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Human Error Analysis in USA Marine Accidents Reports

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ABSTRACT

The analysis of accidents is the most useful instruments to avoid accidents. In the case of marine accidents, from a collision of a boat in a port to the wreck of a gigantic tanker ship, the study of the causes of the accidents is the basis of a large part of the marine legislation.
Some countries have official institutions who investigate the accidents in their shores or in which a ship with their flag is involved. In the case of the USA, the National Transportation Safety Board (NTSB) is responsible for these researches. The NTSB, after a deep investigation into each accident, publishes a Marine Accident Report with the possible cause or causes of the accident.
This paper analyses all the Marine Accident Reports published by the NTBS between June 1975 and April 2015, and focuses its attention in the human errors that led to reported accidents. In this research, the different human errors made by crewmembers are catalogued in 10 different groups.
After a complete analysis of all the reports, the statistical analysis on the human errors typology in marine accidents is presented in order to use it as a tool to avoid the same errors in the future.

1. Introduction.

"Shipping is one of the most risky service industries. Although shipping companies attempt to assure work safety, they are not completely successful in eliminating human failures" (Lu et al. 2012). This is a reality, and all the crew of the ships consider it, as do all shipping companies in the world.

From 1976, when a research board in U.K. said that the human error was the cause of 80% of accidents, (Goulielmos 1997), in most of the published studies on maritime accidents, we find among the conclusions that a large part of maritime accidents are caused by human errors (Berg, Storgärd, and Lappalainen 2013).

However, in many of these studies this conclusion remains there, without exploring what types of human error have caused the accident or without analyzing who caused these mistakes, whether the members of the crew or other parties involved.

This article presents the conclusions obtained from the analysis of 161 maritime incidents in the USA from 1975 to 2015. From this analysis, a typology of human errors is extracted to classify the different types of these errors that have played a decisive role in the cause or causes of these accidents. In addition, these errors have been counted up to see which are the most common ones.

The analysis also serves to provide an additional tool for shipping companies, training centers and maritime authorities to prevent the errors that are the cause of many accidents in the maritime industry.If there is more than one author, it will be necessary to signal with a * the author to whom correspondence should be addressed, his phone and email address.

2. Literature Review

For several decades, many researchers and analysts have published studies on the causes of maritime accidents, focusing both on technical aspects that have been played a role in the accidents and on the errors of the people involved in the work on a ship (crew, ground personnel, pilots, inspectors, etc.).

Many of these studies try to determine in how many accidents there has been a human error as the main cause or as an

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added element.

As an example of these works, we can highlight here some of them:

- "Of a total of 880 accidents analyzed during the investigations between 2011 and 2015, 62% were attributed to erroneous human action." (EMSA 2016).
- "Over 80% of marine accidents are caused or influenced by human and organization factors." (Apostol-Mates and Barbu 2016).
- "Many of the ship accidents (60%) result from human error." (Sercan Erol and Ersan Başar 2015).
- "It is generally stated that 80% of all accidents at sea are as result of human error. In fact, it is probably more correct to say that all accidents at sea are as a result of human error because, no matter how much automation is introduced into the design or operation of a ship or its systems, there is always a human input." (Square et al. 2015).
- "Despite advances in technology, some 80% of all accidents are, according to studies, caused by human errors." (Berg, Storgard, and Lappalainen 2013).
- "It is therefore not surprising that it has been estimated that approximately 80% of shipping accidents are caused by human errors in all phases of the process." (Guedes Soares and Teixeira 2001).
- "Between 75% and 96% of maritime accidents are caused at least in part by some form of human error." (Rothblum 2000)
- "80% of maritime accidents are attributable to human error" (Mitchell and Bright 1995)

Human error is an incorrect decision, a correct but improperly made decision or an omission of action when it should have been done. In the maritime domain, according to the Maritime Transportation Research Board of USA, human error is "the commission or omission of acts by maritime personnel that cause or contribute to merchant marine casualties or near-casualties" (NAS 1976).

