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MARITIME CASUALTIES ANALYSIS AS A TOOL TO IMPROVE RESEARCH ABOUT HUMAN FACTORS ON MARITIME ENVIRONMENT.

R. de la Campa Portela[1]

ABSTRACT

It is commonly accepted that approximately 80 per cent of maritime accidents are due to human error. However investigation in human factors, main cause of such accidents, is beginning nowadays, and the methodologies to carry out such an investigation are being developed by several institutions. These methodologies, adopted from the investigation on risk analysis are frequently based on the estimation of risk levels, whose values, in the case of human factor investigation are not always clear.

This article tries to develop a methodology that helps us to identify the human factors existing on a maritime accident with the aim of making them processable on a statistical basis, in any case the aim of the study is not to exchange the existing and well –established systems of accidents analysis, but to put more stress on the human element, that is included in the existing analytical systems.

Keywords: risk assessment, maritime accidents, human factors.

INTRODUCTION

Following Garrick (1999) there are several basic aspects of maritime activity that make it unique: ships are confined and isolated systems, self-sufficient on energy supply, they have a limited manpower and resources, and they have a limited

[1] Profesora de la Escuela Técnica Superior de Náutica y Máquinas, Universidad de A Coruña, (rosamary@udc.es), Telf. 981167000- 4282, 981167101, Paseo de ronda 51, 15011, A Coruña, Spain.

response capacity to face emergencies. These particular characteristics made maritime trade a risky activity, where a fault in navigation or in usual port operations can give rise to injuries or lost of life, to damage of property and some times irreparable damage to maritime environment. Environmental and operational risks that can give rise to costly demands and complaints, are nowadays, in opinion of Palmgren (1999), a significant matter to owners, and the evaluation of these and other risks is an essential requirement to maritime trade safety.

Although risk, inherent to maritime industry, can not be completely removed (UK P&I Club, 1999; Peek and Rawson, 2000), it can be reduced to acceptable levels through the use of risk management principles. However before putting in practice a risk management plan, the owner must identify, evaluate and prioritize the main existing risks.

On the other hand, several researches (UK P&I Club, 1999, US Department of Transportation, 1999) identify human error as cause of 60 and 80 per cent of maritime accidents, giving us an idea of the importance on maritime safety of quality living conditions on board –related to ship condition and maintenance– and quality of crews – related to crew competence and qualification.

Since human factors –trigger of human errors– are the main source of risk in maritime activities, it seems interesting to develop methodologies that allow evaluating quantitatively and qualitatively the real incidence of several human factors over maritime accidents happening with the aim of taking human factors into account in properly developing risk management plans.

So present article shows a methodology that takes easy to determine human factors risk levels through statistical analysis of maritime accidents.

HUMAN FACTORS AS MAIN CAUSE OF MARITIME ACCIDENTS

Maritime activity is, without any doubt, a risky activity, and maritime disasters, that had happened through the years and which will happen in an inevitable way, are due to the complex environment of ship operation. Although maritime transport has a relatively low death and injury rate –180 estimated fatalities in 1995, against 45 000 fatalities in road accidents happened the same year in the European Union–, the consequences of an accident happening are sometimes far reaching. The repercussions of oil pollution or large loss of life in a passenger carrying vessel, can reverberate for many years and take their toll on businesses, small economies and even governments (European Transport Safety Council, 2001a).

On the other hand, and such it is indicated by Caridis (1999:11) "despite the significant advances that have been achieved in recent years in the field of marine technology, the number of maritime accidents that occur on a world –wide basis has not reduced significantly". This is due to, without any doubt, and as it has been shown in several studies, the high proportion of maritime accidents related to human factors– up to 80%.

So, even nowadays, when navigation instruments use new and advanced technologies, human error is generally accepted to be the main cause of such casualties. In relation to this, it is pointed out (Moreton, 1997) the wrong tendency to think that these new and improved technologies and rules can counteract the human limits increasing safety at sea, even when such technologies and rules are frequently developed in an isolated way, instead of being developed in an integrated way as a component of the navigation system.

In that sense, and following the *Report on suggestion for the integration of human factors in safety and environmental analysis* (Thematic Network for Safety Assessment of Waterborne Transport, 2003), there is a broad agreement that the key means of lessen the human element contribution to accidents will be via safety management, including inspection and training.

