Analysis of the Correlation Between Casualties and Human Perception, Cognition & Decision-Making at Sea

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ABSTRACT
Analysis of maritime casualties conducted over the last 30 years showed no improvement in any aspect, and proved that the human factor is still dominant in most casualties.

To improve this situation, technology has been introduced to marine navigation an integrated navigation systems, however, this situation remains the same.

The collisions and groundings of ocean-going vessels continue to concern those within the maritime community, whose environment and livelihood are put at risk by such casualties. This concern does not stem from any proportional increase of such casualties with increasing trade, but from the disproportionate consequences of such casualties, in recent years and even after the application of the International Safety Management (ISM) Code.

The present research objectives are:

- Recognizing the human errors linked to the maritime casualties, i.e., collisions and groundings, before and after the application of the ISM Code.
- Determining the causal factors closely linked to those casualties, mainly, the special human factors including human perception and cognition.
- Helping officers on watch adjust to changes in the industry with a high priority given to education with great concentration on scientific background; training/retraining programs, especially emergency situations, human perception, cognition and decision-making.

1. Introduction

Situational awareness is the accurate perception of the factors and conditions that affect a vessel and crew during a defined period of time. More simply stated, it is 'knowing what is going on around the individual'.

At the level of the individual, situational awareness can be thought of as a mental model that an individual has of a given situation and time. Mental models develop from cues in the immediate situation and environment, e.g., location, speed, presence of hazard, as well as information from education, training and experience. In the absence of a complete set of cues for a given situation, fragmentary information is sometimes combined with mental expectations and integrated into the mental model.

The rallying cry that most of casualties were caused by 'human factors' led to the natural corollary which human, about 75 – 96% of maritime casualties are caused, at least in part, by some form of human error (Rothblum, 1999). The resulting quest for a human to blame has become a raison d'etre of many investigation systems. Such systems have found this a convenient stop rule, i.e., once the expected outcome dictated by the human factors injunction has been satisfied, the investigation need proceed no further. Sadly this line of investigation has not prevented some of the most notorious casualties of modern times such as the "*Herald of Free Enterprise*", the "*Estonia*", the "*Exxon Valdez*" and more casualties after the application of the ISM Code and STCW 95, such as "*Erika*", "*Norwegian Dream",* "*New Carissa*", "*Prestige*" and recently "*Rocknes*".

A major perspective in approaches to risk assessment has been centred on quantification in terms of probability. But this approach does little to explain the social/behavioural influences on risk. There have been major contributions to this area of risk assessment in the work of Turner, (1978) and Douglas, (1986), but the area is still clearly underdeveloped. Both Turner and Douglas offer useful frameworks in terms of a social-anthropological approach.

Jackson and Carter, (1992) are concerned at the epistemological level and they attempt to assess the potential contribution of post-structuralist epistemological theory to understanding the social construction of risk assessment. In particular, on the basis of the maxim that the greatest levels of information are contained within those events which are least probable, they consider how this body of theory offers ways of expanding consideration of risk which legitimates inclusion of elements which enhance potential for information, as well as those which enhance meaning (cf. on the relationship between information, meaning and probability, (Robbe-Grillet, 1977; Cooper, 1981).

As investigated by Jackson and Carter, (1992) their interest is in the failure to perceive causal relationships that lead to system failure. The concept of system used here can be seen in an ordinary language or its more rigorous scientific sense, but it is used, generically, to refer to a set of interrelated activities which function for a specific purpose.

2. Classification of Maritime Casualties and their Causes with Emphasis on Human Error

2.1 Analytical Study and Cause Relationships of Collisions and Groundings of Vessels

In this analytical study the researcher intends to look into the causes of maritime casualties centering around collisions and groundings as well as the relationships between the causes of casualties and such factors as deficiencies in education, training and ship operating skills of OOWs, based on the actual shipping casualty records of the world before and after the implementation of the ISM Code (Hanafi, 2003).

In comparison with the previous analytical studies, a series of maritime casualties that occurred to bulkers, tankers, ferries and passenger ships worldwide over the period throughout 1995 to 2002 has brought the nature of these terrible disasters to the forefront of international concern as issues having a serious impact on the world's natural environment.

