptive if appropriate for the subject, or remain at a high level with reference to other standards and their assurance processes. The goal based approach also permits innovation by allowing alternative arrangements to be justified as complying with the higher level requirements.

The increasing width of the triangle as the "NSC" descends through the tiers implies an increasing level of detail. Limit state design methods are good, but in practice can be rather academic and purist; they will not generally be familiar to the shipping industry. The thought processes behind them are transparent and, while ending up at much the same place, do provide a good philosophical framework. The opportunity to know how the variability is in one parameter may affect the resultant demand or capacity. Limit State methodology also provides essentially a two-stage digitization of the analogue concept of graceful degradation. Another way of looking at the approach is to define green, amber and red zones where green equates to safe, amber to take care/start taking remedial action, and red equates to take remedial action immediately. Such information is of great use in providing guidance information to the ship and to inform decision-making in an emergency. The hierarchy of limits states is not well understood in marine circles. There are only two generic limit states: the Serviceability Limit State and the Ultimate Limit State. For each of these two limit states a number of scenarios need to be developed, and these should generally be based on the reaching of a defined structural capacity (e.g. fracture, elastic-

SOURCE: Guide to the Naval Ship Code. Prepared for MCG6 Specialist Team

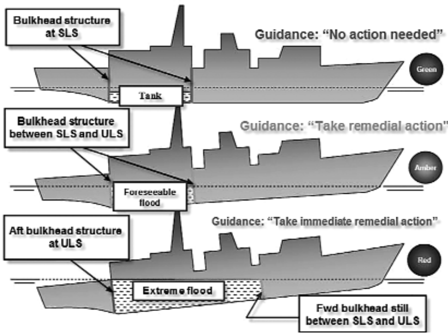

Figure 4. Structural Limit State Zones.

plastic buckling of a hull girder flange in compression when subjected to a characterization of loads and load combinations as a single load, and avoidance of fatigue crack initiation as established from a series of laboratory-scale fatigue specimens, commonly referred to as the Fatigue Limit State etc. Terms like Accident Limit State may be convenient but have no meaning without a precise definition of the limiting criteria, or the demand.

Environment

Foreseeable environmental conditions include extremes of wind, wave height, modal period and temperature. Operating environments refer to the ship specific conditions which limit the operational capability. For example, an aircraft carrier would not be expected to be able to launch aircraft in very high sea states. To assist in defining the foreseeable operating conditions and therefore bounding the risks due to the sea environment for a given ship, the type of service and environment that a ship is expected to endure should be defined in the Concept of Operations Statement.

SOURCE: Extract from DEF (AUST) 5000, Royal Australian Navy. Stability of Surface Ships and Boats, May 2003

Service	Description	Weather & Sea Characteristics	Survival & Rescue Infrastructure
Ocean Unlimited	Fully independent operation at sea, able to hold station in all but extreme conditions, able to resume duties after conditions abate	Severe tropical cyclone or equivalent, extreme winds and extreme seas	Early rescue not likely. Probable extended period in survival mode
Ocean Limited	Independent operation at sea, avoiding centres of tropical disturbance, able to resume duties when conditions abate	Storm force weather or equivalent. Very high winds and very high seas	Early rescue not likely. Probable extended period in survival mode
Offshore	Independent operation within 200 nautical miles or 12 hours at cruising speed (whichever is less) of a safe haven. Return to safe haven if winds likely to exceed Beaufort 8	Gale force weather and very rough seas	Survival in moderate conditions or early location likely and within helicopter range for rescue
Restricted Offshore	Restricted operations within 4 hours travel at cruising speed of a safe haven	Near gale force weather and rough seas	Survival in benign conditions or early rescue
Protected Waters	Operates within specified geographical limits or within 2 hours travel at cruising speed of a safe haven in waters specified as ‘partially smooth’	Strong breeze winds and moderate seas	Rescue facilities and/or shoreline nearby

Table 2. Service classifications.

Loss of Watertight or Weathertight Integrity

A damage incident for the purposes of this chapter is defined as a breach of watertight or weathertight integrity. When the watertight or weathertight integrity of a ship is breached by any mechanism the ship is at risk of loss due to flooding. The extent of the breach and the ship's initial loading condition and material state will dictate the likelihood of the ship being lost. Irrespective of whether the damage is caused by an accidental or hostile event all damage can be categorized. The level of safety and performance following damage will depend on the severity of the damage incident. This is illustrated in "Figure 5" showing a green, amber and red condition corresponding to foreseeable, extreme and catastrophic events.

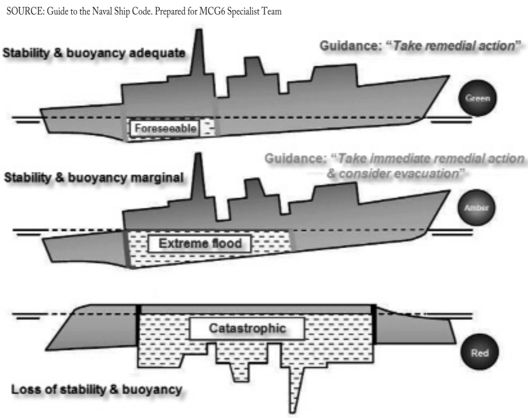

Figure 5. Severity of Damage Event for Stability

A catastrophic event caused by damage that the ship and persons on board would not be expected to survive, will result in rapid loss of the ship. Following an extreme event, resulting from damage more severe than foreseeable but not catastrophic, the ship would be expected to remain afloat in a condition that will allow personnel to evacuate if required. In the event of damage below the extreme level, foreseeable damage, the ship would be expected to survive although the level of real operational capability will depend on a particular navy's concept of operations. "Chapter III" is primarily concerned with foreseeable operating conditions up to extreme damage, with exception of the Regulation *6* preservation of life.

Dynamic Capsize

The loss of dynamic stability will occur due to a lack of righting energy under a variety of conditions, intact or damaged. The capsize mode is often one of four phenomena:

- Dynamic Rolling. Generally occurs in stern quartering seas. This is the generation of large amplitude fluctuations in roll, surge, sway and yaw motions. The roll behaviour is asymmetric in nature and builds with each wave encounter finally resulting in capsize.
- Parametric Excitation. This mode of capsize is as a result of a gradual build up of excessively large rolling. A low cycle resonance can occur when travel-

ling at the wave group speed at approximately the natural roll period and simultaneously at twice the wave encounter period.

— Resonant Excitation. This mode of capsize occurs in beam seas when a ship is excited at or close to its natural roll period.

