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Human - Transport Interaction
Preliminary Communication
Accepted: Oct. 20, 2011
Approved: July 5, 2012

OFFICERS' SUBJECTIVE NEAR MISS NOTION IN SITUATIONS OF COLLISION AVOIDANCE AT SEA

ABSTRACT

International studies have determined a strong connection between maritime casualties and human error. Most of the studied effects of human factor on casualties in maritime transport are connected to individual ship crew member's subjective approach to solving the problem. Therefore, the aim of this research was to determine the relationship between different subjective definitions of a near miss in situations of immediate danger of collision for different categories of examinees. The categories of officers and masters with regard to years of service, type of ship they are on board, ship's size, etc., were considered. Over a period of four years the research was performed on officers and masters (N=234) that attended specialized courses (3 to 6 attendants) on navigation simulators of the Faculty of Maritime Studies in Rijeka. Based on the results obtained by nonparametric tests for small independent samples, certain significant differences with respect to differently defined divisions of the examinees were identified.

KEY WORDS

human error, maritime casualties, near miss, maritime officers

1. INTRODUCTION

Maritime transport takes up more than 90% of the global exchange of goods on the world market. Modern maritime transport is a combination of expert and complex operations united and defined by various international and national regulations and standards. In the last thirty years maritime industry has been dedicated to increase the quality and safety of the ship structure and the reliability of ship systems with the aim to decrease the number of casualties and increase the efficiency of maritime transport. As a result, today's ships are, technologically speaking, very advanced system units with a high degree of reliability of all the implemented systems. However, this modern technology of ship managing through a specific work environment modifies the behaviour of the master and the officer on watch [2].

The number of casualties and their consequences in maritime economy still define maritime transport as a high risk transport when compared to other branches of transport [20]. A significant prerequisite for raising the level of ship safety is a qualified and well trained crew, because in most cases, casualties are attributed to human error. Ship systems are basically subject to a human, who manages them in a given moment. Therefore, in research, human error emerges as one of the main factors (75 – 96%) of all maritime casualties.

The success of ship management greatly depends on skills, knowledge and experience of the master and the officer. Inadequate officer's or master's estimation based on personal perception can result in an event that can be, subjectively as well as objectively, recognized as a near miss. A near miss can be defined as a sequence of events and/or conditions that could have resulted in a casualty, and the casualty was prevented by a certain action that led to a discontinuance of the sequence of events and/or conditions.

Most papers dealing with the issue of emergencies study maritime casualties, with the emphasis on collisions at sea. This paper addresses the issue of a near miss and examines the subjective approach to safe distances of passing between two ships during collision avoidance.

2. THE EFFECT OF HUMAN ERROR ON MARITIME CASUALTIES

Today, human error is the subject matter of research in almost all branches and professions of in-

dustry. It is commonly described as an incorrect decision, improperly performed action or failure to perform certain actions (omission). In the available literature, there are several definitions of human error. In an International Maritime Organization (IMO) resolution [14], human error is defined as a complex multidimensional outcome that affects maritime safety and sea environment protection. According to the definition, human error includes the entire spectrum of activities performed by ship's crew, shore management and logistic support, various kinds of ship's supervisors, shipyards and all other involved parties. According to the UK P&I Club [6], human error can be defined as "an activity (or omission) that can be identified as a direct cause of some event (that leads to liability)". The American Bureau of Shipping (ABS) [1] defines human error as "a deviation from acceptable or desirable actions by an individual that results in an unacceptable or undesirable outcome". In air transport [21], human error could be defined as "a difference between that which should have been performed and that which was actually performed".

Maritime casualties very rarely occur as a result of a single human error, but typically take place as a sequence of interconnected errors of people that manage the ship. Errors that most frequently lead to maritime casualties are a result of the activities on the commanding bridge, where one decision-making error leads to another, while the danger of the first error had not even been detected. In a research conducted in Denmark [19] on a sample of 100 maritime casualties, it was determined that the number of interconnected errors spanned from 7 to 58 errors that preceded a single casualty. In 93% of the cases, the casualty was preceded by a chain of errors done by one or, most frequently, several individuals involved in maritime undertaking. The research also shows that each human error that preceded the casualty was necessary for the casualty to actually happen, which means that only one "omission" of an error in the sequence of errors would have resulted in the non-occurrence of the maritime casualty.

Human factor effect is the most commonly studied factor in view of elements such as weariness, experience/inexperience, moral, motivation, management structure, standards for acquiring a level of education, service conditions, environment, loyalty, language of communication, training and a positive approach to technology.

It is commonly held that it is in human nature to constantly violate the defined rules, regardless of what they might be, and although not all violations are fatal, constant broadening of acceptable risk boundaries leads to undesirable consequences. If the fact that rules mean safe following of work procedures stands, then every violation of those rules increases the risk of casualty occurrence. Rule violation does not necessarily bring about a casualty, but it brings the entire process in a situation where every following error has an increased potential for inopportune, potentially hazardous outcome of the entire process.