The researcher found, after more than 20 years, and even after the application of the ISM Code and the STCW 95 convention, through a classification of maritime casualties and their causes with emphasis on 'human error', that the same common causal factors remain nearly the same.

2.2 Statistical Survey of Collisions and Groundings for Ocean-Going Ships for the Period (1995-2002)

Figure (1) presents a summary of the number of collisions and groundings as one group for each year within the specified period. In addition, separate Figures are given for the two individual types of casualty.

The graph is only approximately accurate seen in proper relation to the number of vessels that have been actually exposed to the risk of

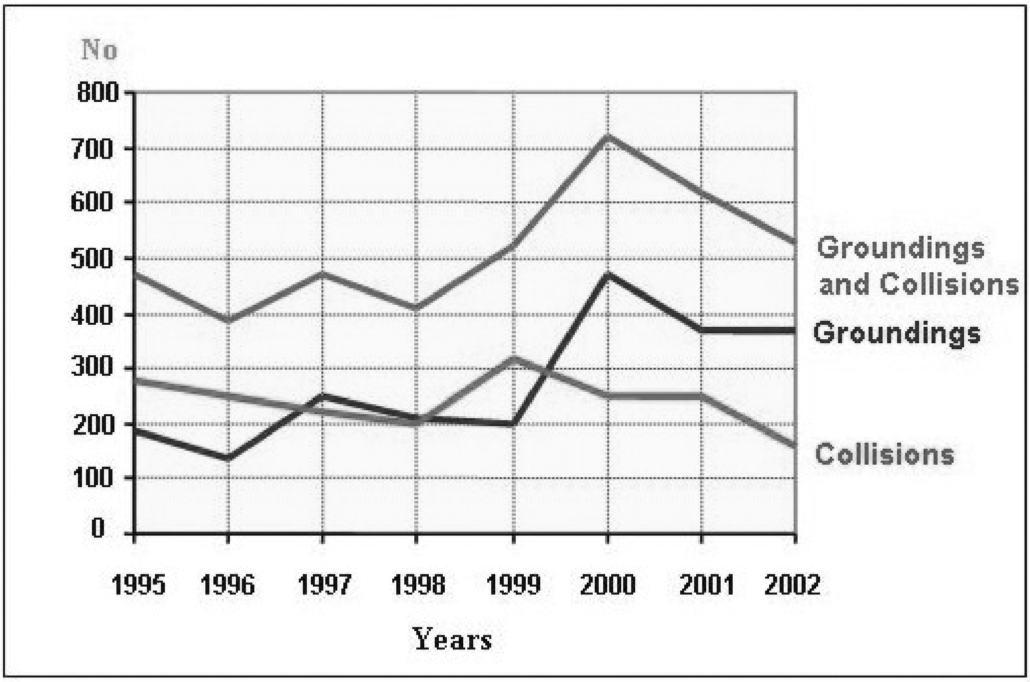

Figure (1) Yearly Distribution of Collisions & Groundings of Passenger Ships, Tankers and Bulkers.

collisions and groundings in each of the years.

2.3 Overview of the Causal Factors

The total sum of casualties and registered causal factors in Table (1) is 4258 and 8416.

According to the Table there is on average more than one cause registered per casualty and there are 21 groups of causes broken down into more detailed causal factors.

2.4 Analysis of Causal Factors and Situation-Dependent Factors For the Period (1995-2002)

Finally, from the analysis of this research, a discussion here of the most critical problems concerning the "human errors" resulting from causal group (V) 'Special Human Factors - Human Perception/Cognition Factors', which represent the highest percentage, and how to react to this essential factors at sea.

The four largest groups are among the most important for all casualty types are:

V.	**Special human factors – Human Perception/ Cognition factor.**	**19.3%**
R.	**Navigation and maneuvering factors applicable to personnel on own ship.**	**14.7%**
X.	**Knowledge, experience regard navigator.**	**11.7%**
N.	**Watchkeeping situation.**	**10.1%**

Table (1) Causal Groups / Casualty Type (1995-2002)