— Impact Excitation. This mode of capsize occurs when steep or breaking waves impact the ship and cause extreme rolling.

DAMAGE STABILITY CRITERIA ACCORDING TO IMO

Historically, most changes in international regulations for ship design and operation have been introduced as a result of major disasters with a large loss of life. The first notable of such disasters was the sinking of the "HMS Titanic", which led a year later to the first international convention for the safety of life at sea in London. The first damage stability requirements were introduced, however, following the 1948 "SOLAS" convention and the first specific criterion on residual stability standards at the 1960 "SOLAS" convention with the requirement for a minimum residual "GM" *0.05* (*m*). This represented an attempt to introduce a margin to compensate for the upsetting environmental forces. Additionally, in cases where the administration considered the range of stability in the damaged condition to be doubtful, it could request further investigation to their satisfaction.

Although this was a very vague statement, it was the first attempt to legislate on the range of stability in the damaged condition. It is interesting to mention that a new regulation on watertight integrity above the margin line was also introduced reflecting the general desire to do all that was reasonably practical to ensure survival after severe collision damage by taking all necessary measures to limit the entry and spread of water above the bulkhead deck. The first probabilistic damage stability rules for passenger vessels, (Wendel, 1968), were introduced in the late sixties as an alternative to the deterministic requirements of "SOLAS '60". Subsequently and at about the same time as the 1974 "SOLAS" convention was introduced, the "IMO", published Resolution *A.265(VIII).* These regulations used a probabilistic approach to assessing damage location and extent drawing upon statistical data to derive estimates for the likelihood of particular damage cases. The method consists of the calculation of an attained index of subdivision (A), for the ship which must be greater than or equal to a required subdivision index (R), which is a function of ship length, passenger/crew numbers and lifeboat capacity. The equivalent regulations raised new damage stability criteria addressing equilibrium as well as recommending a minimum "GZ" of *0.05* (*m*) to ensure sufficient residual stability during intermediate stages of flooding. The next major step in the development of stability standards came in 1992 with the introduction of "SOLAS" part *B-1*, in "Chapter II-1", containing a probabilistic standard for cargo vessels, using the same principles embodied in the aforementioned regulations. The same principle is also the basis for the current "IMO" regulatory development of harmonization of damage stability provisions in "SOLAS" based on the probabilistic concept of survival. The 1980 UK passenger ship construction regulations introduced requirements on the range of the residual stability curve as well as on the stability of the vessel at intermediate stages of flooding.

The loss of the "Herald of Free Enterprise" in 1987 drew particular attention to roll on-roll off ferries in which the absence of watertight subdivision above the bulkhead deck is a particular feature. The implications of this feature were highlighted by the court of inquiry, which observed that the "SOLAS" conventions and UK passenger ship construction rules had been aimed primarily at conventional passenger ships in which there is normally a degree of subdivision above the bulkhead deck, albeit of unspecified ability to impede the spread of floodwater. In response to this, the UK department of transport issued consultative document number three in 1987, which outlined a level of residual stability that required all existing roll on-roll off ferries to demonstrate compliance with the 1984 passenger ship construction regulations. This standard had previously formed the basis of a submission by the UK and other governments to "IMO", which considered the question of passenger ship stability in some detail. This was the forerunner to "SOLAS '90". Due to its idiosyncrasies, purpose and function, there is not, in the world, naval equivalent to the "IMO" to regulate the minimum standards of construction of warships. This is reflected explicitly in the third rule of "SOLAS", warships and troop carriers are excluded of the compliance of these regulations.

After the disaster of the "MV Estonia", that in September 1994 killed more than eight passengers, eight countries from northern Europe, Denmark, Finland, Germany, Ireland, the Netherlands, Norway, Sweden and the United Kingdom, decided in February 1996, in Stockholm, impose standards stricter than those were adopted a few years earlier by the "SOLAS-90" of "IMO". The basic idea of this initiative was that passenger ships should be designed for road transport so as to withstand the anxiety even when a given quantity of water has reached the car deck. The Stockholm Agreement was established in the context of resolution of the fourteen "SOLAS" of the "IMO" in 1995, and authorized government contractors to enter into such commitments if they believe that the predominant sea conditions and other conditions require specific local stability in a certain sea area. In short, these rules are complementary to the rules "SOLAS-90", with the addition of technical specifications to explicitly take into account the risk of accumulation of water on the car deck. Compliance with these requirements is measured in terms of numerical calculations defined in the treaty or by testing models, according to the model test of the resolution fourteen "SOLAS-95". The introduction of the Stockholm Agreement is closely associated with three unprecedented stops in the history of damage stability/survivability assessment:

— Water on deck was explicitly taken into account for the first time. This is remarkable in view of the knowledge that *85* (*%*) of all deaths with ferry accidents relate to car deck flooding.

— The effect of waves, and this is even more remarkable, was explicitly taken into account also for the first time.
— It paved the way to the introduction of performance-based standards for assessing the damage survivability of ships.

All three steps represent gigantic improvements in the approach to addressing ferry safety but any potential benefits will have to be balanced against any likely costs that might be incurred through the introduction of inappropriate standards.

DEVELOPMENT

Explanation

Nowadays, in both practical navigation and shipyard technical offices, stability tests in load and sea conditions, as in working or faulty conditions, are performed with software packages that starting from the ship design are able to quickly computed the required data. Even, in the comparative studies regarding model behaviour, combined with actual physical models these type of software packages are also needed. Managing, as user, this computerized technique is completely independent of the design. The precision will depend of the accuracy of calculations performed and its numerical-graphical output. This research focuses on evaluating the configuration of warships, with empty deck that could be a frigate, using the working and faulty stability "FORAN" modules, in particular Architecture-Project subsystem property of "SENER Ingeniería y Sistemas". The approach taken to perform the analysis has been the following: In the "FSURF" module, shapes, decks and walls are defined. Then, "VOLUME" module defines ship volumes and computes their volumetric capacity. The "LOAD" volume allows visualization of the detailed requirements generated from the stability requirement chosen, and also enables data entry to compute minimum "GM's". Inside this module, "LOAD", it is possible to check the most common standard stability criteria and a user define criteria obtaining if necessary the limiting "KG" values. The naval architecture calculations that will be with this module use the sections generated in "HYDROS" module. These sections take information about the forms of the ship and the designed decks that give limits to the ship.