We can see, in the references above, that, despite the discrepancy in the percentage, there is unanimity in the studies carried out on the attribution of human error as the main cause of marine accidents.

However, few studies make an exhaustive classification of the categories of human error that influence a maritime accident.

For example, for Maritime Transportation Research Board of USA in the cited research, the following 14 factors are the causes of casualties:

- Inattention.
- Ambiguous Pilot-Master relationship.
- Inefficient bridge design.
- Poor operational procedures.
- Poor physical fitness.
- Poor eyesight.
- Excessive fatigue.
- Excessive alcohol use.
- Excessive personnel turnover.
- High level of calculated risk.
- Inadequate lights and markers.
- Misuse of radar.
- Uncertain use of sounds signals.
- Inadequate rules of the road.

About this classification, the investigators considered "workplace factors, procedures, fatigue, health and management into consideration" (Kristiansen 2005).

In an article published in October 2000 in "Professional Safety" entitled "Management of Human Errors in Shipping Operations" (Wang and Zhang 2000), the causes of human error are classified into:

- Lack of knowledge and experience.
- Overconfidence.
- Recklessness in responding to commercial pressures.
- Fatigue (related mainly to collisions).
- Discomfort, boredom, anger, unhappiness, illness, confusion and lack of adequate communication.

In other article published in 2013 in "AMET International Journal of Management" entitled "A Study on Human Errors and Classification of Commonly Prevalent Errors in Shipping Operational Practices" (Suraj, Ramanad, and Bina 2013), the authors set this identification of human errors in shipping industry:

- Fatigue.
- Inadequate communication.
- Inadequate general technical knowledge.
- Inadequate knowledge of own ship systems.
- Lack of situation awareness and complacency.
- Test of suitability.
- Decisions based on inadequate information.
- Faulty standards, policies, or practices.
- Poor maintenance.

- Hazardous natural environment.
- Complacency - a state of mind.

As we can see, these classifications are too wide if we want to analyze the actual causes of maritime accidents.

Carl Macrae, in his paper "Human factors at sea: common patterns of error in grounding and collisions" (Macrea 2009), give us a more concrete analysis of the classification of the mistakes made by the crew of the ships evolved in this kind of accidents. In this paper, the author conclude that the most common mistakes in groundings and collisions are: planning errors, position finding errors and communication errors.

About the same subject, Graziano, Teixeira and Guedes Soares, in a paper about the classification of human errors in grounding and collision accidents (Graziano, Teixeira & Guedes Soares 2016), conclude that in almost a 69% of these accidents main users task errors were related to navigation, supervision and traffic monitoring.

Considering the numerous literature on the influence of human errors on marine casualties, it is clear that there is a great majority of accidents whose cause is human error. In addition, many of these accidents can be easily avoided taken care in the behavior of individuals and organizations (Hetherington et al. 2006).

However, it is important to study whether these errors were committed by members of the crews of the damaged ships or were also errors committed by other people outside the crew, such as shore and port personnel, pilots, inspectors, shipyard personnel, etc.

This paper, based in a large sample of accidents, tries to determine what percentage of human errors were attributable to the crew, and also presents a detailed classification on the type of committed human errors.

3. Method.

In order to arrive at valid conclusions in this paper, it has been necessary to study a large number of marine casualties. For this purpose, the reports of marine accident of the National Transportation Safety Board (NTSB) have been used as a working tool. Finally, 161 accident reports were analyzed, involving 192 ships in these accidents.

First, these reports were classified according to whether or not there was human error of the crew in the cause, or causes, of the accident. They were also classified by type of vessel: merchant ships, fishing vessels, recreational boats and other ships.

Then, the types of human errors that can be committed by the crew members of a ship were classified into 29 descriptors. These descriptors were divided into 10 groups related to the different type of errors. In addition, for each report with human error of the crew in the causes of the accident, what kind of human errors had been committed within that classification was noted.

Finally, in which reports were reported human errors of other people outside the crew was also studied.