ACCIDENT PREVENTION: RISK ASSESMENT AND INVESTIGATION.

Generally it can be said that maritime accidents prevention has nowadays two sides that use, to a great extent, as work base data, those from maritime accidents and incidents reports:

— Proactive work, commonly named as risk assessment, whereby the risks are assessed beforehand and measures are introduced to reduce them happening; and

— Reactive work, where accidents are investigated and analysed to find the causes to prevent a reoccurrence. The European Transport Safety Council indicates in the "Transport accident and incident investigation in the European Union" (European Transport Safety Council, 2001a) that many states recognise that this approach makes a major contribution to improve safety.

Risk Assessment

The application of risk assessment techniques, as pointed by Fowler and Sorgard (2000) has been identified as an important tool for risk management by the International Maritime Organization.

There are, in fact, a considerable number of methodologies and techniques aimed to the identification and analysis of human error as to its prevention and decrease of its occurrence (European Commission, 1999). These can be emphasized amongst others:

— Formal safety assessment developed by International Maritime Organization.

— The method of performance influencing factors (PIF) applied by SINTEF group.

— TRIPOD- method: it was developed by SHELL.

— THERP (Technique for human error rate prediction): developed at Sandia National Laboratories.

In any case, risk assessment consists of:

1. Identifying the hazard in the system
2. Evaluating the frequency of each type of accident
3. Estimating accident consequences
4. Calculating various measures of risk, such as death or injuries in the system per year, individual risks or frequency of accidents of a particular kind.

The results obtained from risk assessment can be used as basis to the implementation of new safety measures or to the change of those existing: "assessment of risk contributes to effective strategies for casualty reduction, by helping to show where scope for applying different safety measures lies" (European Transport Safety Council, 2003:7).

Accident Analysis

On the other hand we have the reactive work consisting, as we pointed formerly, on the investigation over accidents with the aim of revealing its original causes and based on it, to establish prevention measures to face similar situations: "effective accident and incident investigation makes a positive, and long lasting, contribution to the improvement of transport safety" (European Transport Safety Council, 2001a:1).

In the particular case of human factor investigation, Marine Accident Investigators International Forum (MAIIF) states, in its *Accident Investigation Guide*, the next objectives when an analysis over maritime accidents is being done:

— discovering how limitation in human performance could have caused or contributed to the occurrence;
— identifying safety hazards conductive to human error or arising out of limitations in human performance; and
— making recommendations designed to eliminate or reduce the consequences of faulty actions or decisions made by any individual or groups involved in the occurrence.

At the same time, it is broadly recognised that accidents rarely are due to an only event, but more often they are caused by a combination of individual, technological and organizational factors. In maritime settings it can be said that human element is the most important factor, acting in near 80% of accidents. Therefore, accident analysis consists basically in determining the causes that started it and to establish, in a later stage, the relationship between them. Following Hollnagel (2005) accident starting causes can be interrelated in several ways, giving rise to three kinds of accident models:

— Sequential accident models;
— Epidemiological accident models; and
— Systematic accident models.

Such factors can be, at the same time, classified as carrier or latent – the first ones influence directly over the performance and the probability of making errors,

and the second ones are errors whose effects are only clear some time after they are made (Gil de Egea et al., 2003) –and as observable or inferred factors– the first ones are directly referred on accident reports, and the second ones must be deduced from a depth study of the accident with the aid of expert investigators (Jacinto and Aspinwall, 2003).

In any case these factors must be perfectly identified and the relationship between them must be established in the most possible accurate way. With this purpose, Marine Accident Investigators Forum points in its *Accident Investigation Guide*, four kinds of analytical techniques to determine the relationship amongst human factors as cause of accidents in maritime settings:

— Events and causal factor charting analysis
— Barrier analysis;
— Change analysis; and
— Root cause analysis.

Lastly it is necessary to point out that the selection of accidents to carry out the investigation may have significant impact on the results, then it is useful to make a list of exclusive criteria to determine which accidents are suitable to analyse. The *Report on suggestion for the integration of human factors in safety and environmental analysis* (Thematic Network for Safety Assessment of Waterborne Transport) establishes the next criteria list to be used on an accident investigation over human factors:

— Reports must contain a high variety of human factors which can be clearly identified
— Reports should be related to typical and not extra-ordinary accidents;
— In relation to size and kind of ship it is recommended to use accidents related to ships of 500 GT and over, which are involved in international trade and are operated under IMO regulations.

