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Human Element and Accidents in Greek Shipping

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The purpose of this paper is to analyse the significance of the human element in accidents involving Greek-flagged ships, during 1993–2006, worldwide. In this context, the human element as a general factor of accident initiation and most importantly its constituent components, in the form of specific onboard duties (functions) and/or off-board (mainly ashore) entities, were presented and analysed. It was found that 57·1% of all accidents were attributed to the human element, whereas 75·8% of the latter were detected onboard and 80·4% of the onboard human-induced accidents were linked to errors and violations of the ship's master. Furthermore, since the timeframe examined covers the implementation of the ISM Code, the current analysis was aimed at producing valuable information with regard to its effectiveness upon Greek shipping. In this respect, a 12·2% reduction of human-caused accidents has been found during the post-ISM period. Finally, the association between specific accident types and human element components was examined utilising the technique of correspondence analysis and it was found that groundings and collisions were closely related to the ship's Master, whereas mechanical failures and fires were associated with the engine officers, and cargo shifts and flooding with bridge officers.

KEY WORDS

1. Human element. 2. Shipping accidents. 3. ISM Code. 4. Greek shipping.

1. INTRODUCTION. According to the International Maritime Organization (IMO) "*the human element is a complex multi-dimensional issue that affects maritime safety and marine environmental protection. It involves the entire spectrum of human activities performed by ships' crews, shore-based management, regulatory bodies, recognised organisations, shipyards, legislators, and other relevant parties, all of whom need to cooperate to address human element issues effectively*"[1].

Research within the human element domain, apart from producing the statistics of human influence upon shipping accidents, has also focussed on providing the knowledge of why people make mistakes, thus proposing appropriate remedial action. Most of the initial research effort concentrated on demonstrating that shipping is a 'people system' and should be treated as such (Hetherington et al, 2006). This approach was also justified by the realisation that the relative impact of human error as an underlying source of accidents acquired increasing importance as various

[1] http://www.imo.org/HumanElement/mainframe.asp?topic_id=177

technical (structural and equipment) improvements were producing the expected safety benefits (Tzannatos, 2005).

However, the introduction of new and often complex technologies in shipping inevitably revealed the need to further optimise the onboard man-machine interface. In this context, human factor research in shipping produced valuable information towards the detection of weaknesses in this interface and paved the way to achieving an improved harmonisation of shipboard equipment and operators. (Grech et al, 2008; Mills, 2005; Whittingham, 2004; Baker et al, 2004; Tzannatos, 2002; Pomeroy et al, 2002).

In view of the acquired significance of the human element in shipping, the International Safety Management (ISM) Code was enforced in mid-1998 in accordance with IMO Assembly Resolution A.741(18) of 1993.[2] The preamble of the Code opens with the statement that: "*The purpose of this Code is to provide an international standard for the safe management and operation of ships and for pollution prevention*".

All articles of the ISM Code[3] are aimed at controlling human error in shipping, although some have more direct impact than others. More specifically, the article regarding the Master's Responsibility and Authority makes the company responsible for defining the Master's responsibilities in regards to implementing the company's safety and environmental protection policy, motivating the crew, issuing appropriate orders and instructions and reporting deficiencies to shore-based management. Furthermore, it states that management must clearly establish that the Master has overriding authority and the responsibility to make decisions with respect to safety and pollution prevention. This is very important because the Master directly experiences all incidents, therefore he should be able to freely but responsibly assess the developing situation and decide on appropriate corrective action. Similarly, on the direct control of human error, the article referring to Resources and Personnel obligates the company to ensure that all employees, both ashore and afloat, shall be appropriately trained and qualified to perform their duties and have an adequate understanding of the codes, guidelines and regulations relevant to marine industry management. This requirement inevitably leads to other ISM articles, which refer to the need for the company to establish procedures in order to identify, to describe and respond to potential emergency situations, as well as to maintain updated documentation (instructions, checklists etc) for the carrying out of critical and hazardous operations with regard to safety and pollution prevention. Therefore, the ISM Code constitutes the universal legislative measure on human-centred safety policy in shipping, through applying a process control procedure of "who does what and when", which is a fundamental prerequisite of any quality management system.