Causal Groups		Total	Collisions	Groundings & Strandings	Contact Damages
A	Faults in equipment in the bridge	132	49	58	25
B	Bridge design and arrangement	51	25	18	8
C	Serviceability of navigation aids	83	26	56	1
D	Remote control of steering and propulsion	131	53	42	36
E	Failure or deficiency in communication equipment	57	31	17	9
F	Errors or deficiencies in charts or nautical publications	128	18	82	28
G	External conditions which reduce the efficiency of navigational aids	159	31	113	15
H	Faults or deficiency in other ship	89	86	3	0
I	Fault deficiency or misleading information from lights and marks	117	7	96	14
M	Bridge manning and organization	585	202	325	58
N	Watchkeeping situation	850	320	503	27
O	Poor communication / internal	445	153	279	13
P	Reduced visibility	325	147	158	20
Q	Manoeuvering factor to own ship	675	100	465	110
R	Navigation and manoeuvering factors-applicable to personnel on own ship	1235	570	634	31
S	Operating of equipment -own ship	103	28	60	15
T	Information from fixed objects (lights, landmarks)	77	2	68	7
U	Wrong appreciation of traffic information	99	81	14	4
V	**Special human factors**	**1625**	**640**	**935**	**50**
X	Knowledge, experience with regard to navigator	985	427	528	30
Y	Casualty related to personnel on the other ship	465	425	15	25
Registered Causal Factors		**8416**	**3421**	**4469**	**526**
Number of Casualties		**4258**	**2104**	**2018**	**136**

3. Maritime Casualties Caused by Special Human Factors

From the analysis of previous casualties in four years period before and after the implementation of the ISM Code, it was found that in average 18.25% and 21.25% increase, respectively, of the casualties are attributed to 'human error' resulting from causal group (V) 'special human factors'.

This requires systematic scientific analysis in order to explore varied aspects of 'human perception' as a factor of casualties that are classified into:

- Non-perceived risk: unable to perceive how quickly the situation is changing and risk is developing, (Risk Assessment).
- Violation of spatial conditions.
- Non-epistemological factors, i.e., requirements of navigational accuracy depend on type of navigation: open sea, coastal and inland navigation.
- Inability to determine the proper ship's speed in dangerous conditions.
- Lack of scientific knowledge and facts necessary for apprehending the situations.
- Poor information analysis leading to wrong decision-making**.**

4. Perception and Reaction at Sea Problem

As indicated by Lussier, (1990) the term perception refers to a person's interpretation of reality. Through the perception process man selects, organizes, and interprets all environmental stimuli through his senses. No two people experience anything exactly the same through this perception process. Man's perception is influenced by heredity, environment, and, more specifically, by his personality, intelligence, needs, self-concept, attitudes and values. Some of the biases affecting perception include stereotypes, frame of reference, expectations, selective exposure, interest, and projection.

As an initial guide we take the following definition:

> "*Perception is the active psychological process in which stimuli are selected and organized into meaningful patterns*", (Huczynski and Buchanan, 1991).

5. The Perception of Risk

As studied by Jackson and Carter, (1992) the formulation of human cognition and the acquisition of knowledge highlights very clearly the enormous difficulty in assessing whether, and if so, to what extent, risk is present in any particular set of conditions. Obviously, it would be a considerable advantage to be able to specify the nature of the relationship between data and meaning, between signifier and signified.

Thus, suppose that the data set under consideration are a ship moving at speed into an ice field. In the case of the "*Titanic*", at the time, this was perceived as no-risk, but events showed that it was in fact a situation of very high risk. If a metaphorical approach is added to this negative feedback, it might reasonably be reformulated, at the level of principal as a problem of two objects moving relative to one another and trying to occupy the same space at the same time. Thus, the question to be asked might be, in what other data sets, which might not contain icebergs but which do contain two subjects, might the same effect be produced?

Conversely, in the case of "*Exxon Valdez*", the OOW couldn't deal with two problems happening at the same time with two different dimensions (collision with ice or grounding), i.e., a risk above the water and a risk below the water, in other words, he couldn't perceive the risks. He chose to avoid some patches of ice that were not dangerous instead of monitoring below the surface.

Risk is a human problem. System failure inevitably stems from human action, when the people involved in operation of a system fail to perceive some sets of conditions that might arise and cause the system to fail.

Preventing specific system failure requires the perception of system conditions that will cause failure. While learning from maritime casualties and their system failure undoubtedly contributes to enhancing system security, its utility is circumscribed by the epistemological conditions of cognition. Thus, because of our intrinsic limitations as information processors, we have to filter out a proportion of the available information that is perceived as irrelevant, using only that which is perceived as relevant for decision-making purposes.

