INDUCED MARITIME ACCIDENTS

MSc. Reynaldo Montes de Oca (I) ; Dr. Jesús E. Martínez Marin (II) ; Dr. F. Xavier Martínez de Osés (II), Dr. Ernesto Madariaga (III)

(I) Universidad Marítima del Caribe. 3ra Av. Con 10ma Transversal de Los Palos Grandes. Caracas, 1060, Venezuela.

(II) Nautical Engineering and Science Department, Universitat Politècnica de Catalunya, Pla del Palau, 18. 08003 Barcelona. ;

(III) Navigation Science and Technics and Naval Construction Department, Universidad de Cantabria, Gamazo, 1. 39004 Santander.

montesdeocar44@yahoo.com, jemartinez@fnb.upc.edu, fmartinez@cen.upc.edu, ernesto.madariaga@unican.es

Abstract

Humanity system of life is highly supported by maritime transport when circa 8 thousand million people require about 8.800 million tons of merchandises by sea, going in some 105.000 merchant ships of over 100 GT, sailing every thinkable dangerous waters 365 days year 24 hours day. All that Enormous activity plus others different factors produce accidents, as is shown in an ascendant 1.7 rate related to ships lost with big number in life, cargoes losses, and pollution. That is why this study pretend to detect causes factors of maritime accidents, to try to reduce them, and with that target in mind it was tested the new theory of Induced Maritime Accidents, crossing its proposals with relevant sinister of different times and circumstances, as Andrea Doria, Torrey Canyon, Costa Concordia, among others. Those cases were re evaluated to establish the key points of such theory, as they are the Production Pressure, the Risk Homeostasis, technological advances and the rupture of safety margin. Cases studies gave as result the existence of referred key points, in a manner combined that the chain of events derived to the fatality, and more than that highlights the possibility that been suppressed to acceptable limits the production pressure or the risk homeostasis, a permissible safety margin were been maintained, avoiding catastrophe

Keywords

Maritime Accident, Production Pressure, Risk Homeostasis, Safety Margin

1. INTRODUCTION

Resolution MSC.255 (84) of International Maritime Organization, IMO, (OMI, 2010) establish that a marine casualty means an event, or a sequence of events, that has resulted in any of the following which has occurred directly in connection with the operations of a ship:

1. The death of, or serious injury to, a person;.
2. The loss of a person from a ship; .
3. The loss, presumed loss or abandonment of a ship; .
4. Material damage to a ship; .
5. the stranding or disabling of a ship, or the involvement of a ship in a collision;
6. material damage to marine infrastructure external to a ship, that could seriously endanger the safety of the ship, another ship or an individual; or
7. Severe damage to the environment, or the potential for severe damage to the environment, brought about by the damage of a ship or ships.

However, a marine casualty does not include a deliberate act or omission, with the intention to cause harm to the safety of a ship, an individual or the environment.

This match with Babylonian Hammurabi Code wrote between 1955 1912 BC when stabilising that the accident is not an intentional act: In the sentences meted out to each offense, the code distinguishes whether or not there is intentionality, and also: The penalty is increased if it has been done deliberately. (clasica, n.d.)

2. DISSEMINATION OF ACCIDENTS

In regard to the public knowledge of these accidents, previously, cases as Titanic, took more time to be disclosed, however at the present time, cases such as Prestige or Costa Concordia, among others, they do so in real time, which promotes a reaction of the public opinion more swift and forceful, and that, joined with the maritime transport system supports to a large extent the life forms of humanity, whose international trade is transported by more than 90 %, by sea (IMO, 2012, p. 7) some 8408 million tons of various loads transported in 2010 (UNCTAD Review of Maritime Transport 2011, p.7) on board of 104304 = >100 GT merchant propelled ships, highlights the fact that this is not a system of which we can dispense with, and therefore it is essential to know the causes that motivate the marine casualties to minimize its recurrence.

This core activity of the maritime transport has been adapting to commercial and technological requirements, transforming what it in the past it was considered by society as a safe activity, to an insecure and high-risk in the present. The modest size of the vessels of the past, in contrast to the enormous today, in themselves represent greater risk potential, either by the loss of lives and/or goods, environmental pollution, etc.

Upcoming major technological advances to the ships to reduce the consumption of fuel, the use of liquefied gas as fuel, the hull lubrication by air to decrease the friction with the sea, in the bridge is already normal the use of integrated systems, Automatic Identification System, Long-range identification and tracking of ships, to electronic navigational charts, among others.

These technological advances assumptions to improve maritime safety probably are activated, as they did in the past, the adaptation and balance of the safety margin accepted by the operator (Homeostasis of risk) which could compromise for a period of time, the safety. (Montes de Oca & Martínez Marín, 2013, p. 42)

3. FATAL STATISTICS & CASUISTRY

The maritime accidents have left huge amounts of dead, in 1820 during the North Sea winter, more than two thousand ships foundered with the consequent loss of the lives of more than twenty thousand people (L., Boisson, 1928, p. 10), by then the United Kingdom (UK) adopted the Passengers Act, which led to the English Parliament to research on the causes of shipwrecks, focused on ten determinants, as the inadequate equipment, failures of construction, excess load or its inappropriate assurance, inadequate maintenance, incompetence of the Captain, etc. (Boisson opcit, p50). Later during 1848 France and the UK agreed to in writing the first regulating navigation at sea on the navigation lights, continuing with regulations to avoid collisions at sea. However, the reiteration of maritime accidents and multiple actions or regulations to minimize them, gender in the global maritime community, the need for their research and to identify causes and avoid as far as possible its recurrence. This has helped the international cooperation and the advent of the common ways to investigate them and in January 2010 came into force the Resolution MSC 255(84) that imposes mandatory internationally, the Code for the Investigation of Marine Casualties.