This data is initial draft and trim values, and also a description that is used as identified in the minimum "GM's" drawing. In order to calculate the maximum "GM's" that is needed to define the drafts value range between minimum, empty load draft and maximum, scantling draft. It is also required to define the number of increments between minimum and maximum values (Pérez Fernández, 2009). Finally, in addition to the draft range definition, it is needed to define the initial trim. Then the calculation in intact is performed, in order to verify that the ship meets the intact stability requirements, if these requirements would not be met, the final results would be invalid. As a function of the draft and flooding conditions, the faulty stability results are obtained as load conditions are not required to calculate the faulty stability conditions given that stability is a function of bottom what is lost when a ship is flooded. The faulty condition could be caused by flooding through a breach in the side, bottom or a breach on the deck that allows water into the ship hull and provokes the flooding of the ship. When a compartment is flooded, there is a lost of floatability, a change of trim, and changes of transversal metacentric height and longitudinal metacentric height. Therefore, in order to study the stability in faulty conditions a capable software package is needed to perform the calculations. In this research work, "FLOOD" module will perform required calculation.

Application

A flooding condition is made up of initial condition, defined by a load condition, or by the drafts at aft, fore and height of the centre of gravity or by a set of drafts and by a faulty condition characterized by the identifiers of the flooded compartments. Regarding the computation of stability, it could be considered; either free communication amends flooded compartments or held sea water once floatability condition is reached. The calculations could be taken care of by two different methods thrust loss or additional weight. In this paper, the study will make use of the thrust loss. The method of thrust loss establishes that the volume remains constant throughout the different calculations, except when there will be flooded compartments with liquid load, what could happen when the initial situation will be given by a load condition. In this case, the fist step is losing the weights corresponding to the liquid loads. Then, volumes for compartments flooded up to initial floating condition are calculated, with the corresponding modifications for thrust, bottom centre, floating characteristics etc. This new situation will not be an equilibrium one, but it will be necessary to re-estimate the new draft, trim and heel to achieve equilibrium. The first thing to do is the ship selection that will be used for the study. For this selection, different factors, such as type of ship and compartment layout must be taken into consideration. Compartment layout not only consists on having a number of transversal and longitudinal walls separated from each other by optimum distances, but also a number of generic considerations and specific details that demand special attention paying to.

The ship must remain afloat during enough time, the people evacuation must be performed without major shifts in centre of gravity that could impact its viability and the safety equipment (boats and etc) must be available and usable at 100 (%) independently of ship equilibrium condition. These principles drive that the condition to be searched after of the damage will be without heel, i.e. a symmetrical condition. Then, the chosen ship for this analysis is a support ship with the dimensions shown in "Table 3", with one propeller shaft; which has a double bottom with a height upper to a tenth of the beam (*B/10*), where "B" is beam to the scantling draft. To find these dimensions, a database with other ships of similar characteristics has been used. While there are not requirements regarding the longitudinal walls, these should be placed one fifth of the beam (*B/5*) respecting to the shell, because this is the distance of the transversal penetration of the flood that the rules considers. As it was mentioned in the above paragraphs, as results of the "Parsiphae" accident, in this support ship, lateral tanks have been chosen. These tanks quickly connect with each other through tunnels placed on the superior side of the double bottom and are impregnable to water in case of any breach.

Length at waterline	125 (m)
Design beam	12 (m)
Design draft	6 (m)
Design height	10 (m)

Table 3. Main dimensions of the "NVSH" project.

The "LOAD" volume allows visualization of the detailed requirements generated from the stability requirement chosen, and also enables data entry to compute minimum "GM's". This data is the initial draft and trim values, and also a description that is used as identified in the minimum GM's drawing. The ship that we have selected, that we have called "NVSH", has a minimum draft *3.650* (*m*) and a maximum draft *6.210 (m)*. We need to define the increments between both of the drafts. In this case, the number of the increments will be two. We have defined trim equal to zero. Both, ship and configuration have been evaluated with high degree of detail in order to achieve equivalent comparisons. The fact of placing a longitudinal bulkhead below the deck number three has not been random. By designing the compartment layout in this way, a bigger number of faulty conditions and higher number of possible combinations are achieved. In the module called "VOLUME", we have defined the next compartments:

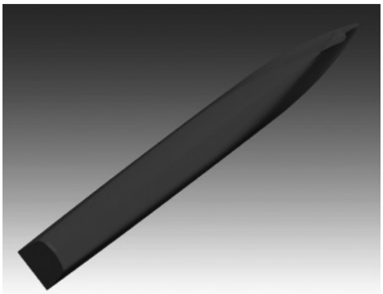

Figure 6. Visualization of "NVSH" project with the "FORAN System" design module.

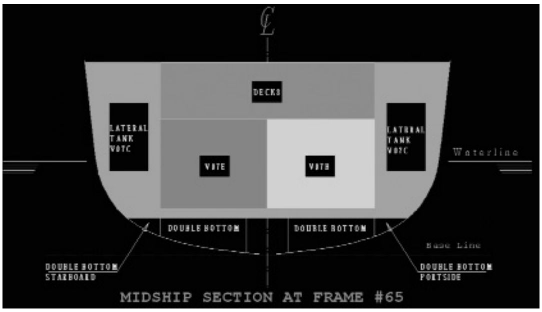

Figure 7. Midship section of the "NVSH" project.

RESULTS

Safety at sea has improved considerably in recent decades thanks to the incorporation of new technologies to the ships and the legislative effort made by the "IMO", without forgetting the work of ship inspections and Classification Societies ensuring that vessels are constructed and operated according to existing regulations. The major maritime disasters have traditionally been coupled with the pressure of public opinion, alarmed at the loss of life at sea. It has prompted the governments of the major maritime nations in a legislative effort to improve the safety of ships. This is the first case of "SOLAS", held in London in 1914, two years after the sinking of the "RMS Titanic", though it was not actually due to the outbreak of the World War I. It is not necessary to go back to early last century to find new examples, the collapse and subsequent overturning of the "MV Estonia" in 1994, in waters of the Baltic Sea, was the driver, as discussed in chapter two of this article of the Stockholm Agreement and a series of resolutions "IMO" related to the stability of such vessels. The "IMO", as a UN agency, was founded in Geneva in 1948, but did not start its activity until 1952, to develop and maintain the regulatory framework for governing the shipping, including aspects such as security or pollution, taking into account the international conventions as "SOLAS", "MARPOL" or International convention on standards of training, among others. It is organized into specialized committees and subcommittees, consisting of experts from member countries to study various aspects of maritime safety and the updating of legislation regulating. This is the case of the "MSC", which means all aspects that directly affect the sea, such as construction and equipment or the training of crews.