However, it is important to note that the preamble closes by stating that: "*The cornerstone of good safety management is commitment from the top. In matters of safety and pollution prevention it is the commitment, competence, attitudes and motivation of individuals at all levels that determines the end result.*"

Therefore, the pressure for continuous improvement of shipping safety and the inevitable delays and uncertainties involved in any effort aiming at changing people's attitudes and culture dictates the need for prompt and reliable assessment of the

[2] Compliance with the Code has been mandatory for tankers, passenger ships and bulk carriers since July 1998, under the first phase of ISM implementation, and since July 2002 for all other vessels covered by the SOLAS Convention, which includes all but the smallest vessels (< 500 gt).

[3] http://www.imo.org/includes/blastDataOnly.asp/data_id%3D23714/741%2818%29.pdf

implemented safety policy measures. In this context, the analysis of shipping accidents offers a widely accepted approach towards ISM Code assessment, the other being that of recorded deficiencies within the framework of inspections performed by MoUs on PSC[4]. In the latter approach, however, inconsistencies exist in reporting and administration between different MoUs, as well as amongst the signatory nations of each MoU. Furthermore, recorded deficiencies (and especially those of ISM relevance) are the result of an PSC inspector's opinion and are easily influenced by a host of subjective issues, such as the attitude of the crew, the ease of inspection, the inspector's mood etc[5]. On the other hand, with relevance to ISM Code assessment or otherwise, the analysis of shipping accidents provides a more objective approach and hence more reliable information for policy makers, shipping operators, ship designers, maritime educators, marine insurers and all the stakeholders of the shipping community. In this context, research by Psaraftis et al, 1998, and more recently by Akten, 2004, constitute indicative examples of in depth analysis of the human element as a factor in shipping accidents.

The current work provides an analysis of accidents of Greek-flagged ships worldwide over the period of 1993 to 2006, based upon the findings of formal inquiries conducted by the Hellenic Coast Guard. Its main objective is to capture the overall and functional (duty-based) influence of the human element in shipping accidents, utilising the fact that Greek shipping, by virtue of its size and diversity, as well as the timeframe examined, constitutes a reliable reference for such analysis.

2. ACCIDENT RECORD.

In terms of the accident information under analysis, it is important to note that the prerequisites for the launch of a formal investigation by the Hellenic Coast Guard are any of the following:

- Total or partial loss of a ship or floating structure.
- Ship or floating structure is taken-over by insurers.
- Permanent or temporary abandonment of ship by the crew.
- Cargo loss or damage (more than 25%).
- Prolonged loss of ship command due to serious failure.
- Loss of life or serious injury to a crew member or passenger.

For the purpose of the current analysis all accidents involving vessels under 500 gt (mainly fishing vessels, tugs etc) were discarded, since their reduced manning requirements would inevitably lead to a distortion of results with regard to the human element influence. Furthermore, ships under 500 gt are exempted from ISM Code compliance. On the basis of this criterion, the overall accident dataset consisted of 268 shipping accidents.

[4] Port State Control (PSC) is the inspection of foreign ships in national ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these rules. IMO has encouraged the establishment of regional port State control organizations and agreements on Port State Control – Memoranda of Understanding or MOUs – have been signed covering all of the world's oceans.

[5] http://maritimemarketresearch.com/Ten%20Years%20of%20ISM.html

Table 1. Vessel type, vessel age and type of accident.

Type of Vessel	No.	%	Vessel Age Group (years)	No.	%	Type of Accident	No.	%
GEN. CARGO SHIP	47	17·5	<9	26	9·7	GROUNDING	133	49·6
BULKER	89	33·2	9–22	84	31·3	TECH. FAILURE	77	28·7
CONTAINER SHIP	13	4·9	23–26	54	20·2	FIRE/EXPLOSION	26	9·7
TANKER	56	20·9	>27	104	38·8	COLLISION	11	4·1
CRUISE SHIP	4	1·5	—	—	—	FLOODING	15	5·6
RO-PAX	59	22·0	—	—	—	OTHER	6	2·2
TOTAL	**268**	**100·0**	**TOTAL**	**268**	**100.0**	**TOTAL**	**268**	**100.0**

Note: The GEN. CARGO vessel type includes three (3) Ro-Ro vessels.
The OTHER accident type covers arson, capsize and cargo shift.