In spite of these efforts, however, the rate of losses of vessels has increased, from 1.3 in 2006 to 1.7 in 2010 (relation of ships lost/total number of vessels =>100GT) (IMO document CWGSP12/3) and the index of spills to the sea from 1970 to 2011, indicates that the 2% are product of fires or explosions, 2% due to collisions, groundings 3 %, hull failure 7 %, equipment failures 21%, and surprisingly 64% of the causes of such spills, it is for another reason or the cause is unknown (annual statistics from the International Tanker Owners Pollution Federation, ITOPF's) and even more, from 1989 to 2010 were lost (totally) 4443 ships and 18189 lives as a result (UPC, 2012). (R. Montes de Oca, O.Marquez, Jesús Martínez, 2012)

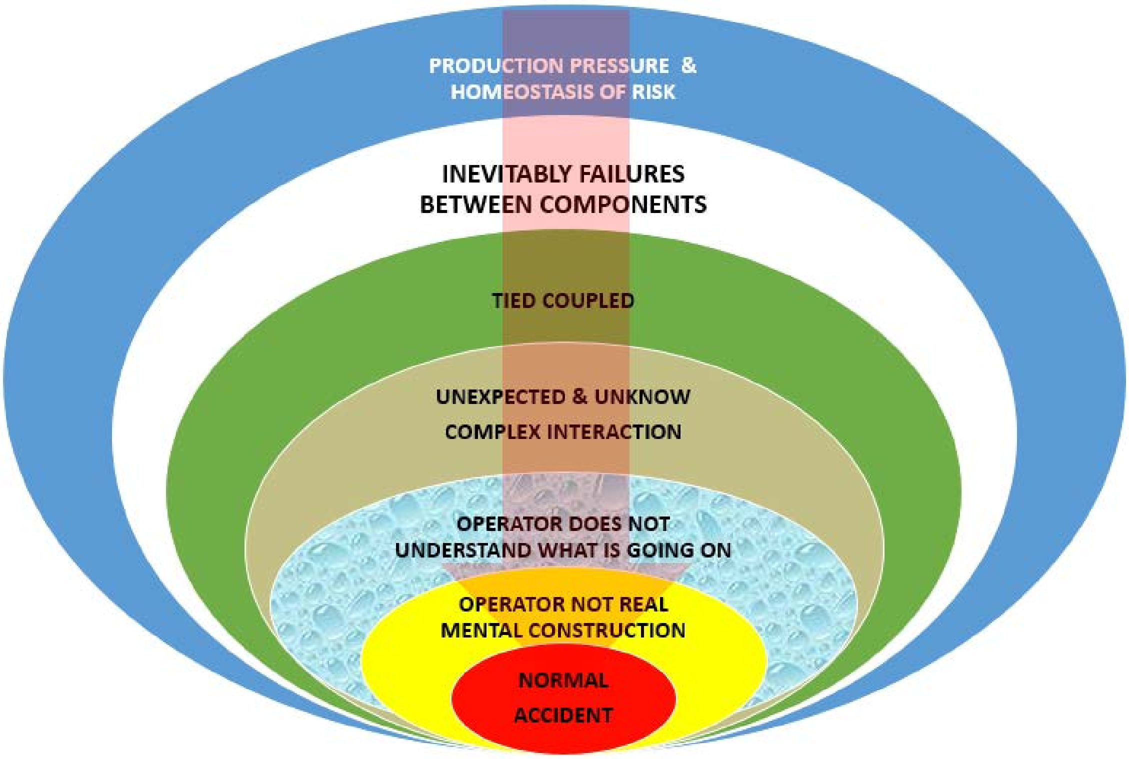
4. ANALYTICAL REVIEW & PROPOSALS

Faced with this concern in various branches of industry, the scientific world has produced alternating thoughts, among them as indicated by Charles Perrow in his book NORMAL ACCIDENTS (Living with High-Risk Technologies) (Perrow, 1999) which presents the theory of why accidents occur and some of them inevitably due to the fact that the productive systems that builds society, are too complex and their components or parts can interact in unexpected ways, thus leading to the accident. He also claims that with this new approach, it could be finalized with charges to persons and/or wrong factors, as commonly happens in the present, and also stop the attempts to repair the systems in a way that only make them more risky. (Montes de Oca & Martínez Marín, 2013, p. 43)

It is based on the fact that there isn't a good management of high-risk technologies, which the patient research of many disasters proves that in a certain time no one knew what was happening in reality, and even though they acted with the best practice, the results were worse. Highlights the gap between the human being and the technology (where the operator is left behind in the understanding of the given system). Perrow concludes, that the true cause of the Normal Accident is the complexity of the system because all the failures may be small in themselves and each to have a backup, but on the whole, it is their interaction (complex coordination of failures) that explains the accident, and these occur because the system is complex. (Montes de Oca & Martínez Marín, 2013, p. 43)

According to our interpretation of Perrow, (adding the risk homeostasis) develops this Figure representing a possible sequence toward the accident. (Figure 1)

Figure 1: Normal Accidents Sequence



Source: Author Reynaldo Montes de Oca

Another production of the scientific world that we might consider, are failures of design raised by Henry Petroski (Design paradigms, case histories of error and judgment in engineering) (Petroski, 2010) or modifications to the original design that might influence the failures, and negatively impacting on the couplings of some of the parts of the system pointed out by Perrow, making them strongly bound or rigid, what would facilitate the generation of unexpected or unknown interactions. So, we can assume the matrix of Perrow, enhanced by the vision of Petroski and this lead to the wrong mental construction of the operator and then take the wrong decision (although the operator was thought to be correct) and consequently detonate the sinister. (Figure 1)

Recalling the collision in July 1956 of passenger ships Stockholm and Andrea Doria, it might be clear to us that if the ships had not had radar, the Andrea Doria has sailed at a slower rate in the dense fog prevailing, and none of the two has produced such changes of course. In the meantime the presence of radars and detection one each other, then the speed remained high, and in ships approximation both operators, generated mental images erroneous to the reality and consequently manoeuvred toward the collision, although they tried to avoid it.

In considering the sinister of the oil tanker Torrey Canyon in March 1967 that ran aground and break his hull with the consequent total loss of the ship and its cargo spill, generating this dreadful pollution in the waters around the semi-submerged reef Seven Stones, with Dietrich Dörner´s theory (The Logic of Failure, Recognizing and Avoiding Error in Complex Situations) (Dörner) we could consider that there was the decisions of the Captain of the oil tanker, when taking an unusual route and not recommended in defeat toward the port of Milford Haven, besides accepting as true the position given by bridge Pilot in the approach to the reef, as the cause of the catastrophe.

With Henry Petroski´s theory, we might want to consider that was the modification of the physical characteristics of the ship's hull (lengthening for greater load capacity) leading to the loss of manoeuvrability due to that the rudder is not restructured for the new size of the vessel, which in the end caused the incident to not be able to fall on the port side quickly and avoid the reef.