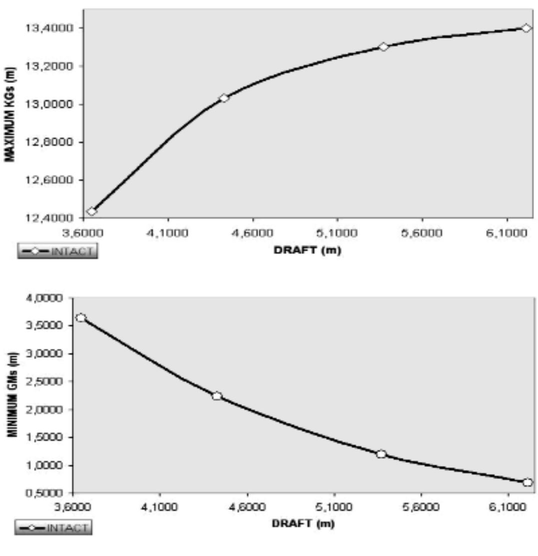

Figure 8. Intact stability criteria curves for "NVSH" project according to "IMO".

The establishment of an international maritime law, especially regarding safety, is a long process that is not without difficulties, it requires a lengthy period of research and analysis, consensus and ratification by a sufficient number of countries. Its implementation is not always possible in older ships. The first result is that ships can coexist for years, with two standards widely depending on their seniority or banner, as happens with the well-known case of oil tankers without double hull as the "Prestige". However, despite the remarkable technical and legislative effort that are carried out by "IMO" or the major advances in the safety convention "SOLAS". Warships are exempt from these rules and do not exist. In the naval field, there are not organization equivalent to "IMO" to understand the international level about the safety of such vessels. Traditionally, the warships are taking the rules of "IMO" exists that do not interfere with naval objectives and adapting them to the extent as far as possible. Then the calculations are made on intact to see if the warship, "NVSH", complies with the stability intact, and that if not fulfilled, the values were obtained at the end of the study would be worthless.

The angle of progressive flooding is greater than forty degrees. Depending on the drafts and the flood conditions will get stability in damage, and to remember that for stability in damage, it is not necessary to know the load conditions, since it depends on the stability of the hull forms, it is this that is lost when a ship is flooded. The flood damage can be considered by an opening in the side, at the bottom or the failure of the deck to allow the entry of water and lead to flooding of the ship. In this paper, the fault occurs on one side, bottom up. For this paper, the ship has been damaged, compartment by compartment. When one compartment is flooded, there is a loss of buoyancy, a change of trim, a variation of a transverse metacentric height and longitudinal metacentric height variation. Now intends to study the "GM´s" minimum, or "KG´s" maximum for the three criteria that we want to compare. To explore the stability problems, it needs the help of software to carry out the calculations. In the case of this research to study the "SOLAS", the U.S. Navy and the British Royal Navy criteria, the calculations were made using the module "FLOOD", choosing a damage condition and a load condition of the vessel intact, and are getting results that are developed below. The worst damage is whose "KG´s" maximum is the minimum among all possible failures, or put another way, which has the stronger "GM´s" minimum for each draft.

CRITERIA NUMBER	DESCRIPTION
1	"GZ" of 0.2 (m) between 30° and 90°
2	"DN" of 55.0 (mm.rd) between 0° and 30°
3	"DN" of 90.0 (mm.rd) between 0° and 40°
4	"DN" of 30.0 (mm.rd) between 30° and 40°
5	"GM" > 0.150 (m)
6	Angle for which a maximum "GZ" is obtained > 25°
7	"IMO" weather criterion

Table 4. "NVSH" project criteria.

Draft (m)	DP (T)	Criteria	GZ (m)	GM (m)
3.65	4069.5	7	12.43	3.64
4.43	4801.9	7	13.03	2.23
5.37	6364.5	7	13.30	1.19
6.21	7488.1	7	13.40	0.68

Table 5. Limit values for the "NVSH" project.

Where "DP" is displacement in tons, "GM" is minimum permissible metacentric height in meters and "KG" is permissible height of the centre of gravity in meters.

SOLAS. Stockholm Agreement

"SOLAS" implies safety, but by no means applicable to all types of vessel, mainly because many of those rules are unworkable or unrealistic for warships. For example, the orange colour of the lifeboats. Shipyards are based primarily on the experience, or benefiting from the lower standards in other countries, the consequences of ignorance and dependency involved. Due to the need to unify criteria for the countries of the "NATO" and the spirit of the lack of a security policy that ensures compliance minimal, formed a group of specialists with the task of developing the "NSC", a naval military code based on national standards, international standards such as High Speed Craft, high-speed vessels, and primarily, the applicable rules of the "SOLAS", to promote improvements in the design construction and in specific areas such as navigation in international waters, communications or environmental protection. The criterion "SOLAS" begins by defining the extent of damage to consider. These dimensions, based on statistics of failure, are defined as a fault length equal to 3 (%) of the length plus three meters, a penetration of damage equal to (*B/5*) and a height of damage that goes from bottom to top without limit (Riola, Perez Fernandez, 2009). The worst damage in "SOLAS", considering water on deck, is composed of two compartments, from the frame # 138 to frame # 162. The following is the "Table 6" with the data obtained with the "FLOOD" and its corresponding graph, "Figure 9".

MAXIMUM KG AND MINIMUM GM CALCULATION				
Trim (m)	Draft (m)	Displacement (T)	$KG_{MÁX}$ (m)	GM_{MIN} (m)
0	3.65	4069.5	14.761	1.301
0	4.43	4801.9	13.959	1.048
0	5.37	6364.5	13.335	0.889
0	6.21	7488.1	12.996	0.791

Table 6. Worst damage according to "IMO" criteria for the "NVSH" project.

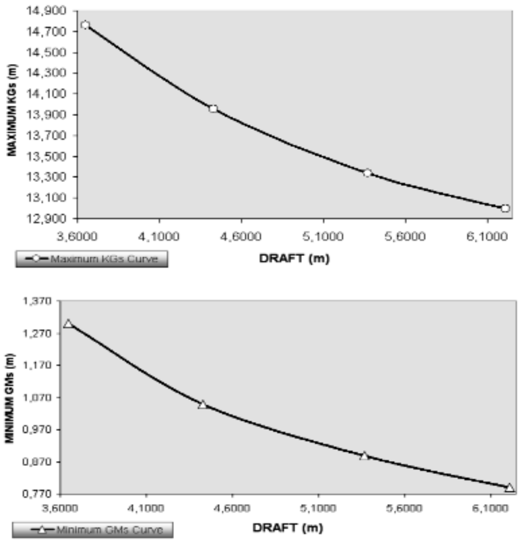

Figure 9. Damage stability criteria curves for "NVSH" project according to "IMO".