Accident and casualty databases containing highly reliable data are, therefore, essential tools to do that kind of investigations. Unfortunately, the maritime setting is characterized for having a shortage in this kind of statistical data appropriately compiled and processed. Maritime accident and incident databases are scarce and hardly accessible. Also, not all countries have a systematic method to gather information related to human factors, which makes difficult this kind of investigation (Caridis, 1999; European Transport Safety Council, 2001b; European Transport Safety Council, 2003; Harrald et al., 1998).

USEFULNESS OF MARITIME ACCIDENT ANALYSIS FOR INVESTIGATION ON HUMAN FACTORS

It is clear that total safety over ships operation can not be achieved, but it is possible to obtain a high degree on it. Research on the influence of human factors over maritime accidents is, also, very difficult. On the one hand we find that an accident involves the interaction of individuals, equipment and environment, as well as

unforeseen factors (Caridis, 1999), and on the other hand, human factors comprise operative human errors –derived from personnel own qualifications, or from their physical, mental and personal conditions- and situational errors– derived form work environment design, management problems, or human-machine interface, amongst others (Gil de Egea et al., 2003).

To carry out these investigations with success, it seems necessary to face up to the next points:

1. Developing a common methodology for human error classification, which, at the same time, as pointed out by Caridis (1999) can be adopted at an international level and which can become an accepted rule. Only by this way useful and significant comparisons could be done between accidents happened in several countries.

2. It seems essential to develop research methods which allow to define maritime accidents causes with the aim of establishing, at a later stage and over these results, the more appropriate defences to avoid the recurrence of such accidents, as to design processes capable of calculating the probability of a human error to happen on a determined environment (Gil de Egea et al., 2003). These latter processes, that permit to predict with some accuracy human reliability are, for us, of increasing interest, because it is clear that it is an advance to be able to calculate the probability of an human error to happen in a specific situation.

3. Finally it is necessary to develop a common taxonomy for the storage of information in relation to accidents at sea. A high quality research is not possible without reliable, up to date and well-classified data. However maritime trade, as we have seen before, has a strong shortage in this sense, because current accident causation taxonomies and databases are untested with regard to reliability and adequacy.

With regard to investigation about human factors, several authors (Moreton, 1997; Morrison, 1997; Sröeder and Zade, 2002; Ordiz y Maza, 2002) put forward the analysis of maritime accidents as a way to understand why people make mistakes. On maritime environment such an investigation is centred in studying seamen perceptual, mental and physical capabilities, so as physical environment and working organization. The results of such investigations can be to the advantage of improving both seamen working conditions and the requirements, means and methodologies of training, having into account that ship safety starts on crew, and that a correct training is a vital element of her safe operation.

On the other hand, being risk an inherent factor of maritime activity that can not be totally removed, and being error part of human experience, it is expected that elements such as good management policies, effective training and having suitable qualifications and experience, can reduce the occurrence of human errors.

Unfortunately, the lack of objective data to evaluate the risk levels, which is a feature of maritime activity, that has no global detailed statistical data offered by International Maritime Organization (IMO) (Parker, 1999), is one of the biggest impediments for the progress of international maritime industry.

METHODOLOGICAL PROPOSAL TO AID IN HUMAN FACTOR INVESTIGATION

The investigation into an only maritime accident reveals its original causes and the relationship between them, which are specific for this particular accident. Such an investigation allows to take corrective actions with the aim of preventing accidents in similar circumstances. However it seems unlikely that the interaction between causes, or the chain of causes that originated a particular maritime accident would be repeated exactly the same way or highly similar in another accident.

However, if we take one of the causes in an isolated way and we investigate how many times such a cause appears in several maritime accidents, we would establish the probability of occurrence of such a cause in maritime accidents, and we could determine the risk that such a factor involves to maritime trade.