With Charles Perrow´s theory, we would consider that still so many commercial pressures and inaccuracy of the equipment that you've set up a gap in the dynamics of navigation that concluded in disaster.

It should be noted that in all theoretical scenarios of this case, the mental image wrong was present.

We can also infer that the bridge operators in the luxurious and ultra-modern passenger ship Costa Concordia, generated, believed and decided according erroneous mental images, which allowed his ship will contact the submerged rock. (Montes de Oca & Martínez Marín, 2013, p. 44)

Just thinking in the last exposed cases, allows us to glimpse something prior to the act itself, had accumulated and inter linking with the consequent reduction of the appropriate margin of safety, to the point of inducing decisions that led to the accident. (Table 1)

If focussing on this final phase (decision) we can get closer to Dietrich Dörner theory in which he said that we are so prone to make mistakes; our brains are not fundamentally defective; quite simply, we have developed bad habits. When we fail to solve a problem, we do so by the tendency to make a mistake here, a small error beyond, and these accumulate, thus contributing to fail. Although he further maintains that the violation of safety standards by the operator is due to the fact that frequently has already violated before (negative reinforcement) it is well that Dorner postulates the complexity and operational intelligence. So in summary, the causes of our mistakes when handling complex systems are: the slowness of our thinking and the small amount of information that we can process in a given time, our tendency to protect our sense of competence, the limited capacity of income flow of information to our memory, and to our tendency to focus only on the immediate problems.

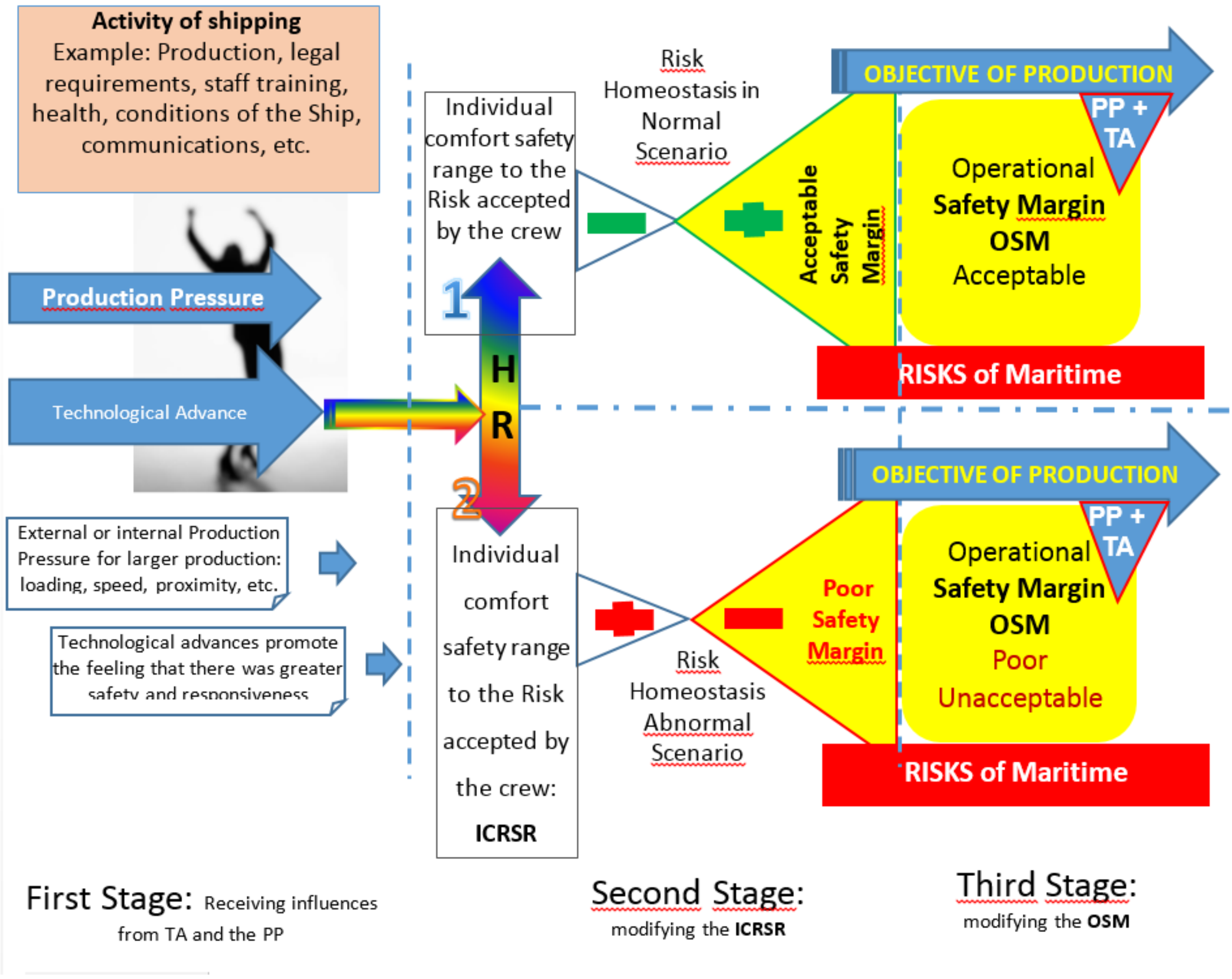
We have so that the human being is to some extent lags behind in the technological advances, and as a possible reaction the operator acts to balance its area of conformity / satisfaction (risk´s homeostasis) which to my way of seeing is not another thing that modify the Risk (increasing), by the way of the Margin of Safety (downwards) (formerly did not have radar on board and maintained highly careful attitude, while having them, increases the speed, or changes in direction). To this end, the proposal of the Slow Shipping to retrieve a greater margin of safety, lost through the rapid technological progress, the homeostasis of risk in combination with the pressures of production, or in other words, keep the previous preventive attitudes (when the risk was greater without present technology) in conjunction with the positive technological advances in the decline of the risk. In this way avoiding failures (increasing the margin of safety by lowering the pressure of production with the Slow Shipping) could be generated sufficient time to adapt persons and systems to avoid errors in complex situations, which require that the design of such systems taking advantage of our natural talent of perception, presenting our attention to the precise information that we require at the exact moment.