There are certainly some obvious weaknesses in the requirements of the Agreement and this must be borne in mind when assessing roll on-roll off safety. The Stockholm Agreement was created on the presumption that a vessel designed, or modified, to "SOLAS '90" standards ensures survival at sea states with Hs of only *1.5* (*m*). This was suggested in the face of uncertainty and lack of understanding of the phenomena involved. The evidence amassed so far and presented in the following suggests that this was a considerable underestimate. The maximum penalty of *0.5* (*m*) height of water on deck is ill based. It is to be noted that the forty-nine tests used to measure water accumulation on the car deck comprised only four open-decked ships, the others having car decks with: three transverse bulkheads, five central casing, nineteen central casing with transverse bulkheads, eight side casings and ten side casings with transverse bulkheads. It is straightforward to prove that the height of water accumulated on a subdivided deck is considerably larger than the height of water accumulated on open decks. More importantly, requirements based on subdivided decks are likely to promote designs with similar arrangements, which is contrary to the roll on-roll off concept itself. Finally, the effect of water on deck is taken into account by a calculation method that does not preserve the physics of the problem, and being based on static and deterministic approaches, it tends to negate the potential for adopting rational approaches to safety through the introduction of operational sea states and performance-based standards.

U.S. Navy

The US stability criteria are documented in the Design Data Sheet (DDS 079-1) printed in 1975, which is divided into criteria for damage stability for both sideprotected and non-protected vessels. The non-protected criteria relate to the 270 (*ft*) cutter that is the class used in this investigation. The "DDS 079-1" states that an angle of less than fifthteen degrees is required after damage for operational requirements. There is no mention of cross-flood systems except for in the side-protected vessels, which states that the maximum list shall not exceed twenty degrees and that

MAXIMUM KG AND MINIMUM GM CALCULATION				
Trim (m)	Draft (m)	Displacement (T)	$KG_{\text{MÁX}}$ (m)	GM_{MIN} (m)
0	3.65	4069.5	15.147	0.919
0	4.43	4801.9	14.232	0.787
0	5.37	6364.5	13.641	0.673
0	6.21	7488.1	13.412	0.620

Table 7. Worst damage according to US Navy criteria for the "NVSH" project.

arrangements exist for rapidly reducing the list to less than five degrees. The current stability criteria used by the US Navy were developed during and shortly after World War II (Sarchin, Goldberg, 1962). These criteria are based on static righting arm curve, are largely empirical, and do not explicitly consider many variables which can have a major impact on dynamic intact stability. However, they are well-accepted by the naval architecture community, and within the bounds of conventional hull forms, have proven to be a reliable, generally conservative, ordinal measure of intact stability. Current international efforts for improving naval ships stability criteria are focused on time domain analysis including the capability to model a steered ship. Commercial ship intact stability is addressed in a number of "IMO" regulations. The following is the "Table 7" and its corresponding graph, "Figure 10".

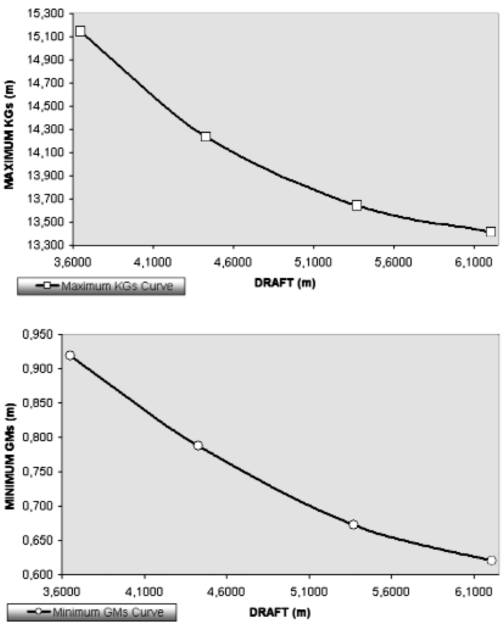

Figure 10. Damage stability criteria curves for "NVSH" project according to US Navy.

The "IMO" weather criteria considers wind with gusts and a roll-back angle which is dependent on the ship's static righting arm and other ship roll characteristics (IMO 1994). The US Navy and other navies have not kept pace with "IMO" developments. They continue to rely on the empirical World War II criteria until the more sophisticated methods are developed and validated. Current naval ship can be greatly improved with a few small changes which maintain the integrity of their basic approach, and increase their commonality with the "IMO" criteria. These changes are worth making now, to support the design of new ships until more sophisticated methods are in place. The worst damage is that which includes three compartments, ranging from frame #138 to frame #174.

British Royal Navy

The damage categories, in the "NSC", are based on defined shapes:

— Sphere. To be used for explosions. For explosions detonating against the outside of the hull, half the sphere to be used.

— Cube. To be used to define the volume directly affected by fire and which may change in shape to fit the compartment.

— Raking/grounding. To be used in the appropriate horizontal orientation to describe the extent of raking or grounding damage, the apex representing the maximum penetration.

— Collision. To be used in the correct vertical orientation to describe the extent of collision damage from the bow of another ship, the apex representing the maximum penetration.

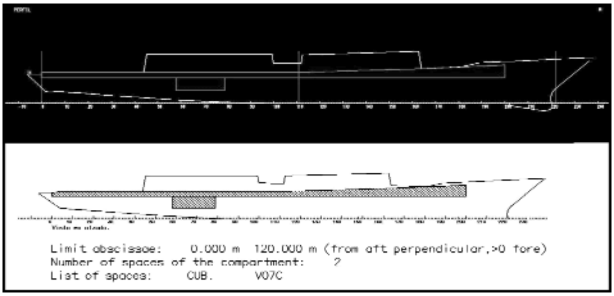

Figure 11. Longitudinal section in the "NVSH" project for the first flood.

The extent of the worst damage category is defined as damage category C, significant: sphere with *10 (m)* of radius, cube with *20 (m)* of sides, raking/grounding with *40 (m)* of length and *5 (m)* of equal sides and collision damage with *40 (m)* of height and *5 (m)* of equal sides. The temperature is heat caused by initiating event assuming no other combustion. Time to rise to peak of *20 (min)*, peak temperature *400° (C)*, duration of peak temperature *400 (min)* and time for temperature to revert to normal *200 (min)*.