3. PRESENTATION AND DISCUSSION OF RESULTS. According to the analysis of shipping accidents (Table 1), the most frequent type of accident was that of groundings (49·6%), followed by technical failures with a significant difference of occurrence (28·7%). The other accident types (fire/explosion, collision, flooding etc) accounted for 21·6% in total and were all individually under 10%. Bulk carriers suffered most accidents (33·2%), whereas general cargo carriers, tankers and Ro-Pax entered into the accident record at around 20%. In terms of age, the older (>27 years) and mid-aged (9–22 years) ships were involved in most accidents with 38·8% and 31·3%, respectively. The younger vessels (<9 years) suffered the least accidents (9·7%). With respect to vessel type and age these findings are as expected since they are in close proportion to the synthesis of the fleet administered by the Greek flag, whereas the dominance of groundings is in agreement with the picture of shipping accidents whether specific flag administrations or sea areas are analysed[6].

Further analysis into the accident record revealed that although all vessel types suffered primarily from groundings, technical failures and further down fires/explosions followed with particular significance in the case of tankers and Ro-Pax vessels. Also, the dominance of groundings was found to be irrespective of vessel age, whereas technical failures were more profound in the higher age group. These findings are related to the extent and complexity of the technologies as well as cargo/passenger vulnerabilities present in the above mentioned vessel types, in conjunction with their increasing significance with vessel age, hence ageing failures of structure and equipment.

On average, during the period 1993 to 2006, the Human Element was found to be responsible for 57·1% of the investigated accidents, whereas Random Events, Unidentified Causes and Acts of God accounted for 31·1%, 7·9% and 3·9%, respectively (Figure 1). Furthermore, a significant share (78·5%) of the human element as a cause of accidents was detected onboard, whereas human causes ashore, as well as onboard and ashore (combined) covered 12·6% and 8·9%, respectively, of all the human-caused accidents. According to these findings, both the overall and the onboard presence of the human element as a cause of shipping accidents is lower than

[6] see: a) Reports on shipping accidents in the Baltic Sea area, by HELSINKI COMMISSION, http://www.helcom.fi/shipping/accidents/en_GB/accidents/, b) TSB Canada, Marine Occurrences, http://www.tsb.gc.ca/eng/stats/marine/

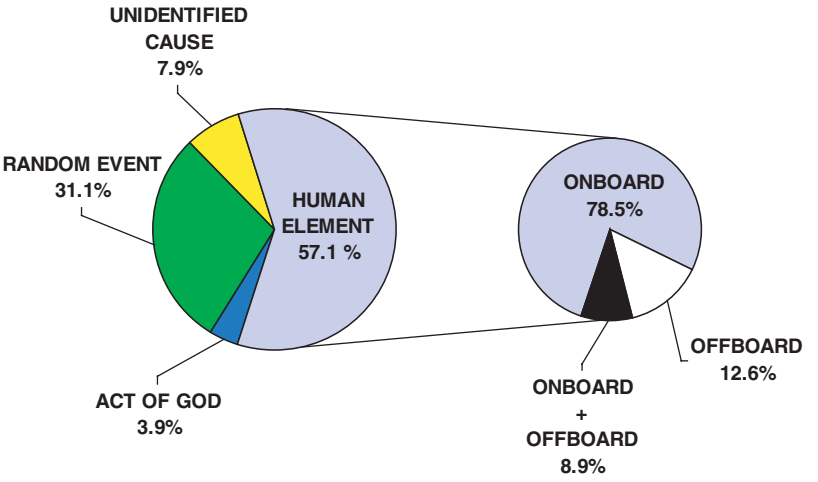

Figure 1. General and human causes of Greek shipping accidents.

the widely acknowledged statistics of 80% and 65%, respectively. However, it must be pointed out that the current analysis is based upon shipping accidents (as opposed to incidents) and the formal investigation procedure is thorough and cautious in allocating human responsibility for the accident, as this has dire consequences for the offender. Therefore, if the investigation did not produce firm evidence for a human cause of the accident, the accident accountability was shifted towards the other causes and mainly to random events.