The rule violation by disrespect of safe work procedures is not related only to imprudence, negligence or disregard of people involved in a given process. The results of a study performed with 4,000 mariners and published in *Fairplay Daily News Service* (8 June 2006) [5], show that even half of all the examinees often violate rules of safe work procedures. This kind of indicator is not to be viewed as an error of an individual mariner, but more often as an error in the approach of managing a particular organization in which the mariner works. The effects that lead to disregarding the rules, besides through individual's liability, can also be considered in view of the organizational structure, namely in view of:

- workplace requirements,
- apparatus and equipment quality,
- whether the person who monitors the overall process approves or does not approve of rules violation for the work to be done,
- quality and expediency of regulations, rules and procedures,
- culture and organizational structure of the company according to safety standards.

The importance of the mentioned effects is also indicated by certain research [12] that shows that only 25% of the entire world fleet is involved in more than 50% of all maritime casualties in the world. It has also been noticed that 25% of "safe" ships is involved in less than 7% of all casualties, which leads to the conclusion that accomplishing the same security standard on all ships would decrease the total number of maritime casualties in the world by 72%.

Furthermore, the research conducted by the Marine Accident Investigation Branch (MAIB) [8], performed on a sample of 1,647 collisions, groundings or reported near misses, led to three fundamental causes of sea casualties:

- grounding and weariness – one third of all groundings happened due to the weariness of the officer who was on watch alone on the commanding bridge,
- collision and surveillance – one third of all collision situations happened due to inadequate surveillance of the area around the ship,
- safety procedures and the master's role – one third of all casualties happened in night conditions with one crew member on the commanding bridge.

According to the results of the mentioned research, even 55% of all casualties are collisions, while 31% of the casualties are groundings, and most of all casualties (67%) happened in sunny weather and under relatively favourable weather conditions.

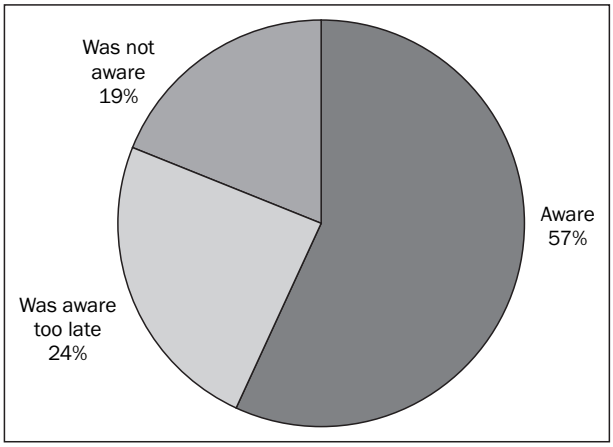

Figure 1 - The watch member's (or members') awareness of the presence of other ships before the collision

Source: Marine Accident Investigation Branch (MAIB), http://www.maib.gov.uk (14.05.2011.)

According to other research [11], even half of all casualties happening in maritime affairs can be attributed to navigation error, 7% of which are various contacts, 20% are ship groundings, while 22% are collisions of two or more ships. In this kind of casualties, human role, in this case the role of the officer keeping navigation watch on the commanding bridge is more than significant and is present in almost all cases.

The awareness of the circumstances taking place is the ability to properly oversee the situation around the ship, and the possibility of predicting future unfolding of that situation. This awareness depends on the possibilities of each individual separately, and is defined by the attentiveness, observation, memory, predicting, manner of decision-making, and is therefore subject to personal differences of the maritime undertaking participants.

These differences are extremely important for navigation officers that, while keeping watch, and based upon these possibilities, make decisions regarding the manner of maritime undertaking realization while comparing the predefined voyage plan with all the newly found situations that happen during the voyage. The just mentioned characteristics are different for every single officer depending on their abilities, character, knowledge, training, and experience.

Different understanding of certain situations brought about during a maritime undertaking of two officers on separate ships most frequently leads to extremely undesirable situations, such as ship collisions. Although both officers conduct the navigation according to the same rules for collision avoidance at sea, different interpretations of the same rules, different approaches and interpretations of the newly found situations, as well as insufficiently explained rules for collision avoidance at sea make these kinds of casualties possible.

3. SURVEY RESEARCH OF SUBJECTIVE "NEAR MISS" NOTION OF OFFICERS AND MASTERS

In a near miss that happened as a sequence of events and/or conditions that might have resulted in a casualty, the occurrence of which was prevented by a certain action that led to a discontinuance of the sequence of events and/or conditions, the distance between ships appears as a key factor. The distance between two ships, that was result of collision avoidance, and which was subjectively recognized as the presence of an avoided danger by the examinees can be considered in view of the notion of maritime casualty. Maritime casualty [13] is an event related to ship operation, except for maritime accidents, that has endangered or could endanger the safety of the ship, persons on board or any other person, or the sea environment. According to the subjective assessment of the officer/master on the commanding bridge at the time of avoiding an immediate danger of collision, the distance between two ships was jeopardizing the ships safety, and the immediate danger of collision was avoided at the last moment.