As studied by Ashby, (1970) perception is influenced by non-epistemological factors and that this is an irreducible condition; it seems exceedingly poor. But there may be ways to ameliorate this depressing scenario. Whereas conventional monist understandings of systems where system failures have occurred have clearly failed to include potentially relevant formulations of explanation by virtue of their lack of authority, deconstructionist approaches deny the authority of a single interpretation and thereby permit any reasonable interpretation to be included. This expansive pluralist approach gives better chance that all relevant information will be discovered and, given that such claims of relevance can be judged and tested in terms of explanatory power, the possibility of identifying causes of system failure should be considerably enhanced.

The truth is the whole system, not any model of it. Thus the models of the system, whichever system may be in question, with which we work are fundamentally ideological, i.e., non-epistemological in that they derive from opinion rather than fact, (Ashby, 1970).

Some may take it to mean atmospheric and sea conditions, while others may take it to mean atmospheric conditions only. The use of the qualifier 'at master's discretion', which is often appended to the limitation further calls into question the effectiveness of such limitation, such as the grounding of "*New Carissa*".

The master's perception of risk is tempered usually by his previous exposure to similar conditions in over his previous years of operating his vessel in the same area. The master understood neither the serious shortcomings of the vessel's condition (with regard to watertight integrity) nor the effect that the strong wind would have on his vessel; he overestimated the ability of his vessel to withstand the head-on encounter with waves, and under estimated the result of shipping water, such as the sinking of the "*Erika*".

6. Decision-Making under Complexity and Uncertainty

In practice, ship safety is not merely a matter of track keeping, which can take care of fixed or known constraint. In the real world environment, other constraints are found such as traffic, currents, regulatory measures, and from time to time, uncharted obstacles which limit the degree of control and vary the ongoing objectives in real time. The capacity of the navigator, whether master, watchkeeper or pilot, to invoke these into the decision process will influence the likelihood of casualty.

Decision-making is the penultimate stage in processing a problem, lying as it does just before the taking of action in a typical event. Many decisions can be taken easily even by inexperienced novices in the maneuvering context as has been demonstrated by Schuffel, (1987).

At other times, decision-making in complex conditions can be represented by the two ends of a continuum where, at the one extreme, the situation is obviously complex and difficult to resolve in real time, and at the other extreme, the situation appears to be simplistic, but careful analysis reveals the existence of complex uncertainties. The two extremes are illustrated by the collision of the "*Norwegian Dream*" and "*Ever Decent*". In this case, the collision can be considered to be a confounding factor in the decision-making environment and the presence of land was a lack of perception and cognition.

7. Managing of Risk

The concept of managing risk is not new, even to the shipping industry. It has been practiced formally and informally on board ships from time immemorial by means of standing orders and established working practices. When a master or a chief engineer writes in the night order book 'call the master in case of fog' or 'call me 30 minutes before standby', they are managing risk. Unfortunately these working practices have been allowed to deteriorate to the extent that, in some cases, they have disappeared completely. The reason for their disappearance is purely because the people on board ships have by and large not been trained adequately.

By analysing the maritime casualties which occurred, specially the major casualties since the "*Titanic*" disaster to the recent "*New Carissa*", and after the application of the ISM Code it was found that 'special human factors', i.e., human perception and cognition were common factors in all those casualties.

8. Major Cases of Casualties Related to Relationship between Human Perception, Cognition and Decision -Making

8.1 The Collision / Sinking of the Cruise Ship "Titanic"

On 14 April 1912, the white star liner "*Titanic*", in the hours of darkness whilst in the vicinity of a known ice field, sailed at full speed into an iceberg. The ship, which was on her maiden voyage, sank in approximately 2 hours and 40 minutes and out of a total of 2201 passengers and crew only 712 were saved, (Eaton, 1987).

- ***Salient Features***

- From 0900 to 2140, "*Titanic*" received a total of six separate ice warnings described an area of ice 78 miles long. Unfortunately, there is doubt about whether the messages were ever delivered to the bridge or plotted on the chartroom map. Apparently not, since no one seems to have made the connection.