5. THE THEORY OF THE INDUCED ACCIDENTS

This leads me to try to launch the configuration of a new theory, initially named as Induced Accidents, (Montes de Oca, 2013) based on the fact that accidents occur motivated to the infringement, decrease or absence of an acceptable margin of safety, generated among others due to the pressures of production, technological progress and the risk homeostasis (Figure 1 & 2) in an at least two of three combination.

As seen in Figure 1, human being (individual part of a ship crew) is doing his job on board to reach target production with safety. What happens (first stage) is that in a particular moment these production pressures arise, pushing to more risky decisions, as per example to change a route with plenty room for a dangerous path because of thinking in an early arrival to profit the tide, or to don´t reduce speed, or to don´t make a clear change of bearing with enough time because of trying to maintain the schedule, or to don’t use in parallel generators or helm mechanism in some special circumstances because thinking in save paying fuel payments or overtime, or because of the fact that these equipment were not 100% available due to poor maintenance. But what reason allows a person agree to take these risky decisions? Well, because each person (Routinely the Master, Chief Engineer, personnel in watch) have his own individual capability to accept risk, **ICRSR** (Figure 1, Second stage), what we shall call individual comfort safety range to accept risk, or just: Comfort to the Risk, being that **ICRSR** in a normal situation in a well-trained crew is maintained within a range of preventive and precautionary. This range of comfort to the risk, it can be disturbed by both the pressures of production such as the sense of greater safety generated by technological advances, for example when the advent of radar, also appeared the super power of the vision even in thick fog or seeing through darkness.

Figure 1: Homeostasis of Risk



Source: Author Reynaldo Montes de Oca

After receiving the influence from one or both of these factors (production pressure, technological advance) we arrived at the stage two. This variation of comfort to the Risk range is so called Homeostasis of the Risk (Balance before the feeling of risk).

When in this second stage, the individual comfort to the risk range became bigger (so person accept more risk in a comfort way), it means to that person he will accept a smaller operational margin of risk (Third Stage), which will take us closer to the risk with the consequent increased likelihood of the occurrence of the incident. (Figure 2)

5.1 HOMEOSTASIS

The concept of homeostasis was created by Claude Bernard, often regarded as the father of physiology, and published in 1865.

It is a characteristic of a system, either open or closed, attributed to a living organism, (biological or social). This trend to balance allows them to regulate the internal or external environment to maintain a stable condition and constant that in our case of the proposed theory of induced accident we shall call as an individual comfort zone (Comfort to the Risk). The multiple adjustments of dynamic balance and self-regulating mechanisms make the homeostasis possible. (Bransiforte, 2009)

5.1.1 PSYCHOLOGICAL HOMEOSTASIS

The term was introduced by W. B. Cannon in 1932, appoints the general trend of any organism to the restoration of internal balance each time it is altered. These internal imbalances that can occur both in the physiological level and psychological, are produced by a timely damage or because of a need. In this way, an organism's life can be defined as a constant search for balance between his needs and his satisfaction which we have named in this proposal of theory of (Induced Accident) as the individual range of comfort to accept risk. Any action aimed at the search of the balance is, in the strict sense, behaviour.

Interaction between animal and environment: responses to changes: Normally, to alterations in the environment, an animal responds with one of the three possible answers: avoidance, conformity or regulation. This last is the one that has received more attention; in fact, one of the main themes of the physiology is the study of the mechanisms that are used by the organism to maintain a stable internal environment.

Avoidance: minimize the internal variations using some behavioural escape mechanism that allows them to avoid environmental changes, either space (looking for microhabitats not stressful like caves, burrows; or on a larger scale, migration) or temporary (hibernate, drowsiness), As example from our case, when watch at the bridge avoids issuing contrary to the opinion of the captain when he commands the manoeuvre. Conformity: the internal environment of the animal changes in parallel with the external conditions. There may be a functional compensation with the acclimation or the acclimatisation, recovering from the previous functional speed to change. Regulatory: a disturbance triggers compensatory actions that keep the internal environment relatively constant.

5.2 Risk:

Risk is defined as the combination of the probability of occurrence of an event and its negative consequences. The factors that compose it are the threat and vulnerability (CIIFEN, 2010)

Figure 2: Induced Accidents / Risk and Safety Margin

Source: Author Reynaldo Montes de Oca

Margin of Safety up and down (See Figure 2): Increase and decrease of margin of safety, because of technological progress and the risk´s Homeostasis of the operator, who perceive the higher margin due to technological progress, then decreases with his more risky actions. (Montes de Oca & Martínez Marín, 2013, p. 45)

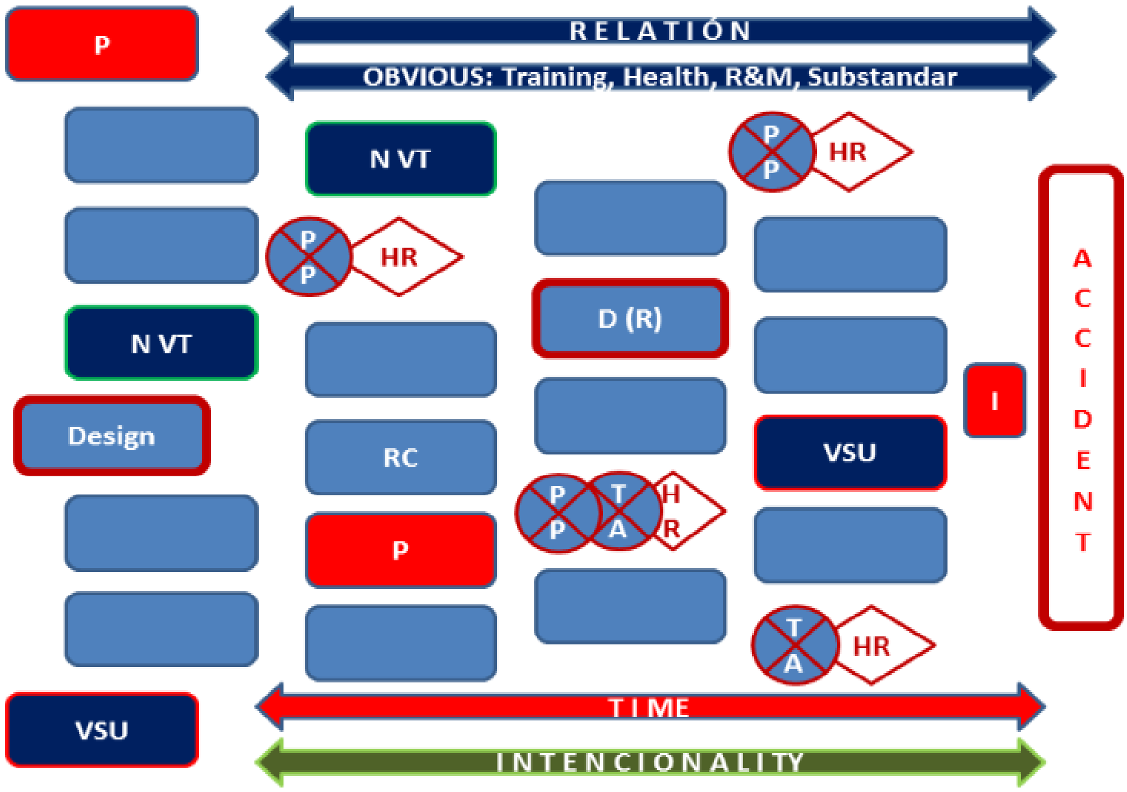
a: Reduction of the Margin of Safety by homeostasis of the operator with the consequent increase of the Risk