With regard to the effectiveness of the ISM Code implementation in July 1998, it should be mentioned that the human-caused accidents of the pre-ISM period and post-ISM period averaged 63·9% and 51·7%, respectively. This 12·2% reduction in human-caused accidents, in conjunction with the adequate timeframe involved on either side of the ISM Code implementation point, provides a reliable indication of its positive impact upon the safety of Greek shipping (Figure 2).

On average, the ship's Master (solely or collectively) was found to be the accident cause in 43·1% of all investigated accidents, the remaining 14% making the overall contribution of all human causes (57·1%) coming from other onboard and/or off-board personnel and entities (Figure 3). With regard to the impact of ISM Code implementation, the presence of the ship's Master as a (sole or collective) cause of accidents was reduced from a pre-ISM average of 43·8% to a post-ISM of 42·5%. This reduction of 1·3%, in conjunction with the corresponding reduction of 12·2% of all human caused accidents, indicates that the ISM Code was mostly effective in the control and hence reduction of human causes other than the ship's Master. More specifically, the reduction of human causes in the post-ISM period was mainly related to the reduction of errors and violations performed by engine officers, crew and shipping companies.

As shown in Figure 4, amongst the accidents due to onboard human causes, the ship's Master was involved in 80·4% of the accidents (either solely or collectively), whereas the engine officers, bridge officers and crew followed with 8·1%, 6·8% and 4·7%, respectively. Furthermore, within the group of accidents involving the ship's Master, he was found to be solely responsible in 85·6% and collectively (with engine

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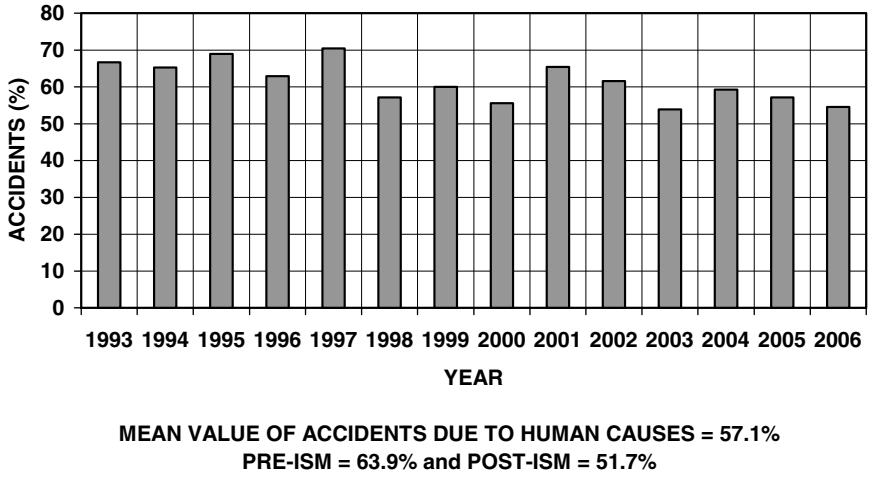

Figure 2. Histogram of human element as a cause of Greek shipping accidents.

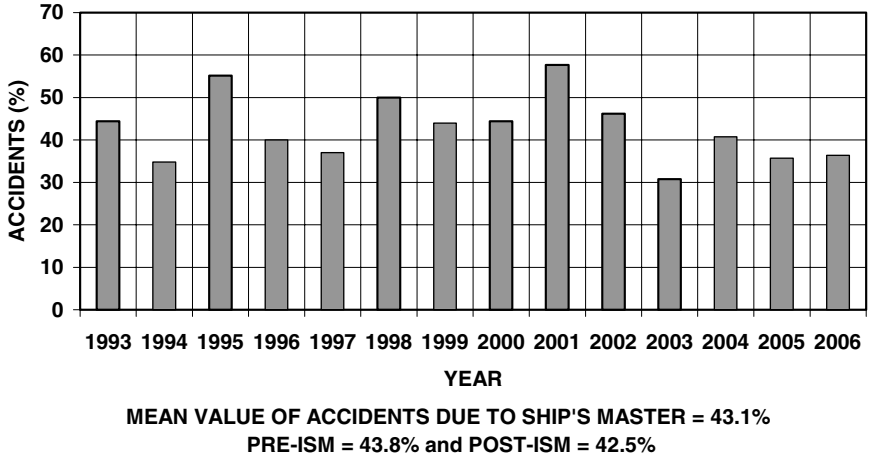

Figure 3. Histogram of accidents caused by the ship's master.