Raking/grounding is the worst of all, proof that our ship, "NVSH" meets all known criteria, will not tolerate a failure of forty meters in length in the double bottom. Therefore, for comparison between the criteria, we will not use the failure of raking/grounding which was defined in the "NSC". Of the other three types of damage, and if comparable with the "SOLAS", the worst of all is the one defined by a cube of twenty meters on the side, which affects the compartments that are defined between frames # 138 and # 162. Such as the title of the work submitted for this article it is important to note that a detailed study of the navies criteria to use for the calculations, made by the CAD/CAE “FORAN”, the criterion of the British Royal Navy “NES-109”. It is necessary in this case study the damage defined as the “NSC” with a cube. The following is the “Table 8” with the data obtained with the “FLOOD” and its corresponding “Figure 12”.

MAXIMUM KG AND MINIMUM GM CALCULATION				
Trim (m)	Draft (m)	Displacement (T)	$KG_{MÁX}$ (m)	GM_{MIN} (m)
0	3.65	4069.5	15.034	1.045
0	4.43	4801.9	14.089	0.902
0	5.37	6364.5	13.501	0.771
0	6.21	7488.1	13.248	0.663

Table 8. Worst damage according to British Navy criteria for the “NVSH” project.

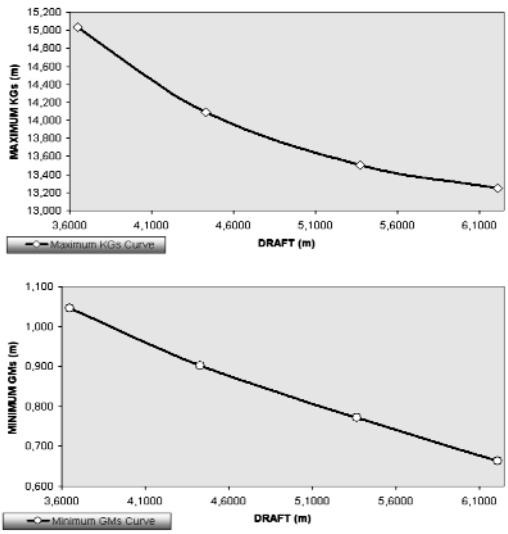

Figure 12. Damage stability criteria curves for “NVSH” project according British Navy.

CONCLUSIONS

In this paper, we have proposed a comparative analysis of the different criteria of stability after damage. In fact, very interesting results have been obtained. The theoretical calculations are made taking into account the affect of the damage in the ship’s side. It dispenses, in the calculation the effect of the superstructure that surrounds the garage of the main deck and the only thrust the boat is which gives the volume of vessel that lies beneath this deck. The concept by which it calculates the effect of the superstructure is due to the damage that always occurs, equalizing the water levels outside and inside. It should be borne in mind that it does not correlate with the theoretical model test results. In the tests, once the water is on the deck the boat is heeling to one side of the equilibrium due to the balance of the ship. The flood occurs on one side and, therefore, when trim to the side is not damaged a clear thrust of the intact side, which in turn is causing right.

When the heel toward the damaged side exterior water levels are never the same so there may be a push, when the level inside is greater than the outside inside. These effects of thrust, related with the balance of the ship, are ignored in the calculations

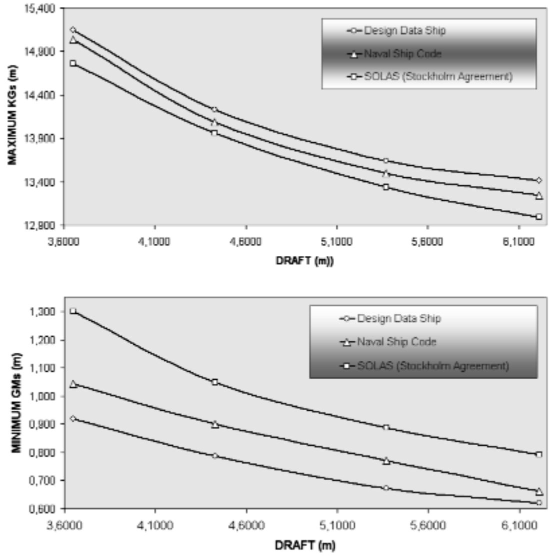

Figure 13. Comparative between criteria.

and whether any effect they have on the test. The solution could be adopted to give the true value of a superstructure permeability to allow for this right effect, if only for the calculation of water on deck, this value could be inferred from the trials to date and of tests to be conducted in the near future. Curiously this consideration of buoyancy, as a concept of open superstructure, was considered in the Rules of Freeboard in 1930, but was subsequently deleted in the Load Line Rules of 1966. Also in the summary of trials survival ferries, made by the United Kingdom as a result of the sinking of the "MS Herald of Free Enterprise" is induced to think of the obvious effect of the superstructure of the garage as a right arm, although affirms the difficulty of their assessment. It should be stressed that while the "SOLAS" floods one compartment in merchant ships such as tankers, ro-pax and roll on-roll off two; warships governed by the US Navy "DDS" three. For this research the various studies and calculations have been carried out on purpose designed test vessel. We have created a vessel to comply with different conditions, like having an empty deck, without pillars, one propeller shaft and whose forms are the same as far as possible to a warship, in fact, to a frigate. Having created a ship, which by its nature would be a warship, she might consider that the criteria are compared in this article, on the same ship. "Figure 13" presents a chart that summarizes the behaviour of each criterion.

A most important conclusion to emphasize, that while the approach of the British Royal Navy is more restrictive than the US Navy, if we are considering the Stockholm Agreement to "SOLAS", is that this convention is the most restrictive of all. If water is seen on deck, no military approach is more restrictive than the "IMO". Depending of these damages, we expose a comparison between the "NSC" damages in the warship studied, see "Figure 14".