b: Reduction of the Margin of Safety by the increase in the production pressure with the consequent increase of the Risk

In cases 1 and 2, the safety margin was enough to make the system will recover, while in case 3 the operator´s risk Homeostasis in combination with a production pressure increase, decreased the margin of safety to the point of deleting it thereby undermining the system, causing the disaster.

There are many causes that could lead to the disaster; show as blue rectangles (See Figure 3). It could be failures of design or redesign (D(R)), ones so called immediate cause (I), proximate cause (P), root cause (RC), etc. (Figure 3)

Figure 3: Induced Accidents



Source: Author Reynaldo Montes de Oca

The ones we are talking about are from Production Pressure (PP), Technological Advance (TA), Homeostasis of Risk (HR), circumstances or events not very tied (NVT), or very strong united (VSU). As told before HR can be generated by the PP and/or TA, so in a first consequence HR vary to accept an individual wide range of comfort to the risk, and in a second consequence, to a shorter operational margin to risk, that in some cases lead to the disaster. (Figure 3)

The technological progress makes us feel safer and then the operator actuates until that feeling reach to the level of previous risk, with catastrophic consequences already known.

5.3 GIVING BASES FOR THE THEORY PROPOSAL

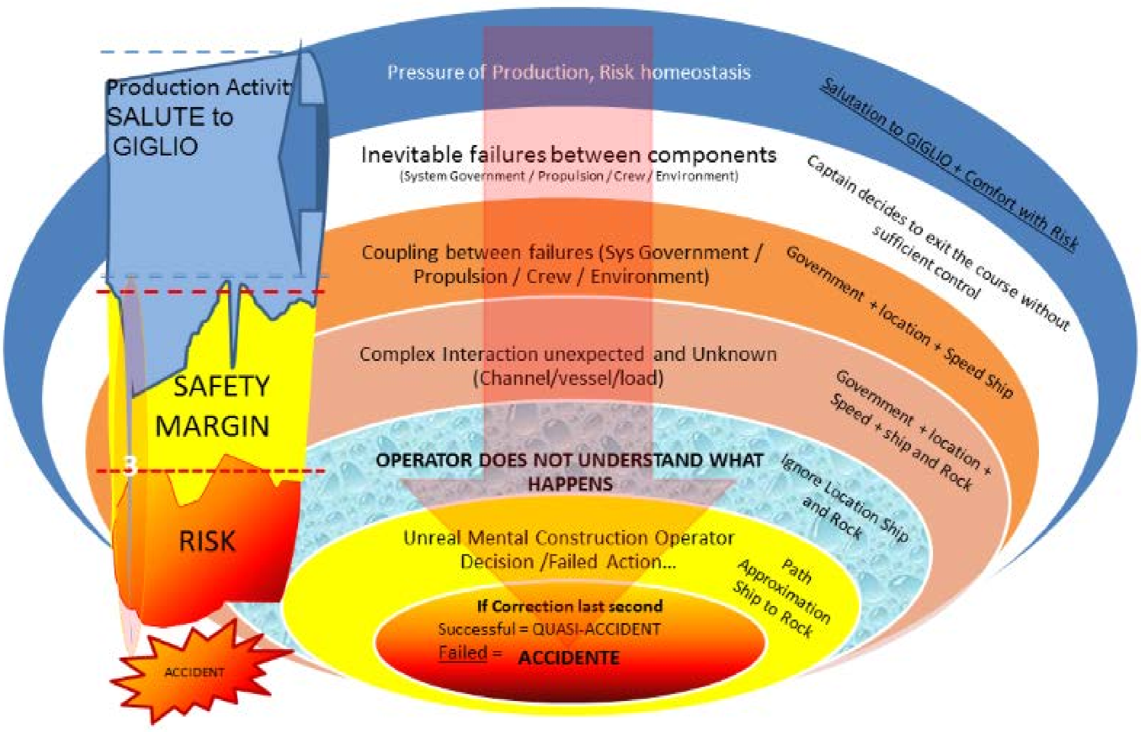
The study within the three theories of accidents of the authors Perrow, Petroski and Dörner, have been carried out with a vision for epistemological to establish a specific structural base on the applicable concept to all of them. The same validation will have to be done with the theory proposal (Induced Accidents).

As planned, on the methodology of scientific research programs, from Imre Lakatos, in which there is a structure composed of: Strong Core, where reside the basic assumptions or general hypotheses of the theory, centre from which rotates the mentioned theory. Protective Belt, with hypothesis assistants, definitions, basic conditions that serve to describe the uniqueness of the situation, since the basic assumptions contained in the nucleus are insufficient to predict or explain details. So that the belt is responsible for defending the core to be distorted. Positive Heuristics, which represents the operational techniques, mathematics with which one can develop the research program on a methodology to enable it to explain and predict in cases before the reality of the proposed scenario. Negative Heuristic, which puts the framework of what not to do because it is in conflict with the strong core (Lakatos, 1978 pp. 13, 66).