On the other hand, accidents were also divided between those that occurred until 2010 and from 2010. This was intended to study if there has been a significant change in the total number of accidents and in the causes of them in recent years.Below are listed the types of articles accepted in the JMR, in order to exemplify the structure of the second and third level subsections.

4. Results

The results obtained by type of vessel involved in the accidents analyzed are presented in the Table 1:

Table 1: Classification by type of vessel analyzed.

MERCHANT SHIPS							
	Ships	**Human error of the crew: Yes**		**Human error of the crew: No**		**Human error of others**	
General cargo:	5	4	80,00%	1	20,00%	2	40,00%
Tanker:	18	9	50,00%	9	50,00%	7	38,89%
Bulk carrier:	14	7	50,00%	7	50,00%	5	35,71%
Passenger ship:	32	12	37,50%	20	62,50%	11	34,38%
Container ship:	10	3	30,00%	7	70,00%	6	60,00%
Car carrier:	1	0	0,00%	1	100,00%		0,00%
Tugboats	37	22	59,46%	15	40,54%	7	18,92%
Ferry:	5	4	80,00%	1	20,00%	1	20,00%
Offshore / supply / lift boat:	12	6	50,00%	6	50,00%	4	33,33%
Dredges:	1	0	0,00%	1	100,00%		0,00%
Barges:	3	0	0,00%	3	100,00%	1	33,33%
Total Merchant Ships:	**138**	**67**	**48,55%**	**71**	**51,45%**	**44**	**31,88%**
MERCHANT SHIPS (only cargo and passenger ships)							
	Ships	**Human error of the crew: Yes**		**Human error of the crew: No**		**Human error of others**	
	80	**35**	**43,75%**	**45**	**56,25%**	**31**	**38,75%**
FISHING VESSELS:							
	Ships	**Human error of the crew: Yes**		**Human error of the crew: No**		**Human error of others**	
	32	**16**	**50,00%**	**16**	**50,00%**	**5**	**15,63%**
RECREATIONAL BOATS:							
	Ships	**Human error of the crew: Yes**		**Human error of the crew: No**		**Human error of others**	
	9	**5**	**55,56%**	**4**	**44,44%**	**1**	**11,11%**
OTHER SHIPS:							
	Ships	**Human error of the crew: Yes**		**Human error of the crew: No**		**Human error of others**	
Coastguard:	8	6	75,00%	2	25,00%		0,00%
Navy:	2	2	100,00%	0	0,00%		0,00%
Diving boat:	1	0	0,00%	1	100,00%		0,00%
Oceanographic:	1	0	0,00%	1	100,00%	1	100,00%
Sailboat:	1	1	100,00%	0	0,00%		0,00%
Total Others:	**13**	**9**	**69,23%**	**4**	**30,77%**	**1**	**7,69%**
Total Ships:	**192**	**97**	**50,52%**	**95**	**49,48%**	**54**	**28,13%**
Total Reports:	**161**	**86**	***53,42%***	**75**	***46,58%***	**53**	***32,92%***

Source: Authors.

In addition, this is the classification obtained studying the different human errors that can commit a crewmember of a ship. These errors were classified according to 29 descriptors grouped into 10 type of human errors (Table 2):

5. Discussion.

Once all the results were analyzed, the following data were obtained:

Percentage of accidents with crew error:

In 50.5% of the total number of vessels (192) there was crew error (53.4% of the reports) in the cause or causes of the accident.

- 43.7% in merchant ships (cargo or passenger).
- 59.5% in tugboats.
- 50.0% in fishing ships.
- 55.6% in recreational boats.
- 69.2% in other ships.

Percentage of other people's mistakes:

In 32.9% of the reports, there were errors of other people outside the crew in the cause or causes of the accident.

- 38.7% in merchant ships (cargo or passenger).
- 18.9% in tugboats.
- 15.6% in fishing ships.
- 11.1% in recreational boats.
- 7.7% in other ships.