On the research about human error, these factors that cause the accident, commonly named as human factors, are, at least, more imprecise than the errors due to materials or equipment failure, therefore they are difficult to determine and to quantify. For this reason, a previous investigation about the presence of these factors, the different kinds of them, their root or previous cause or their occurrence frequency, seem to be interesting with the aim of establishing a clear and quantifiable object of study, capable of being investigated using statistical methodologies. In this way we could determine the risk level that the occurrence of each factor in an isolated way adds to the outbreak of accidents on the maritime environment.

A previous investigation of this kind, that combines risk assessment and maritime accidents analysis, was developed at the School of Nautical Studies of University of A Coruña, with the aim of establishing to what extent the communication problems due to linguistic differences, can be, nowadays, direct or indirect cause of maritime accidents (de la Campa, 2003).

The aim of this article is not to present the results obtained in such an investigation on a strict sense, but to show the process carried on, with the object that this process could be used as a tool to carry out other investigations aimed to study the influence of several parameters related to human factors on maritime accidents.

So, the investigation carried out at University of A Coruña consisted of the next steps:

1. Step 1: Hazard identification and quantification: through maritime accident analysis it is determined the probability of appearance of the studied human factor, and the consequences derived from its appearance. This step consists of:

a. Choice of investigation field.

b. Data collection.

c. Data processing and analysis.

d. Conclusions establishment.

2. Step 2: Risk level determination: from probability and consequence values established on step 1, and with the help of a risk matrix we could determine the risk level of the studied human factor.

Hazard Identification

Choice of investigation field

The parameters that must be established in relation to the choice of investigation field could be the next:

1. Working subject: the working point will be the human factor item which is interesting to investigate. In our case, for example, we have chosen to study the communication problems due to linguistic differences.

2. Period of study: another important point is to decide the period we want to investigate on, so the study can be focused on a certain period- for example after or before the coming into force of some rules or regulations related to the human factor of the study- or to look for current data studying accidents happened recently. In our study we have decided to investigate accidents happened between 1994 and 2001.

3. Maritime community of study: the investigation can be focused on a specific country or group of countries with the aim of concentrating on a specific maritime community, or to give it a global nature. The latter option was elected in the example investigation.

Data collection

According to the selected period and maritime community, we can use several information sources that provide us with the data about maritime accidents. In general, every country carry out investigations about the maritime accidents happened within its territorial waters, and about accidents in which any ship authorized to hoist its flag has been involved. The final reports are published on several ways by the country authorities. In our particular case we have made use of the accident reports published on the Internet by several authorities such as "The Australian Transport Safety Bureau", "Transport Safety Board of Canada", "The Maritime Safety Authority of New Zealand", "The Marine Accident Investigation Branch of United Kingdom" or "The National Transportation Safety Board of U.S.A.".

Data processing and analysis

Once reports have been compiled, we proceed to the report selection, first, and to the data analysis, later.

1. Report selection: amongst the obtained reports we must reject those that are not interesting for our investigation, that is to say, those in which the inexistence of the studied factor is proved, or those in which it is proved that the studied factor has not been relevant for causing, developing or ending the notified accident. To

undertake this task it is very beneficial that these reports are in computer support, with the aim of making easier the selection of reports by means of searching for key words directly or indirectly related to the studied factor. So, for example, in our case, the search has been done on PDF format files, using key words such as "English", "seaspeak", "communication", "vocabulary", and so on.

2. Data analysis: once obtained the whole of reports to work on, we must establish a series of "cause parameters". These "cause parameters" will be the several ways how the studied factor appears. Then, for example, to the factor "communication problems related to linguistic differences", we have established the "cause parameter" that are shown in Figure 1: "External communication problems", "Internal communication problems", "Written communication problems", "Misuse of standard vocabularies", "miscommunication between master and pilot", "bridge team working fault" and "misuse of VHF equipment". All these factors can be classified as direct factors or as indirect factors, and both of them can cause the studied factor: communication problems.