Subsequent to that part of the filter parameters of Lakatos, which made it possible to accept or not theories, then selected contrast them; we take cases of marine casualties for based on them, begin to experience the search for causes.

The disaster of TORREY CANYON, in which after a sequence of events that inter reacted unexpectedly, bridge operators (we assume) generated an unrealistic picture of the reality that once they realized and tried to correct, it was already too late. By applying the principles set forth in these theories we perceive that the incident is interpreted differently, depending on the precepts of the theory used. Not excluding each other, but rather, in my view, complementing each other. And so going deepen in these theories and begun to build and to propose one of our own, as has been outlined in this study, the theory of induced accidents, motivated to the treatment given (or not given) to the margin of safety, in which not necessarily the factors involved are in the order plotted, these can happen or interact or interconnect, in a different order, free. (Figure 4), as well as infer that the erroneous image was present as a factor, through the theory proposal, we can also observe how was violated the safety margin to a point to be unrecoverable and the accident occur (in spite of the effort, in extremis, carried out by the captain to evade the obstacle).

Graph 4: Induced Accident / Costa Concordia



Source: Author Reynaldo Montes de Oca

For validation, the theory proposal of the induced accidents, suggests that:

5.3.1 STRONG CORE:

That the accidents are built hard by its protagonists (and/or predecessors) without them being truly aware of this;

That this construction of the accident is based on the decrease of the margin of safety desirable;

That accidents happen because the margin of safety decreases to an intolerable point that enables us to reach the strip of risk, materializing the sinister (or quasi-sinister, if a successful last second action);

Such a reduction of the margin of safety is product mainly (not exclusively) of the interaction of the pressures of production, the homeostasis of the risk, and technological progress (two of three at least).

5.3.2 PROTECTIVE BELT:

The events or actions (that weaken the safety margin real or that increase the real risk) (not the actors still truly aware of this) will occur before or during the phase between the conceptual and the regular operations of the case which is concerned; overwhelming and entering a stage of sudden emergency that leads to the quasi-sinister (if mediate any providential action last second) or irreversibly the accident;

The existence of a network of faults (factors that undermine the safety margin) that accumulated tuned violate suddenly the safety margin;

The safety margin does not appear as a primary factor of decisions, in the chained actions toward the accident.

5.3.3 POSITIVE HEURISTICS:

The scope of calculation and determination of the level of risk in setting the margin of safety associated with a given scenario;

The actions/decisions, training, skills, abilities, capabilities, environment, production requirements, health, fatigue, etc. Method: 1. -establish risk level 2. -establish wide safety margin 3. -set normatively 4. -set them on the conscience of the protagonists 5. -set them in the culture of the company;

Set the safety margin as a primary factor of priority in operational decisions.

5.3.4 NEGATIVE HEURISTICS:

When the intervening events or actions that lead to sinister are carried out with the intent to cause harm, may not be considered in this theory of induced accidents.

Looking at the foundations of the induced accidents theory proposal, you can highlight the concrete fact that the decisions taken in the approach to the sinister have arguments or databases that of undesirable and unconscious way, thus denying the reality that decision makers are living and coming increasingly. For this reason this theory points to a specific rationale, firm, and accurate for those decision-making in such circumstances of much information and time restricted to decide; as it was to rely on the safety margin built, or set it to play previously.

As well it should never Costa Concordia have such a degree of proximity to the coast, or Andrea Doria wait so approximation to decide its route, or Torrey Canyon will lead through the restricted passage, or Titanic maintain speed.

6. CASE STUDY

Ship: CS Costa Concordia **-** Details of the incident: 4229 people were on board – Event Type: Contact, Break, Loss of all Power – Hour/Date: January 13 2012 to 9:45:07PM (VDR) – Accident Location**:** contact against rock "Le Scole", Giglio´s Island, Mediterranean Sea – Italy – Position**:** LAT. 42 ° 22 ' 20N - LONG. 10 ° 55' 50E – Weather/Sea conditions: ROUGH - NE4; Wind 17Knts E-NE, Visibility Partly cloudy to good. - Operations: In Navigation from Civitavecchia to Savona – Ship Affected area: Hull´s left side at the stern - Implications: very serious accident, 32 people were killed or missing, 157 injured, of whom 20 required medical care in hospital, total loss of the Ship. (MIT, 2012)

This report, summarizes the human element (whose key members of the crew showed a poor technical expertise) is the root cause in the accident, both in its first phase, as determined by the non-conventional actions that led to contact with the rock, as well as in the 2nd part of the management of the overall emergency later. (For Induced Accidents theory, we will only take into account the 1st phase of the sinister, "contact with the rock')

According to the verified evidence, it is established that Costa Concordia on the 13 January 2012 at the time of his departure from the port of Civitavecchia, fulfilled completely with all of the safety of life at sea international convention requirements applicable. During the crucial phase prior to impact, in which successive actions that gave rise to the incident when the captain who guided the ship toward restricted shallow waters, and then a very small space in a parallel path to, and in a perpendicular too close to the coast by changing the course of navigation in a way very soft with the rudder to generate a small variation and leisurely pace of the course, but at the same time very wide.

- So it can establish that the ship had sailed with all its margin of safety (figure 2 yellow stripe). However, it is observed the soft manoeuvre of Captain.

- a **–** View from induced accidents theory (IAT): it involves the ignorance of the danger that was stalking and which subsequently is expected to converge. These actions assist to decrease the margin of operational safety.

6.1 IN REGARD TO THE ORGANIZATION, IDENTIFIES THE FOLLOWING PROBLEMS:

- While the ship is heading quickly toward the coast, the Captain took the helm with sufficient time to enable it to have corrected the dangerous course on which the ship progressed, (not having corrected the manoeuvre represents an aggravating factor in his nautical conduct);

- b- (IAT): allowing the ship forward toward the danger without any action to counter it, this is consuming the safety margin up to decrease it to an intolerable point.

The difficulties of the captain to read the radar (because at the time the lack of the reading lenses); c - (IAT): if he does not know with precision (but assume that he knew) the location of the intervening elements (Ship/coastline) sailing now by his own image (unreal) of the scenario. Here we are in front of the decline of the margin of safety due to two reasons: 1. - ignore locations and 2. - Homeostasis of risk in the Captain overrating his control over the situation and continue with his navigation route.