Total percentage of human errors adding up crew errors and other people's errors:

- Total human errors in all ships: 78.6%.
- Total human errors in merchant ships: 82.5%.
- Total human errors in tugboats: 78.4%.
- Total human errors in fishing ships: 65.6%.
- Total human errors in recreational boats: 66.6%.
- Total human errors in other ships: 76.9%.

Table 2: Average values of deadweight, gross tonnage, length, and cargo capacity.

GROUP	*Nº*	*DESCRIPTOR*	*Q*	*% of total of ships with crew human error*
A (Physical problems)	1	Physical problems due to marine environment (storms, cold, etc.)	1	*7,14%*
	2	Fatigue due to lack of sleep / Physical problems	10	*71,43%*
	3	Fatigue due to overwork	3	*21,43%*
		TOTAL GROUP A:	***14***	***14,58%***
B (Damaging substances)	4	Medication adverse effects	3	*42,86%*
	5	Alcohol	3	*42,86%*
	6	Drugs	1	*14,29%*
		TOTAL GROUP B:	***7***	***7,29%***
C (Communication error)	7	Failure to communicate between crew members (misunderstanding, inappropriately expressed orders, language, ...)	8	*27,59%*
	8	Failure to communicate with the pilot (language, etc.)	10	*34,48%*
	9	Communication error between crew members due to personal problems	0	*0,00%*
	10	Communication error with other ships	8	*27,59%*
	11	Communication error with ground personnel	3	*10,34%*
		TOTAL GROUP C:	***29***	***30,21%***
D (Distractions)	12	Distraction in the watch by performing several tasks of the watch at the same time	2	*14,29%*
	13	Distraction in the watch by non-work tasks (telephone, etc.)	5	*35,71%*
	14	Lack of proper monitoring of navigation	7	*50,00%*
		TOTAL GROUP D:	***14***	***14,58%***
E (Navigation error)	15	Navigation error due to misjudgment	22	*28,21%*
	16	Navigation error due to poor technical training or inexperience	16	*20,51%*
	17	Navigation error due to overconfidence error	22	*28,21%*
	18	Navigation error due to misuse of vessel equipment	18	*23,08%*
		TOTAL GROUP E:	***78***	***81,25%***
F (Inadequate planning)	19	Lack of trip planning or maneuver planning	19	*52,78%*
	20	Failure to follow trip planning or maneuver planning	2	*5,56%*
	21	Not following the procedures	15	*41,67%*
		TOTAL GROUP F:	***36***	***37,50%***
G (Lack of training)	22	Ignorance of the procedures	3	*30,00%*
	23	Ignorance of the use of ship equipment	4	*40,00%*
	24	Ignorance of regulations	1	*10,00%*
	25	Ignorance of working language	2	*20,00%*
		TOTAL GROUP G:	***10***	***10,42%***
H (Lack of leadership)	26	Error in the command exercise	4	*100,00%*
		TOTAL GROUP H:	***4***	***4,17%***
I (Maintenance)	27	Poor maintenance of the ship known by crew	6	*85,71%*
	28	Failure to take adequate corrective measures against a known mechanical failure	1	*14,29%*
		TOTAL GROUP I:	***7***	***7,29%***
J (Fear)	29	Fear	1	*100,00%*
		TOTAL GROUP J:	***1***	***1,04%***

Source: Authors.

Most frequent causes of human errors of the crew (in each accident, there may be more than one type of error, for instance, overconfidence and misuse of ship equipment):

- Group E (Navigation error): 81.2%.
- Group F (Inadequate planning): 37.5%.
- Group C (Communication error): 30.2%.
- Group A (Physical problems): 14.6%.
- Group D (Distractions): 14.6%.
- Group G (Lack of training): 10.4%.
- Group B (Damaging substances): 7.3%.
- Group I (Maintenance): 7.3%.
- Group H (Lack of leadership): 4.2%.
- Group J (Fear): 1.0%.