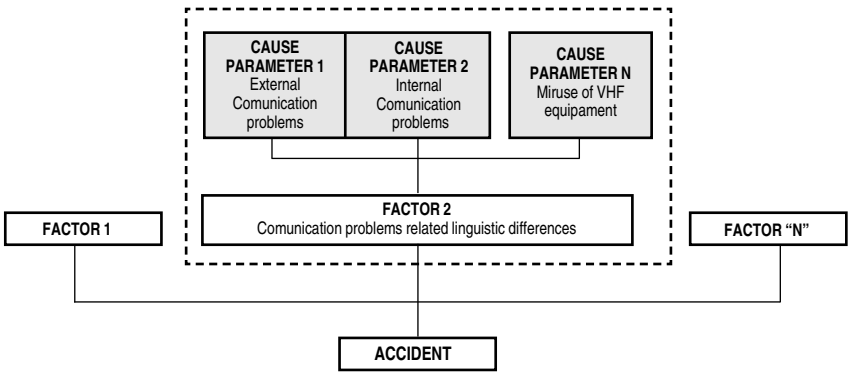

Figure 1: Cause Parameters

On the other hand, a series of "result parameters" must be established. These "result parameters" refer to the kind of accident finally happened and the seriousness of personal injuries and/or material damage suffered. Personal injuries, total loss of ship, grounding, beaching or collision are some examples of result- parameter. The Figure 2 shows the most common cause parameter found in our example investigation.

Conclusions establishment

The next step will be to compare the whole of maritime accidents in relation to "result parameters" and "cause parameters", in such a way that the relationship between them can be established.

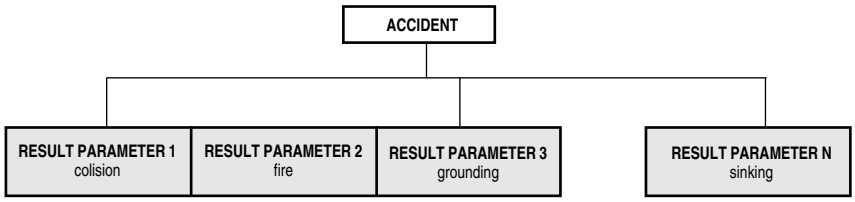

Figure 2: Result Parameters

The relationship between parameters obtained in that way, will give us the occurrence frequency of the studied factor on maritime accidents that took place on a specific period and for a specific maritime community. The occurrence frequency to each cause parameter and the most common consequences derived from such cause parameters could be established too. In the example research the most common cause parameter is "external communication problems", and the most common result parameter is "collision", as shown in Figure 3.

Risk Level Determination.

As it is well known, risk level, which give us idea of the general importance of a specific hazard, can be comprised amongst one of three assumptions:

Intolerable risk level: the risk level is too high to be justified and that it should be reduced regardless of the costs associated with the measures needed to bring the risk down to a tolerable level.

Tolerable risk level: risk levels that are assessed to be below the intolerable limit are regarded as tolerable provided it can be demonstrated to be ALARP – as low as reasonable possible. In order to demonstrate that the risk level is ALARP, cost effectiveness assessment of available risk control options must be performed. If cost effective risk control options are available, the risk level will not be ALARP and thus not regarded as tolerable until these are implemented.

Negligible risk level: the risk level is assessed to be so low that no further risk reduction measures are required.

In our case, to determine the risk level of the studied factor we are going to use a risk matrix, whose parameters are the probability of happening of such a factor in a maritime accident and its consequences, both data derived from the analysis done in step 1. To elaborate the risk matrix, that can be seen in Figure 4, we will proceed to establish five levels of probability and five levels of consequences.

Probability levels could be in this case:

1 .— 0-10%: very low probability risk level
2. — 11- 40% : low probability risk level
3. — 41 – 60%: half probability risk level
4. — 61- 90%: high probability risk level
5. — 91 – 100%: very high probability risk level.