- The use of navigational charts totally inadequate and the inappropriate use of the navigation systems; d - (IAT): Not knowing with precision (but assume that he knew) the location of the intervening elements (Ship/coastline) sailing now by his own image (unreal) of the scenario. We can see now the decline of the margin of safety by: 1. - which is, or represent homeostasis of risk in the Captain when overestimated his capacities and feeling in control of the situation ignoring to verify positions. 2-Allow this condition reinforces the idea of the presence of risk homeostasis in the Captain to sustain decisions only in the belief of his expertise (by perhaps feel comfortable with an individual range of increased risk accepted and a safety operational margin declined) and did not corroborate ship position with its team of bridge. This certainly puts yet another link in the progressive reduction of the safety margin.

- Captain distraction due to the existing presence upon arrival at the bridge, people of the department of hospitality and the telephone conversation sustained by one of them with a colleague from ashore; e. -(IAT): Allow this situation implies the assumption that it had already happened before and it looks normal to them, also that the approximation to Giglio was not considered a restricted manoeuvre but a navigation at open sea. Both of these considerations contribute to the decline of the operational margin of safety that should be, due to waste of precious moments to realize the true situation, on the other hand the condition of normal navigation instead of manoeuvre conditions did not promoted the best attention from the staff of navigation on the bridge. In our view because of an increased comfort to risk range of the Master and perhaps of all the bridge team on watch (Homeostasis of risk).

- Captain orders given to the helmsman, assigning a course to follow, instead of telling the angle of the rudder. f. -(IAT): Implies that the helmsman seek (to his own knowledge and understanding, at their own pace) to follow the course dictated by the Captain, while that of the Captain having ordered by position of the rudder, was direct order in condition for manoeuvre to be made directly and without any delay, which would place the ship on the course quickly. It also notes that the captain did not earn greater danger and therefore sailed comfortably. So the safety margin is diminished with this form of sailing in these conditions and reveals the possible risk homeostasis in the Captain showing serenity when facing the facts and his control over them.

In regard to the specific requirements learned of the procedures of the international safety management code, it is clear the failure of:

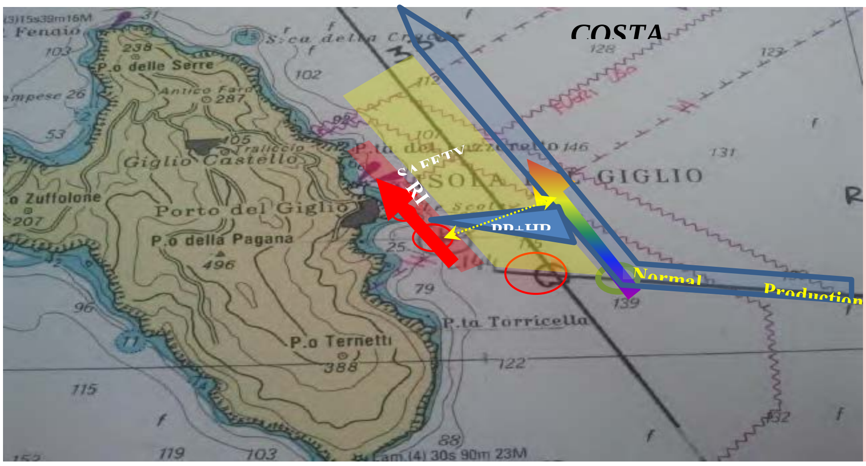
- The conduct of the attention to the watch on the bridge on the distraction of the motivated staff to the presence of strangers in the bridge; g. - (IAT): Above-mentioned as promoted by the captain to navigate as if it were in the open sea, which, however, did not prevent bridge´s human team, to maintain a conduct to a great deal of attention to the navigation environment (perhaps the avoidance, as one of the three possible answers in the physiological homeostasis: avoidance, conformity or regulation); Coupled with the aforementioned distraction. This helped a lot to allow the gradual decline and increasingly alarming of the margin of safety.

- In addition the fails in regard to the verification of the position of the vessel, which was never done; h. - (IAT): Exposed reflects the attitude of confidence of the Captain in the knowledge of the area and control of the situation (he supposed to have) generated by the possible risk homeostasis that he was invaded with.

In this context looks clear anomalous the attitude of the Master not to check the original navigation plan (already failed as a result of the rapprochement to half nautical mile (0.5 nm) using a navigational chart totally inadequate) and go beyond the point of rotation provided without checking the actual distance to the coast (despite that was supported by the navigational equipment and bridge team). The audio recordings in conjunction with the collected evidence ($2^{nd}/3^{rd}/1^{st}$ deck officers, do not match) show the differences of the human team of navigation with the government of the ship. Their passive attitude is reprehensible, and even the greater authority (after the Captain) the first mate (still in his watch) alerted or urged the captain to close/speed up the turn of the ship, nor did he give information of the imminent danger in spite of the fact that before the arrival (of the Captain) to the bridge had been sharply criticized and defined as a true madness the decision to follow that route so close to the coast. (IAT): In regard to the attitude of the first mate, it is clear that for this manoeuvre it was not a open sea case, however did not make any warning to the Captain, the reasons for such attitude we do not know (perhaps the avoidance, physiological homeostasis answer), but the fact of silent entity not contradicting the captain, the owner of command, can be between them. This contributed to the subsequent decline of the safety margin.

It is also reprehensible the bad use of the three decks officers on the bridge, during the phase of the watch of the first officer, such as when the Captain arrived at the bridge and took command of the vessel. Even if in the latter scenario, the first officer could have used the staff of the bridge to warn of the dangerous rapprochement to the coast, rather than simply repeat the commands of the captain at the helm, or change the speed (perhaps the conformity, physiological homeostasis answer).