- At 2340, an Iceberg hidden beneath the surface, bumped and scraped the starboard side of the ship for a distance of 248 feet. [This iceberg is thought to have been the one responsible for sinking the "*Titanic*"].

- The "*Titanic*" was believed by many to be unsinkable, although the designers did not assume was that this was the case. However, as the builders' representative, who was also the designer, and the captain both perished in the disaster, one can assume that key actors in the design and operation of the *"Titanic*" were not expecting it to sink.

- Within 20 minutes of the collision, the designer came to the conclusion that it was inevitable that the "*Titanic*" would sink quite rapidly, (Wreck Commissioner's Report-1912, 1990; Eaton, Haas and Hutchings, 1987).

- ***Accident's Results***

- Clearly, from a rationalist point of view this is problematic. The rational solution is to identify such non-epistemological attenuation and replace it with attenuation based on scientific knowledge.

- This case is precisely analogous to the approach to prevention of system failure and risk assessment that uses negative feedback from a failure to prevent recurrence.

- Yet it is the utterly fundamental and ubiquitous process of attenuation itself that casts doubt on the potential of this case to make negative feedback effective in eliminating risk.

- This ability also depends on how the

problem which caused system failure is defined, which is also influenced by processes of attenuation and the associated non-epistemological factors.

- In this case, the first objective was satisfied in the replacing of the non-epistemological fact that the "*Titanic*" was unsinkable, with the scientific fact that all ships could sink.

- In the case of limitation of cause, the results have been rather different. For the sake of argument, we can suggest two vastly different conceptualizations of the cause of system failure: did the "*Titanic*" sink because it hit an iceberg at speed, or because it violated the physical 'law' that two objects cannot occupy the same space at the same time. If the former is perceived as prime cause then negative feedback can be said to have been remarkably effective in preventing similar occurrences.

- This case has not prevented other ships sinking, grounding or colliding, which also violated the spatial conditions.

- In terms of the latter specification of perceived cause, operating at the level of principle, and which enables extension by analogy to myriad other causes of ships sinking, it may have been less effective, perhaps demonstrating the limitations on the potential of negative feedback to operate efficiently.

- Certain things were done to avoid repetition of the "*Titanic*" disaster. Even this has not prevented ships from traveling at speed in dangerous conditions, (Turner, 1978 on the collision between the MV "*Redthorn*" and the MV "*Efpha*" in 1971).

- Even given a means of rationally defining causes that might overcome the tendencies of attenuation, it could still be argued that the idea of replacing non-epistemological influences with scientific knowledge is utopian, though this should by no means constitute a reason not to pursue it, Fig. (2).

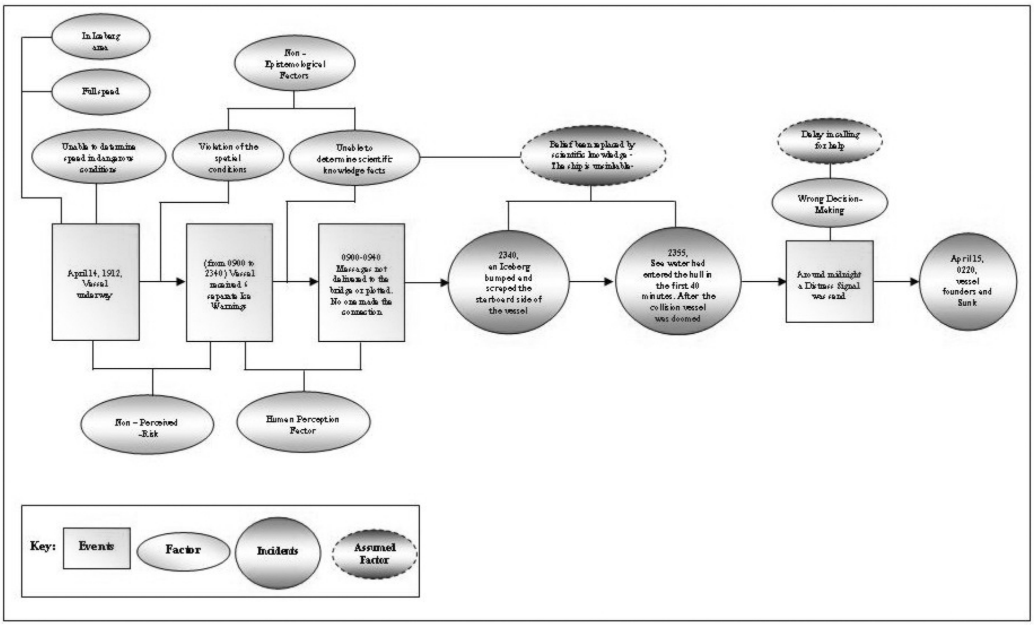

Figure (2) Roadmap to the Collision/Sinking of "Titanic" - Events and Special Human Casual Factors Chart