officers, bridge officers and other onboard personnel) in 14·4%, of these accidents. Therefore, the ship's Master was solely responsible for 68·8% (85·6% of 80·4%) of all accidents due to onboard human causes. The overwhelming presence of the ship's Master as an onboard cause of accidents may be anticipated, due to his expected involvement in the highly occurring groundings (49·6%). Similarly, engine officers, whether solely or collectively (with the ship's Master), were bound to follow as an onboard cause of accidents, since it is very likely that they are responsible for the other types of highly occurring accidents, namely technical failures (28·7%) and fires/explosions (9·7%).

The off-board human causes represent those allocated outside the ship that suffered the accident. Within this group of accident causes, port and pilot operations were predominant with 35% and 25%, respectively, followed by piracy/terrorism,

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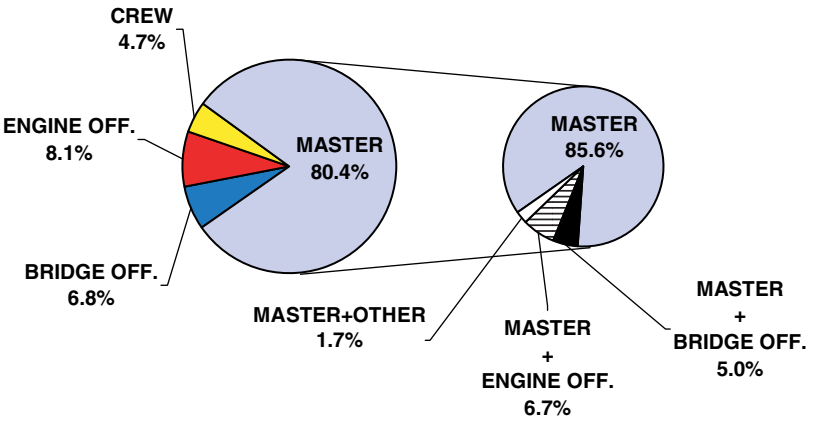

Figure 4. Specification and distribution of onboard human causes.

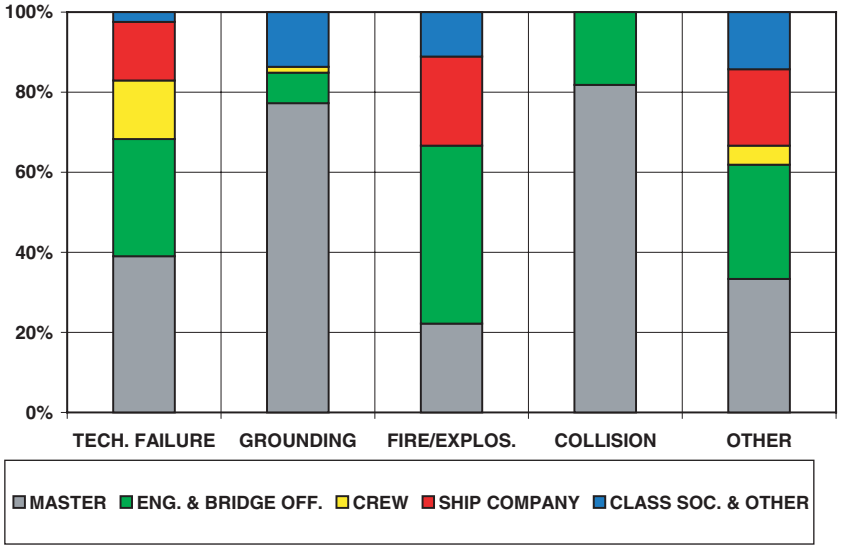

Figure 5. The participation of human causes in accident types.

classification societies and shipping companies. Furthermore, in the case of accidents due to the combined influence of onboard and offboard causes, the combination of shipping company, classification society and ship's Master was found to be the most prevalent occupying 24%, whereas the shipping company and engine officer as a combined cause followed with 12% of these accidents.