Due to the need for an increased economical efficiency of the ship and a decreased number of crew members, greater emphasis of the masters' and officers' activities is placed in the passive control domain, and the workload is increased for reasons of faster ship exploitation. The mentioned elements have a significant effect on the perception of the events and decrease the ability to act in the very moments when appropriate actions should be taken immediately and without delay. The master's or officer's knowledge that the ship was brought into direct danger in a certain, usually very short period of time, and that a casualty had been avoided is of subjective nature, being that the very definition of knowledge states that it is a process taking place in an individual's brain.

3.1 Survey research of subjective "near miss" notion

In order to verify the mentioned theses, a survey research[1] was conducted with 234 ship officers and ship masters at the Faculty of Maritime Studies in Rijeka. All the participants of the survey actively attended one of the courses (3 to 6 participants per course) most of which were affirmed by the STCW Convention [16], and the courses were conducted on one of the specialized simulators (Transas 3000 and Transas 4000). The participation was entirely anonymous and voluntary.

The age of the surveyed officers and masters spanned from 21 to 55 with different navigation experiences on ships. The sizes of the ships that the surveyed participants navigated on under their last con-

tract spanned from 85 to 380 meters in length, and the types of those ships varied.

While examining the subjective impression of a near miss, only 65 of the surveyed participants (28%) confirmed that they had experienced a near miss during their navigation service. Also, of the total number of the examinees, 35 survey participants (15%) took part in a maritime casualty on board one of the ships they had navigated till present time. This kind of sample reduction (65 participants that took part in a near miss) allows for the results obtained in this research to be taken as a trend, and for more detailed results, the sample should be greater.

From the total number of the affirmative answers confirming the near miss experience, the subjective approach led to a significant dispersion of results related to the distance between ships at the moment of near miss. The data regarding the obtained dispersion are shown in *Table 1*.

Table 1 - Different distances between ships with subjective determining of a near miss occurrence

Distance (M)	Number of answers	Percentage (%)
0 - 0.1	19	29.2
0.1 - 0.2	17	26.2
0.2 - 0.3	8	12.3
0.3 - 0.4	2	3.1
0.4 - 0.5	8	12.3
0.5 - 1.0	8	12.3
1.0 - 2.0	3	4.6

Source: the authors
Legend: M – nautical mile; 1 M = 1,852 m

The average distance subjectively taken as a case of near miss by the examinees is 0.43M. The dispersion of the near miss distances from the calculated arithmetic mean is σ = 0.48M. It can be seen from the above mentioned table that the dispersion of the distances subjectively perceived as an occurrence of a near miss is great. This can be interpreted through three fundamental segments that affect the assessment, namely human perception (human being the basic assessment factor), ship's characteristics, and the condition of the environment.

3.2 Survey research results

The examination of the overall sample, obtained by surveying the officers and the masters, was performed using nonparametric tests for small independent samples, such as one-way analysis of variance, χ^2 test, Mann-Whitney test and Kolmogorov–Smirnov test. Using these tests, an attempt was made to determine the dependence between separate groups of examinees. By comparing the years of officer service, divided into three categories (0-2, 3-9, and 10 and more) with the results of the distance between ships at the moment of near miss, no significant difference was found.

Neither was a significant difference found while examining the dependence of the officers' commanding status on board on the distance between ships at the moment of near miss, which leads to the conclusion that the impression of a near miss is a markedly subjective feeling, and that it does not depend upon the years of officer service nor does it depend on the officers' commanding status of the examinees. When comparing the answers provided by the survey participants that experienced a maritime casualty (thirty-four or 14.5% of the total number of the examinees), and also took part in a near miss (seventeen or 26.2% of the examinees that experienced a near miss) with the answers of all the participants that were involved in a near miss regarding the distance between ships, there was also no significant difference found.

A significant difference was obtained comparing the survey participants navigating on tankers and bulk carriers with all other examinees that experienced a near miss. Using the Mann-Whitney test for testing the given sample, it was determined that for U = 70.0 it stands that P = 0.025 ($P < 0.05 \rightarrow 95\%$), which shows with 95% of certainty that officers navigating on tankers and bulk carriers define the notion of a near miss by greater distances between ships when compared to officers of other ships (container ships, passenger ships, ro-ro ships,...). Considering the characteristics of tanker and bulk carriers, and comparing them to the characteristics of ships pertaining to other categories of commercial ships, it can be concluded that they are mostly ships of weaker manoeuvring performance. During avoidance of an immediate danger, the rate of turn is a significant factor, and is shown to be weaker in the considered ship category, primarily due to the ship's construction characteristics. Therefore, the masters and the officers on board ships of this category have to initiate the avoidance manoeuvre earlier in order to avoid dangerous vicinities or collision. Hence, the subjective notion of a near miss with greater distances by the officers and the masters onboard tanker and bulk carriers can be partly interpreted in view of the above stated facts.