8.2 The Grounding of the Bulk Carrier "New Carissa"

On 4 February 1999, during an accurately forecasted winter storm, the 639-foot, Panamanian registered, bulk freighter M/V "*New Carissa*" ran aground on the shore north of the entrance to Coos Bay, Oregon, (NTSB, 1999).

- ***Salient Features***

- At 1900, the "New Carissa", using its port anchor and seven shots of chain (630 feet) eventually anchored in sand, approximately 1.7 n.m. off the beach.
- The wind at this time was from the south-southwest at 31 knots and the swell was approximately 12 feet from the west-southwest, capped by 5-foot wind generated waves.
- The latest national weather service forecast predicted the winds to moderate overnight with the seas to increase in height.
- 1930, the third officer plotted the ship's position using a single radar bearing and range off the end of the north jetty of the Coos Bay Entrance Channel.
- The master placed an anchor drag circle on the chart that was 200 yards larger than it should have been. A drag circle provides a means to readily determine if the ship's anchor is holding properly.
- The plotted positions of a vessel at anchor should remain within the drag circle, generally near its edge as the ship swings (weathervanes) in relationship to changing wind and swell direction, Fig. (3).

- ***Accident's Results***

- The grounding was a result of the master's ill-fated decision to anchor the "New Carissa" 1.7 n.m. from shore, in a gale with forecasted weather conditions calling for rising seas. These seas eventually caused the vessel to drag anchor on the morning of 4 February.
- A contributing factor to this event was the master's imprudent approach to anchoring. He chose to use only one anchor and did not layout more anchor chain as would he expected for the environmental situation.

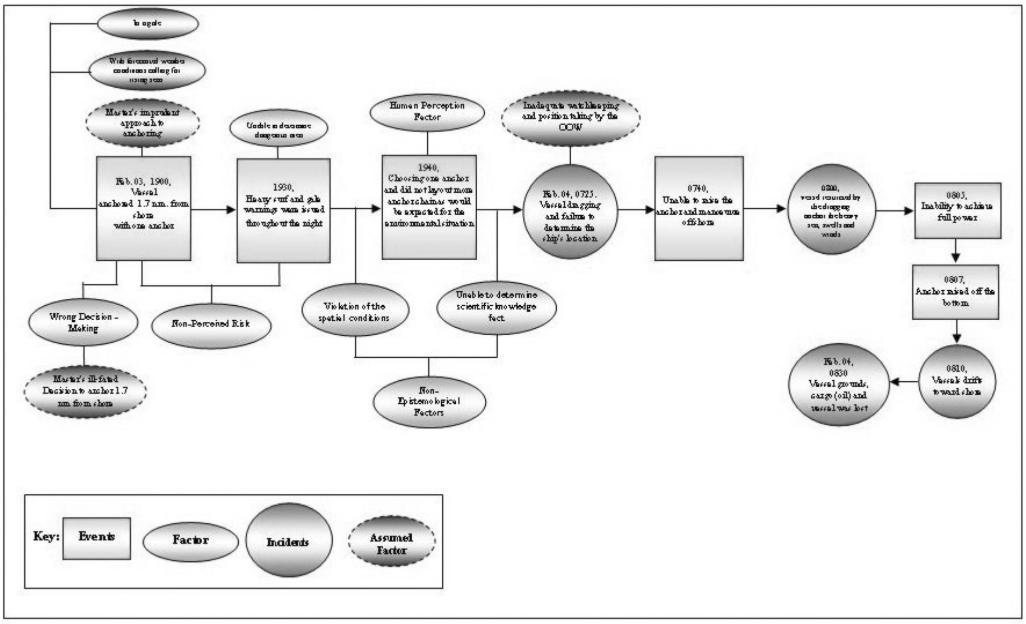

Figure (3) Roadmap to the Grounding of *"New Carissa"* - Events and Special Human Vasal Factors Chart

- Inadequate watchkeeping and position-taking by the ship's OOWs, in combination with an improperly sized anchor drag circle placed on the navigation chart by the master, delayed discovery of the ship's unintended movement.