There are many areas where military vessels could improve safety standards, although not necessarily to be regarded as less secure than the civil vessels. It is the opinion of every government and authority for the establishment of naval security level to offer their equipment and how it is achieved. For example, the "MoD" requires that the security level of the allocations of their vessels at least, whenever possible, similar to the crews of merchant ships. The Classification Societies arose in the early nineteenth century to assess the capacity of a vessel to transport cargo. By the simple process of open and inspect all spaces and compartments of a vessel or measure the wear of the bearing, the inspectors of the Classification Societies were able to estimate the condition of the vessel to which assigned a certain level of class . The owner could, through the favourable report of the inspectors, win the confidence of the owner of the cargo for carriage and to secure favourable conditions. This inspection system has evolved towards preventative maintenance, which the manufacturer of the equipment recommended to replace a number of parts and components over time and reached a number of hours of advanced features, and then towards the maintenance or predictive maintenance based on condition, in which actions depend on the maintenance of certain parameters, such as the vibration level. Since the mid-seventies, the main Classification Societies employ maintenance plans together with the registration books to determine what equipment should be examined, thus avoiding unnecessary inspections that may even damage the proper functioning of a team. At the end of the Cold War, the main armed world have been forced to undertake a transformation of their fleets by varying the way they are constructed, operated and maintained its naval units in order to reduce costs. In this context the contribution of the Classification Societies, has been essential for the incorporation of standard commercial shipbuilding in the area, enabling better resource management or operation more efficiently.

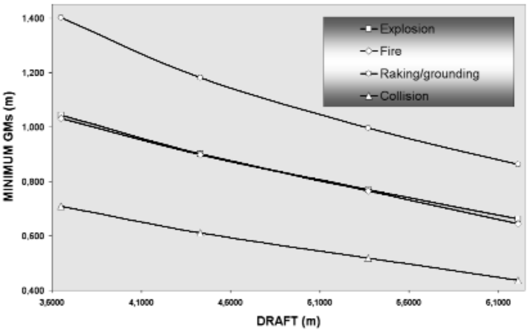

Figure 14. Comparative between "NSC" damage category C (DCC) significant.

The reality is that today, in some countries, warships frontline are built in accordance with rules of the Classification Societies, private agencies for their requirements ensuring compliance with building regulations stricter than the requirements of "SOLAS". An example of this is that ninety percent of the British fleet is classified, in part or in whole, under "LLR" or "DNV" (Ingram, 2007). However, there are major difficulties in implementing all the rules of the Classification Societies at the naval field (Boral, Gurley Tar Becker and Humphrey, 2005); especially to establish a priority mission and capacity combat against security. It is important to distinguish the importance of the new rules "NSC". As we have tried to reflect throughout the paper, the "NSC" has become the criterion of stability in damage than more is acclimating to the standards of the navies in the *XXI* century. For each type of vessel could be a priority for study in terms of damages of the "NSC". For a better under-

Kind of damage	"NSC" damages	Ship affected	Damage level
1	Raking/grounding	Frigate	Dangerous
2	Fire	Aircraft Carrier	Important
3	Explosion	Merchant ship	Important
4	Collision	Roll on-roll off	Severe

Table 9. Explanation about "NSC" by kind of ship.

standing of the damages of the "NSC" and how they affect different types of ships, will be presented in the "Table 9" the most revealing.

As the "NSC" is to provide a level of safety appropriate to the role of the ship and benchmarked against statute while taking into account naval operations, it is necessary to define the degree of survivability in a form that can be taken into account in the development and application of all "NSC" chapters. As an example, the main difference between the approach to fire safety for naval and civilian shipping is that "SOLAS" considers the risk of fire based on the function of each compartment whereas for naval ships, hostile acts may result in fire anywhere on the ship, both externally and internally. The consequence is that the solutions that are adopted for accidents may differ from those that are required to prevent and counteract hostile damage events. Thus, for the effective application of the "NSC", it is necessary to clearly define the extent of damage that reflects both accidental damage and potential damage caused by hostile acts, the damage location, the degree of vulnerability (protection, redundancy of systems, materials used), the required post-damage ship capability and the philosophy for recovery from the damaged state. Each navy will have its own unique approach to this issue, and it is not possible to be prescriptive in the "NSC". However, it is possible to provide a basic framework that can then be adapted by each Naval Administration. It is then essential that the owner and naval administration agree the required level of survivability in these terms for each class of ship.

REFERENCES

Athanassoulis, G. and Skarsoulis, M. (1992): *Wind and Wave Atlas of the North-Eastern Mediterranean Sea*. NTUA-SMHL Publications.

Boulougouris, E.K. and Papanikolaou, A.D. (2004):*Optimisation of the Survivability of Naval Ships by Genetic Algorithms*. 3rd Int. Euro Conference on Computer Applications and Information Technologies in the Maritime Industries. COMPIT'04, Saguenay, Spain.

Boral, P.; Gurley, G.; Tar Bake, E. and Humphrey, R. (2005): *Development of a NATO Naval Ship Code. Safety regulations and Naval Class II*. London: The Royal Institution of Naval Architects.

Ingram, T.J. (2007). *Application of commercial ship maintenance philosophy to naval ships*. American Bureau of Shipping.

International Maritime Organization (1994): *International Convention for the Safety of Life at Sea (SOLAS)*. Author.

Pérez Fernández, R. (2009): *Studio de la adequacies y sufficiency de los "KG´s" limits Para el compliment de los criterions de estabilidad en los diversos campos, para los buques de carga rodada (mercantes-militares)*. 48º Congreso de Ingeniería Naval e Industria Marítima. Vigo, Spain.

Przemieniecki, J.S. (1994): *Mathematical Methods in Defense Analyses*. 2nd Edition, American Institute of Aeronautics and Astronautics.

Rahola, J. (1935). *The judging of the Stability of Ships and the Determination of the Minimum Amount of Stability*. Transactions. Institute of Naval Arquitects.

Riola, J.M. (2003): *Landing and carrier warships´ survivability basin test*. Defense Department. Spain.

Riola, J.M. and Marón, A. (1997): *Survival tests of a damaged ferry vessels*. VI Conferencia Internacional: Stability of Ships and Ocean Vehicles, STAB´97. Varna, Bulgaria.

Riola, J. M. and Pérez Fernández, R. (2009): *Estudio comparativo entre los criterios de estabilidad de la Armada Norteamericana, Británica y del SOLAS*. 48º Congreso de Ingeniería Naval e Industria Marítima. Vigo, Spain.

Riola, J.M. and Pérez Villalonga, F.J. (2008): Naval Ship Code. Una nueva normativa internacional para buques de guerra. *Revista General de Marina*. June. Spain.

Riola, J.M. and Valle, J. (2001). *Transient flooding in a damaged ferry*. PRADS´2001. Shanghai, China.

Sarchin, T.H. and Goldberg, L.L. (1962): *Stability and Buoyancy Criteria for the U.S. Naval Surface Ships*. Trans. SNAME, Vol.70, pp. 418-458.

Surko, S.W. (1994): *An Assessment of Current Warship Damaged Stability Criteria*, Naval Engineers Journal, Vol.106, No.2, pp. 120-131.