Most frequent causes of human errors of the crew (only in merchant and passenger ships):

- Group E (Navigation error): 85.3%.
- Group C (Communication error): 50.0%.
- Group F (Inadequate planning): 41.2%.
- Group D (Distractions): 14.7%.
- Group H (Lack of leadership): 8.8%.
- Group G (Lack of training): 8.8%.
- Group A (Physical problems): 5.9%.
- Group I (Maintenance): 5.9%.
- Group B (Damaging substances): 2.9%.
- Group J (Fear): 0%.

Most frequent causes of human errors of the crew (only in tugboats):

- Group E (Navigation error): 140.9%.
- Group C (Communication error): 22.7%.
- Group F (Inadequate planning): 22.7%.
- Group D (Distractions): 13.6%.
- Group I (Maintenance): 4.6%.
- Group B (Damaging substances): 4.6%.
- Group G (Lack of training): 0%.
- Group H (Lack of leadership): 0%.
- Group A (Physical problems): 0%.
- Group J (Fear): 0%.

Most frequent descriptors noted in the analyzed reports:

- Navigation error due to misjudgment: 22
- Navigation error due to overconfidence: 22
- Lack of trip planning or maneuver planning: 19
- Navigation error due to misuse of vessel equipment: 18
- Navigation error due to poor technical training or inexperience: 16
- Not following the procedures: 15
- Fatigue due to lack of sleep / Physical problems: 10
- Failure to communicate with the pilot (language, etc.): 10
- Failure to communicate between crew members: 8
- Communication error with other ships: 8

Analyzing only the accidents occurred until 2010:

When we analyzed only the accidents occurred until 2010, we see that in 56.6% of the total number of vessels (76) there was crew error (57.8% of the reports).

- 46.5% in merchant ships (cargo or passenger).
- 50.0% in tugboats.
- 71.4% in fishing ships.
- 83.3% in recreational boats.
- 83.3% in other ships.

Percentage of other people's mistakes:

In 34.4% of the reports between 1975 and 2010, there were errors of other people outside the crew.

- 37.2% in merchant ships (cargo or passenger).
- 16.7% in tugboats.
- 28.6% in fishing ships.
- 0% in recreational boats.
- 0% in other ships.

Total human errors adding up crew errors and other people's errors in accidents between 1975 and 2010:

- Total human errors in all ships: 84.2%.
- Total human errors in merchant ships: 83.7%.
- Total human errors in tugboats: 66.7%.
- Total human errors in fishing ships: 100%.
- Total human errors in recreational boats: 83.3%.
- Total human errors in other ships: 83.3%.

Most frequent causes of human errors of the crew:

- Group E (Navigation error): 71.1%.
- Group F (Inadequate planning): 37.8%.
- Group C (Communication error): 22.2%.
- Group G (Lack of training): 15.6%.
- Group A (Physical problems): 13.3%.
- Group D (Distractions): 8.9%.
- Group B (Damaging substances): 6.7%.
- Group H (Lack of leadership): 6.7%.
- Group I (Maintenance): 4.4%.
- Group J (Fear): 0%.

Most frequent descriptors noted in the analyzed reports between 1975 and 2010:

- Navigation error due to poor technical training or inexperience: 9
- Lack of trip planning or maneuver planning: 9
- Navigation error due to overconfidence error: 8
- Navigation error due to misuse of vessel equipment: 8
- Not following the procedures: 8
- Navigation error due to misjudgment: 7
- Fatigue due to lack of sleep / Physical problems: 4
- Failure to communicate with the pilot (language, etc.): 4
- Failure to communicate between crew members: 3
- Ignorance of the procedures: 3
- Error in the command exercise: 3

Analyzing only the accidents occurred from 2010:

When we analyzed only the accidents occurred from 2010, in 46.5% of the total number of vessels (116) there was crew error (50.5% of the reports).

- 40.5% in merchant ships (cargo or passenger).
- 61.3% in tugboats.
- 44.0% in fishing ships.
- 0.0% in recreational boats.
- 57.1% in other ships.

Percentage of other people's mistakes:

In 32% of the analyzed reports from 2010, there were errors of other people outside the crew.