- There is evidence of negligence on the part of the master of the "New Carissa" in deciding to anchor off Coos Bay, Oregon. The decision not to remain underway ultimately resulted in the vessel going aground.

- The master of the "New Carissa" made an error in judgment regarding how he chose to anchor the vessel. He had available additional chain, a second anchor and the ability to motor ahead slowly in an effort to reduce the strain on the chain while anchored.

- There is evidence of negligence on the part of the ship's OOWs in their watch standing. The chief officer and third officer used only one reference point to ascertain the vessel's position, even as the environmental conditions deteriorated, they failed to effectively monitor the vessel's position, to maintain accurate records of their watches, to heed the forecasted weather, and to immediately determine that the vessel was dragging.

- It is possible that the vessel had been dragging slowly for quite awhile and that the master, if given more warning, could have taken better preventive measures.

- Over the next several days, the "New Carissa" gradually worked her way closer to shore, where, on the night of 8 February, she broke into two sections.
- In this case, it was found that the same 'special human factors' were common factors, i.e., attenuation and the associated non- epistemological factors.

Finally, this case is a classic one and proves the relationship between the human perception/ cognition factors and the OOW's decision-making when casualties occur.

9. Conclusion

The statistics and analysis of previous and recent casualties from 1995 till 2002, before and after the application of the ISM Code, reveals any slight improvement in the aspects of collisions and groundings problems.

It is proved that the human factor is still dominant in most of these casualties. Also, it shows no change of the human factor percentage after the application of the ISM Code. In this respect, more deep analysis of the human factor has been done.

Problems resulting from maritime casualties at sea cannot be solved only with regulations or rules as suggested by the ISM Code.

The problems can be identified by following a concept of science and new analysis system.

Following that, the OOW have to go through steps starting from measuring precisely the data and process to get useful information. At the same time he must be able to find the multi solutions and to decide the optimum action (good decision-making).

This research has made an initial breakthrough into the integration of qualitative special human factors as a tool for investigation and analysis of casualties, i.e. collision and grounding.

The measures proposed need to be validated, initially, in the real life situation. A deep framework for understanding such special human factors needs to be developed and field-tested. A framework for the integration of human perception, cognitive thinking and decision-making research into the casualty investigation regime needs to be developed and a uniformity of practice worldwide needs to be established.

Amount of technological innovation can replace the common sense, experience and training of a professional crew, i.e., training in perception, cognition and decision-making. Great concentration on improving the cognitive thinking method to solve problems of multiple dimensions is vital.

To solve one of the most vexing challenges, preventing casualties and saving lives, the best safety device on any ship is a well trained crew by featuring emergency situations and casualties simulations, i.e., real situations which have caused ship casualties.

In conclusion, people who do not deal with emergencies on a routine basis are seldom aware that emergencies require immediate decisions and actions on the scene.

Finally, good training is not a luxury in international shipping. It is essential in order to ensure that ships are run efficiently and that means safely and without harm to the environment. Great concentration on training of OOWs in such cases of emergency and perception in order to gain new skills is vital.

A comprehensive research in the area of maritime casualties will provide great understanding on decision-making training using a scientific method integrated with Maritime Information System (MIS) and the relationship between information analysis and human perception, cognitive thinking to take decisions.

10. Contribution

This research was intended to specify the mechanisms that precipitate casualties resulting in collision or grounding of ocean-going vessels, and to investigate the role of initiatives that carry the potential to interrupt the train of events that culminate in such a collision or grounding.

This has been achieved through the study of casualties, specifically investigated against the findings of human error derived from human perception, cognitive thinking and decision-making, through case studies of casualties worldwide.

The primary contribution of this work was expected to be the initiation of a groundwork for lifting the twin fields of shipboard navigation and casualty investigation from a qualitative poorly validated foundation to a qualitative scientific foundation which could be molded to be intrinsically self validating and capable of error flagging.

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BIOGRAPHY

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