Figure 5 presents the participation of specific human causes (onboard and/or offboard) to specific accident types. The ship's Master was found to be the main cause of groundings and collisions, whereas engine and bridge officers have caused many technical failures, fire/explosions and other types of accidents. Furthermore, whereas collisions and groundings were primarily caused by onboard (and mainly navigational) causes, the other types of accidents (technical failures, fire/explosion,

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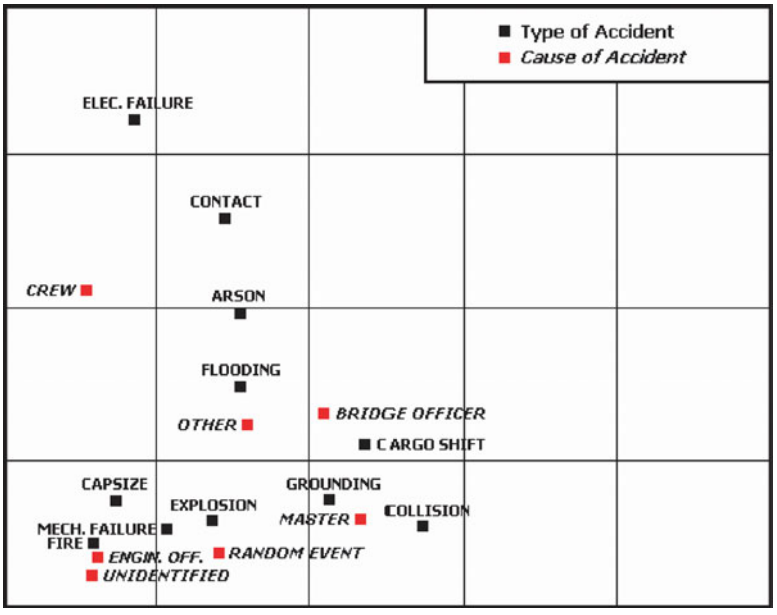

Figure 6. Association of accident types with accident causes.

capsize, cargo shift etc) included the operational shortcomings of the shipping company, classification society and other ashore entities such as shipyard, port, etc.

These findings were also supported through the application of "Correspondence Analysis"[7] in an attempt to capture the unbiased association between all accident causes and accident types (Figure 6). It was again revealed that groundings and collisions were very closely associated with the ship's Master, whereas mechanical failures and fires were associated with the engine officers and cargo shifts and flooding with bridge officers. It is also important to note that the widely acknowledged complexity of investigation into explosions, fires and mechanical failures often led to their association with random events and unidentified causes. Furthermore, it was found that the ship's crew was associated with electrical failures, contact, flooding and arson. According to this presentation, within the domain of other causes most of the offboard (ashore) accident sources reside and they were found to be associated with most types of accidents together with the onboard causes already mentioned.

4. CONCLUSIONS. The analysis of accidents in Greek shipping between 1993–2006 revealed that groundings followed by technical failures dominated the record of safety, whereas the older vessels suffered most accidents. Furthermore, despite the significant reduction of human causes after the ISM Code implementation in mid-1998, the human element remains the main cause of accidents. In

[7] "*Correspondence Analysis*" is an exploratory method of data analysis that visually displays relationships between categorical variables. Small distances between points indicate high association, while large distances indicate low association. One of the major benefits of correspondence analysis is that it provides a multivariate representation of interdependence for non-metric data, which is not possible with other methods.

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terms of the human element analysis, the ship's Master was found to be overwhelmingly the prime cause of accidents in Greek shipping and in most cases he was found to be the sole one too. The ship's Master was less affected by the ISM Code, whereas the beneficial influence of this legislative measure was found to be in the control of operations regarding engine officers, crew and shipping companies. In terms of the association of accident types and causes, the ship's Master was found to be responsible for almost all of the very frequently encountered groundings (inc. collisions), whereas most mechanical failures and fires were caused by engine officers, and cargo shifts and flooding by bridge officers.

Finally, it is considered that the current analysis contributes to the human element research in shipping, as it reveals where the weaknesses of shipping safety lie and indicates where further persistence in support of human operations is necessary. In this context, all the ongoing research and development focussing on improving ship's navigation and aiding the ship Master's command is of the utmost importance to shipping safety.

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