US Navy, Naval Ship Engineering Center. (1975): *Design Data Sheet-Stability and Buoyancy of US Naval Surface Ships, DDS 079-1*. US Navy, currently Naval Sea Systems Command, Washington, DC.

Wendel, K. (1968): *Subdivision of Ships*. Diamond Jubilee International Meeting, New York.

CASO DE ESTUDIO DE LOS CRITERIOS DE ESTABILIDAD PARA BUQUES DE GUERRA SINIESTRADOS

Resumen

En la actualidad todas las armadas se esfuerzan por lograr un equilibrio entre seguridad y capacidad militar, asegurándose que las actividades en tiempo de paz sean realizadas con un nivel aceptable de riesgo. Pese a la necesidad intrínseca de diferencias de construcción, el nivel aceptable de seguridad para las armadas está equiparándose a los buques bajo legislación civil. Por ello, las armadas han recurrido a las Sociedades de Clasificación, cuyos reglamentos para buques mercantes están sujetos a la legislación internacional controlada por "OMI", particularmente el Convenio "SOLAS". Estos convenios "OMI" no son siempre adecuados para la mayor parte de los buques de guerra, de modo que el objetivo militar requiere alternativas de diseño y operación, no enteramente compatibles con la filosofía de los acuerdos "OMI" y sus soluciones.

Separar las reglas de las Sociedades de Clasificación de los convenios "OMI" para aplicación a los buques de guerra puede traducirse en malas interpretaciones y un descenso en los criterios de seguridad, por ello las armadas continúan confiando en los criterios empíricos en vigor desde la II Guerra Mundial, hasta que se validen otros métodos mejores. El artículo presenta una serie de comparaciones, entre los criterios navales más utilizados, dando lugar a conclusiones muy interesantes, como que los actuales criterios de estabilidad pueden ser enormemente implementados con unos pocos cambios que incrementen puntos en común con criterios "OMI", como por ejemplo, el cálculo de agua en cubierta desarrollado en el Acuerdo de Estocolmo.

METODOLOGÍA

En este artículo se realiza un estudio sobre la configuración de un buque de guerra, que podría ser un buque anfibio o una fragata; con los módulos de estabilidad en estado intacto y averías del Sistema "FORAN", subsistema de Arquitectura-Proyecto, propiedad de SENER, Ingeniería y Sistemas. El proceso seguido para realizar el análisis ha sido el siguiente; en el módulo "FSURF" se crean las formas, cubiertas y mamparos, posteriormente con el módulo "VOLUME", se definen los espacios del buque y el cálculo de sus capacidades. El módulo "LOAD" permite visualizar los subcriterios generados a partir del criterio de estabilidad seleccionado, así como posibilita introducir los datos necesarios para el posterior cálculo de "GM´s" mínimos.

El buque escogido para hacer el estudio se llamó "NVSH", proyectado con un calado mínimo de *3.65 (m)* y máximo de *6.21 (m)*. Se definieron dos incrementos entre dichos calados con trimado nulo y se realizaron los cálculos en estabilidad intacta para comprobar que el buque "NVSH" cumple con los criterios mínimos. El diseño del buque se ha realizado con una alternativa de compartimentado, a *(B/5)*. Se calcularon los "GM´s" mínimos o "KG´s" máximos, para los tres criterios que se quieren comparar en estabilidad en averías y para ello se necesitó de un software específico. Para el criterio del "SOLAS", de la armada americana y de la británica, los cálculos se hicieron con el módulo "FLOOD". Se consideró la peor avería la que necesitase mayores "GM´s" mínimos para cada calado.

CONCLUSIONES

La normativa mititar para los cálculos de estabilidad es inicialmente más estricta ya que mientras el "SOLAS" obliga a realizar los cálculos inundando sólo un compartimento en los buques mercantes, tales como lo petroleros, y en los buques roll on-roll off de pasaje dos; las "DDS" americanas exigen un mínimo de tres.

De todas las averías estudiadas, el encallamiento o desgarro del fondo, es la peor posible, tanto que el buque prueba, "NVSH", que cumple todos los criterios conocidos, no aguantaría una abertura de cuarenta metros en eslora en el doble fondo. El criterio de la armada británica "NES-109", es el más riguroso, seguido del criterio de las "DDS" norteamericanas y por ultimo del criterio de las marinas civiles sin considerar agua en cubierta, el "SOLAS" sin Acuerdo de Estocolmo. Si se considera agua en cubierta el anexo del "SOLAS" relativo al Acuerdo de Estocolmo es lo suficientemente riguroso que pasa a considerarse el criterio más rígido de los conocidos hasta el momento, sin contar con el "NSC". La adopción del "NSC" mejorará el modo y la eficacia con que se gestiona la seguridad a lo largo del ciclo de vida del buque.

Una de las razones principales de ser del "NSC" es la de poder aplicar, debidamente adaptadas, normas civiles a buques de guerra, en especial las resoluciones "OMI". Las armadas tienen ahora un criterio de estabilidad después de averías, el "NSC", que se adecua a cada tipo de avería, basándose en las condiciones del diseño de las futuras operaciones del buque y sus posibles daños.

El "NSC" constituye un importante paso en la homogeneización de criterios de seguridad en los buques de guerra, lo que sin duda facilitará en el futuro los proyectos conjuntos internacionales para la construcción de nuevas unidades navales. Es importante destacar la importancia del nuevo código "NSC", que se ha convertido en el criterio de estabilidad después de averías que más se aclimata a las necesidades de las armadas del siglo *XXI*.

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Journal articles

Srivastava, S. K. and Ganapathy, C. (1997) Experimental investigations on loop-manoeuvre of underwater towed cable-array system. *Ocean Engineering* 25 (1), 85-102.

Conference papers and communications

Kroneberg, A. (1999) Preparing for the future by the use of scenarios: innovation shortsea shipping, *Proceedings of the 1st International Congress on Maritime Technological Innovations and Research,* 21-23 April, Barcelona, Spain, pp. 745-754.

Technical Reports

American Trucking Association (2000) *Motor Carrier Annual Report*. Alexandria, VA.

Doctoral theses

Aguter, A. (1995) *The linguistic significance of current British slang*. Thesis (PhD).Edinburgh University.

Patents

Philip Morris Inc., (1981). *Optical perforating apparatus and system*. European patent application 0021165 A1. 1981-01-07.

Web pages and electronic books

Holland, M. (2003). *Guide to citing Internet sources* [online]. Poole,
Bournemouth University. Available from:
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