- 54.0% in merchant ships (cargo or passenger).
- 22.6% in tugboats.
- 12.0% in fishing ships.
- 33.3% in recreational boats.
- 14.3% in other ships.

Total human errors adding up crew errors and other people's errors in the reports from 2010:

- Total human errors in all ships: 77.6%.
- Total human errors in merchant ships: 94.5%.
- Total human errors in tugboats: 83.9%.
- Total human errors in fishing ships: 56.0%.
- Total human errors in recreational boats: 33.3%.
- Total human errors in other ships: 71.4%.

Most frequent causes of human errors of the crew:

- Group E (Navigation error): 85.2%.
- Group F (Inadequate planning): 35.2%.
- Group C (Communication error): 35.2%.
- Group A (Physical problems): 16.7%.
- Group D (Distractions): 16.7%.
- Group I (Maintenance): 9.3%.
- Group B (Damaging substances): 7.4%.
- Group G (Lack of training): 5.6%.
- Group H (Lack of leadership): 1.9%.
- Group J (Fear): 1.9%.

Most frequent descriptors noted in the analyzed reports from 2010:

- Navigation error due to misjudgment: 15
- Navigation error due to overconfidence error: 14
- Lack of trip planning or maneuver planning: 10
- Navigation error due to misuse of vessel equipment: 10
- Navigation error due to poor technical training or inexperience: 7
- Not following the procedures: 7
- Fatigue due to lack of sleep / Physical problems: 6

- Failure to communicate with the pilot (language, etc.): 6
- Communication error with other ships: 6
- Failure to communicate between crew members: 5
- Lack of proper monitoring of navigation: 5

6. Conclusions.

As we see, the percentage of analyzed accidents in which there was human error of the crew is a little more than 50% (43.7% in the case of merchant ships).

It is also noteworthy that, of the total number of accidents analyzed, in 28.1% there was human error from other people outside the crew (38.7% in the case of merchant ships).

Therefore we see that the total percentage of accidents attributable to human error, adding up the errors of crews plus those not attributable to the crew, is 78.6% (82.5% in the case of merchants ships), similar results as in the reviewed literature.

If we look more closely at the number of mistakes made by the crews, we see that in recent years these have declined. In vessels damaged up to 2010, the percentage of crew error was 56.5%, and from that year, the percentage fell to 46.5%.

In the case of merchant ships damaged up to 2010, there was a crew error in 46.5% of the vessels, and from 2010 the percentage decreased to 40.5%.

In reference to this, it is usually said that despite the advances in technology in the ships, the number of accidents has not been reduced. "Not even the state of the art system used to improve the new ships' operation have reduced the number of incidents and accidents at sea" (Apostol-Mates and Barbu 2016).

However, with the data provided by the research presented in this paper, we can conclude that from 2010 the percentage of accidents caused by human error of the ships' crews has been significantly reduced.

One of the reason for this reduction could be, effectively, the advance in the technology in navigation systems in addition to the more responsibility in the professional behavior of the seafarers.

Analyzing the crew mistakes, we see that among the most frequent mistakes made by the crew are the Navigation Errors (Group E) with an 81.2%. However, there is not one epigraph in this group that stands out among the others. The "Navigation error due to misjudgment" or "Navigation error due to overconfidence" are a bit more frequent than "Navigation error due to misuse of vessel equipment" or a "Navigation error due to poor technical training or inexperience".

After group E, the most frequent groups of errors committed by the crews are those of the group F (Inadequate planning), with 37.5%, Group C (Communication errors), with 30.2%, Group A (Physical problems), with 14.6% and Group D (Distractions) also with 14.6%.

There are not too many changes in this section if we look at accidents until 2010 and later, since groups E, F and C maintain similar results.

As a conclusion, we can mention that there are human mistakes of the crew in half of the maritime accidents. In addition, the practical application of this survey lead to insist on the need that Shipping companies and the crewmembers of the ships must concentrate on reducing the errors of Navigation.

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