While comparing the subjective impression of a near miss (the distance between ships) with the ship's size, a division of ships onboard which the survey participants navigated, was made into three categories according to the ship's size: 169 metres and shorter, from 170 to 250 metres, and 250 metres and longer. By one-way analysis of variance, a significant statistical difference between the distance between ships at the moment of a near miss and the ship's size was determined only between the first and the third ship category (169 metres and shorter, and 250 metres

and longer) which is also indicated by the results $F = 3.818$; $P = 0.033$ ($P < 0.05 \rightarrow 95\%$). Therewith, it was determined on the given sample and with 95% accuracy that officers navigating on ships longer than 250 metres define near misses by greater distances between ships when compared to officers onboard ships smaller than 169 metres in length.

Ships longer than 250 metres have a proportionally larger draught and width, and require more room for manoeuvring, because the ship's pivot point while navigating ahead is situated approximately at 0.12 to 0.25 of the ship's length from the bow. Therefore, ships of larger proportions also have a larger turning circle which implies recognizing the proximity and danger from collision at smaller distances from the other ship, object or any obstruction at sea, which is verified by the statements of the masters and the officers on ships longer than 250 metres taken in the conducted survey.

The results of this research show a markedly subjective approach to defining a near miss in collision situations at sea by officers and masters. This leads to the conclusion that officers onboard various ships perceive navigational situations, in which they jointly take part, differently. With such limited knowledge acquired by incorrect information concept regarding the environmental conditions, knowledge is accepted, but incorrectly interpreted, which can potentially lead to taking wrong actions in situations of collision avoidance at sea.

From the above mentioned it can be concluded that human factor plays a significant role in most maritime casualties, especially in case of navigation error, where human factor is possibly the only factor in casualty causes. The observed phenomena related to subjective understanding of immediate danger require continuous education of masters and officers on simulation devices ashore that will be able to realistically simulate real conditions of navigation and ship manoeuvring process.

4. CONCLUSION

The results gained by the conducted research point to a considerably subjective approach by officers while defining the situations of near misses with immediate danger from collision at sea, which verifies the initial hypothesis. It was basically proven that the subjective approach to perceiving the notion of a near miss is not dependent on age nor is it dependent on the years of officers' navigation experience. However, significant differences were obtained by separating officers and masters with regard to types and sizes of the ships they navigated. From the mentioned results, a conclusion can be drawn that the subjective approach to defining the problem primarily depends on the working environment of the officers, which is directly linked to the type and the size of the ship they are navigating.

It should be noted that only 28% of the surveyed officers confirmed that they experienced a near miss during their years of navigation service, which decreased the observed sample considerably. This kind of sample dispersion points to the possibility that officers do not recognize near miss situations or they attribute very small values to distances in near miss situations. Concerning the recommendations for further research, the need for increasing the sample, as well as for defining the sample of the great sample dispersion in case of defining the subjective distances of a near miss with officers and masters in situations of collision avoidance at sea, should be emphasized.

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SAŽETAK

SUBJEKTIVNO POIMANJE IZBJEGNUTE NEZGODE KOD ČASNIKA U SITUACIJAMA IZBJEGAVANJA SUDARA NA MORU

Međunarodna istraživanja utvrdila su veliku povezanost između pomorskih nezgoda i ljudske pogreške. Većina istraženih utjecaja ljudskog čimbenika na nezgode u pomorstvu vezana je upravo na subjektivni pristup rješavanja problema od strane pojedinog člana posade broda. Stoga je cilj ovog istraživanja bio utvrditi vezu između subjektivnog definiranja izbjegnute nezgode kod situacija neposredne opasnosti od sudara za različite kategorije ispitanika. Razmatrane su kategorije časnika i zapovjednika, obzirom na godine staža, vrstu broda na kojem plove, veličinu broda itd. Istraživanje je, tijekom četiri godine, provedeno na časnicima i zapovjednicima (N=234) koji su prisustvovali specijaliziranim tečajevima (3 do 6 polaznika) na navigacijskim simulatorima Pomorskog fakulteta u Rijeci. Na temelju rezultata, dobivenih neparametrijskim testovima za male nezavisne uzorke, utvrđene su određene značajne razlike obzirom na različito definirane podijele ispitanika.

KLJUČNE RIJEČI

ljudska pogreška, pomorske nezgode, izbjegnuta nezgoda, pomorski časnici

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