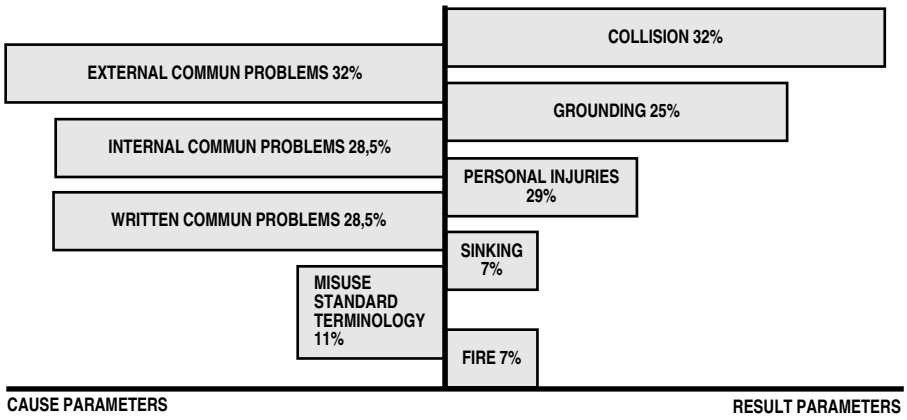

Figure 3. Consequences establishment

Consequence levels could be established as:

1. Disastrous consequences: people death, very serious damage to maritime environment, sinking or any other accident which results in the ship total lost.

2. Serious consequences: people serious injuries, maritime environment serious damage, fire, collision, grounding or any other accident which results in very serious damage to ship structure.

3. Moderate consequences: moderate injuries to people, moderate damage to maritime environment or any other accident which results in moderate damage to ship structure.

4. Minor consequences: minor injuries to people, minor damage to maritime environment, or any other accident which results in minor damage to ship structure.

5. Negligible consequences: very little damage to ship structure.

CONSEQUENCES / PROBABILITY	NEGLIGIBLE	MINOR	MODERATE	SERIOUS	DISASTROUS
0 - 10%	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	TOLERABLE	TOLERABLE
11 - 40%	NEGLIGIBLE	NEGLIGIBLE	TOLERABLE	TOLERABLE	INTOLERABLE
41 - 60%	NEGLIGIBLE	TOLERABLE	TOLERABLE	TOLERABLE	INTOLERABLE
61 - 90%	TOLERABLE	TOLERABLE	TOLERABLE	TOLERABLE	INTOLERABLE
91 - 100%	TOLERABLE	INTOLERABLE	INTOLERABLE	INTOLERABLE	INTOLERABLE

Figure 4. Risk matrix

In this way, to know the risk level of the studied factor we only need to enter in the risk matrix with probability and consequence data previously calculated, obtaining the searched risk level directly from the matrix.

CONSEQUENCES / PROBABILITY	NEGLIGIBLE	MINOR	MODERATE	SERIOUS	DISASTROUS
0 - 10%	NEGLIGIBLE	NEGLIGIBLE	NEGLIGIBLE	TOLERABLE	TOLERABLE
11 - 40%	NEGLIGIBLE	NEGLIGIBLE	TOLERABLE	TOLERABLE	INTOLERABLE
41 - 60%	NEGLIGIBLE	TOLERABLE	TOLERABLE	TOLERABLE	INTOLERABLE
61 - 90%	TOLERABLE	TOLERABLE	TOLERABLE	TOLERABLE	INTOLERABLE
91 - 100%	TOLERABLE	INTOLERABLE	INTOLERABLE	INTOLERABLE	INTOLERABLE

Figure 5. Risk level determination

So, following our example, if we take the probability level of communication problems in maritime accidents, calculated on step 1 as 20%, and we establish the consequences of such accidents between moderate and serious, we will obtain a tolerable risk level, as it is shown in Figure 5.

CONCLUSIONS

The practical application of this kind of analysis seems clear: obtaining the cause parameters, both direct and indirect parameters, from the studied factor, we can better understand the root of the presence of such a factor, and we can take punctual, specific and direct corrective actions to try to minimize the accident risk.

In spite of it is highly simple, the main weakness of this method lies in the lack or shortage of data related to accidents and incidents on maritime domains.

The investigation on maritime accidents is, nowadays, a very important tool to identify the problems related to human factor, that, studied with attention can be one mainstay to accident prevention and to the improvement of maritime safety.

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PROPUESTA METODOLÓGICA PARA LA AYUDA EN LA INVESTIGACIÓN DEL FACTOR HUMANO EN LA NAVEGACIÓN

Resumen

De forma general es aceptado que aproximadamente el 80 por cien de los accidentes marítimos son debidos al error humano. Sin embargo, la investigación en factores humanos en el ámbito marítimo, causa principal de dichos accidentes, está comenzado en nuestros días, y las metodologías apropiadas para llevar a cabo dicha investigación están siendo desarrolladas por diversas instituciones. Estas metodologías, adapatadas de la investigación en análisis de riesgos están frecuentemente basadas en la estimación de los niveles de riesgo, cuyos valores, en el caso de la investigación sobre factores humanos, no están siempre claros.

Este artículo trata de desarrollar una metodología que nos ayude a identificar los factores humanos existentes en un accidentes marítimo con la intención de hacerlos procesables desde un punto de vista estadístico. En cualquier caso este estudio no pretende cambiar los sistemas de análisis de accidentes marítimos bien conocidos y establecidos, sino poner mayor énfasis en el elemento humano ya contemplado en los sistemas analíticos existentes.

DESARROLLO METODOLÓGICO

La investigación sobre un único accidente marítimo revela sus causas originales y la relación entre estas causas, que son además específicas para ese accidente particular. Tal investigación permite tomar acciones correctivas con el fin de prevenir accidentes en circunstancias similares. Sin embargo parece improbable que la interacción entre esas causas, o la cadena de causas que originaron un accidente concreto, puedan repetirse exactamente de la misma forma en otro accidente.

Por otro lado, si tomamos una de las causas de forma aislada e investigamos con qué frecuencia dicha causa aparece en diversos accidentes marítimos, podríamos establecer la probabilidad de aparición de tal causa en los accidentes marítimos, y podríamos determinar el riesgo que dicho factor supone en el comercio marítimo.

En la investigación sobre el error humano los factores que causan los accidentes, denominados comúnmente factores humanos, son, al menos, más imprecisos que los errores debidos a fallos en el material o el equipo, por lo que son más difíciles de determinar y cuantificar. Por este motivo, una investigación previa sobre la presencia de estos factores, sus diferentes tipos, su causa raíz o previa o su frecuencia de ocurrencia, parece interesante con el fin de establecer un objeto de estudio claro y cuantificable, susceptible de ser investigado usando metodologías estadísticas. De

esta forma podríamos determinar el nivel de riesgo que la ocurrencia de cada factor de forma aislada supone en la iniciación de los accidentes en el ámbito marítimo.

Una investigación previa de este tipo, que combina la gestión de riesgos y el análisis de accidentes marítimos, ha sido desarrollada desde la Escuela Técnica Superior de Náutica y Máquinas de la Universidad de A Coruña, con objeto de establecer hasta qué punto los problemas de comunicación oral debidos a la falta o mal uso de una lengua común, pueden ser , hoy en día, causa directa o indirecta de accidentes marítimos.

El objetivo de este artículo no es presentar los resultados obtenidos en dicha investigación de forma estricta, sino presentar el proceso llevado a cabo con objeto de que dicho proceso pueda ser usado como herramienta para realizar investigaciones similares encaminadas al estudio de la influencia del error humano en los accidentes marítimos.

Así pues, la investigación llevada a cabo desde la Universidad de A Coruña comprende los siguientes pasos:

Identificación y cuantificación de peligros: a través del análisis de accidentes marítimos se determinó la probabilidad de aparición del factor estudiado y las consecuencias derivadas de dicha aparición. Este paso consistió particularmente en: elección del campo de investigación, recogida de datos, análisis y procesamiento de datos y establecimiento de conclusiones.

Determinación del nivel de riesgo: a partir de los datos de probabilidad y consecuencias establecidos en el paso previo, y con la ayuda de una matriz de riesgos se determinó el nivel de riesgo del factor humano objeto de estudio.

CONCLUSIONES

La aplicación práctica de este tipo de análisis parece clara: obteniendo los parámetros causa, tanto directos como indirectos, del factor estudiado podemos comprender mejor la raíz de la presencia de dicho factor en los accidentes marítimos, por lo que podremos desarrollar acciones correctivas directas, específicas y puntuales con el fin de minimizar el riesgo de accidentes.

A pesar de ser un método muy sencillo, su principal debilidad radica en la escasez de datos relacionados con los accidentes e incidentes en el ámbito marítimo.

La investigación en accidentes marítimos es, hoy en día, una herramienta de suma importancia que nos ayuda a identificar los problemas relacionados con el factor humano, que, estudiados con atención pueden convertirse en el soporte para la prevención de accidentes y la mejora de la seguridad marítima.