Figure 5: Costa Concordia / Safety Margin

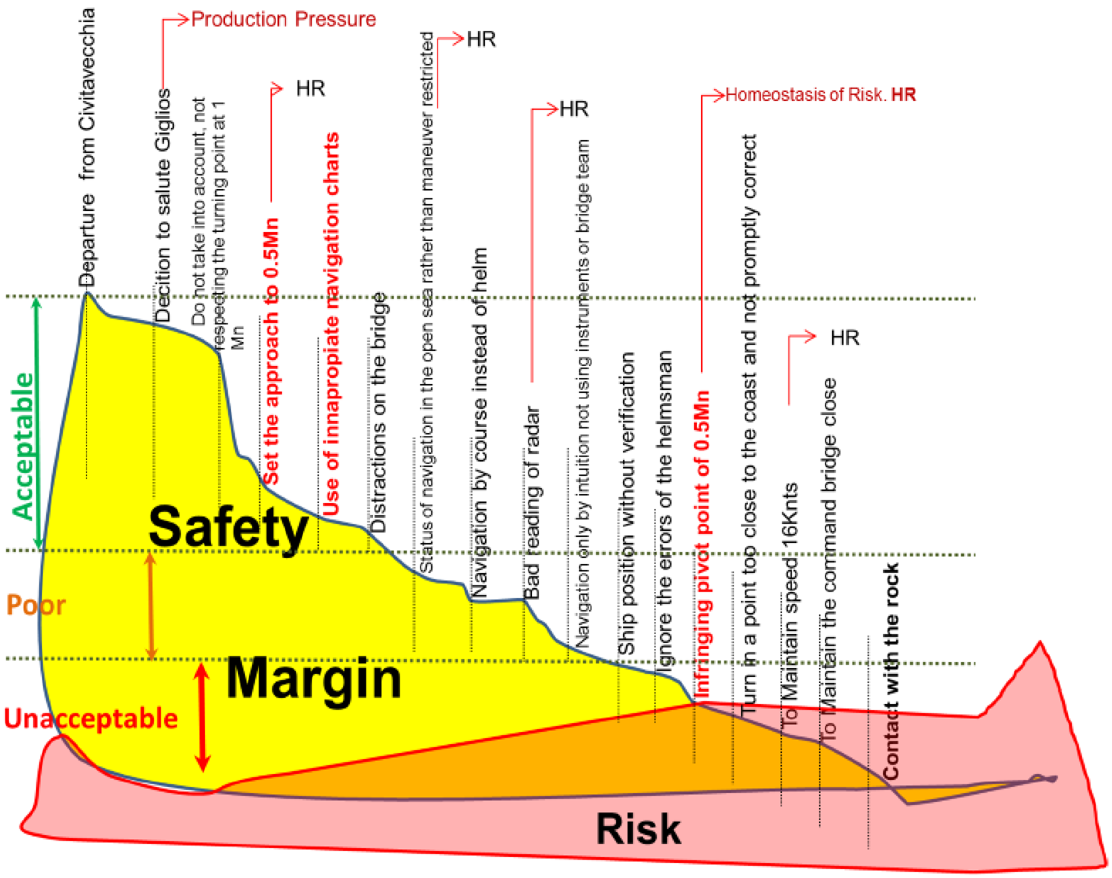


Source: (MIT, 2012) & the Author

The Costa Concordia were complying her normal production activity but in point (A), instead of turning to starboard and maintain its margin of safety, she decided to continue straight ahead approaching Giglio coast (risk area) and reducing the acceptable safety margin in search of the previously calculated new turning point (B) (now located in a small safety margin) and not respectful continued her navigation up to another turning point (C) extremely close to the coast which totally violated the safety margin; After this, and with the failure of last second reaction to avoid the catastrophe, this became inevitable. (See Figure 5)

The production Pressure and Homeostasis of Risk (PP+HR) cone represents the combination of factors which possibly led to the crew in charge of navigation to take those very wrong decisions. When production pressure push to salute Giglio it turn to a bigger individual risk comfort range accepted by the Master, and as a consequence to a smaller operational safety margin (SM). Then after the breakdown of the SM the catastrophe befell (See Figure 5).

Figure 6: Costa Concordia sequence of the loss of the margin of safety



Source: The Author: R Montes de Oca

Figure 6 show a sequence of how the operational safety margin is loss when the decision maker (crew in charge of navigation) changed for a bigger than normal their individual comfort range of acceptance of risk, possibly as a result of the pressure of production by greet Giglio (homeostasis of risk), and as a result allow a safety margin very small to unacceptable limits (See point 2 of Figure 1)

Table 1: Induced Accident Analysis

Case Study	Production Pressure	Technological Advance	Risk Homeostasis	Results	Induced Accident
Costa Concordia	Approach to Giglio coast (Yes)	Ultramodern vessel (Advantages Not used)	Decide upon a individual intuitive navigation type of the open sea without use of ship´s modern facilities, nor order condition of restricted manoeuvre, do not require support of staff at the bridge, accept excessive proximity to the coast.	Two of three (PP & HR)	YES
Torrey Canyon	To profit tide on arrival march 18th or must wait till the 24th to enter Milford Haven – Much time on board without vacations – Lengthening of ship (Yes&Yes&No)	Automatic steering (Yes)	Change from a plenty room navigation route to a dangerous path	Three of three (PP&TA&HR)	YES
Andrea Doria / Stockholm	To maintain arrival time - To take a destination shorter route (Yes & (Yes)	Presence of Radar on both vessels (Yes)	Both parties acceptance of an inadequate passing distance (too close) - Do not consider two ships navigations as a system - Do not slow speed - Do not make a clear change of bearing with enough time	Three of three (PP&TA&HR)	YES

Source: (Cahill, 1992, p. 197) (Richard A, 2002, pp. 3,4) and analysis from authors

REFERENCES

ASIS, G. S. R. A., s.f. *ASIS International Guidelines,* Alexandria: ASIS International.

Bransiforte, A., 2009. *Fundamentos de Psicología.* [En línea] Available at: Fundapsicologia.blogspot.com/2009/07/homeostasis.html[Último acceso: 12 Feb 2014].

Cahill, R., 1992. *Disaster at Sea.* 2nd ed. Chicago(Illinois): Donnelley & Son Co..

CIIFEN, C. I. p. l. I. d. F. d. N., 2010. *CIIFEN.* [En línea] Available at: http//www.ciifen.org/index.php?option=com content&view=category&id=84&layout=blog&Itemid=111&lang=es [Último acceso: 10 Feb 2014].

clasica, H., n.d. *historiaclasica.com.* [Online] Available at: http://www.historiaclasica.com/2007/05/el-cdigo-de-hammurabi.htlm [Accessed 13 feb 2014].

Dörner, D., s.f. *The Logic of Failure, Recognizing and Avoiding Error in Complex Situations.* s.l.:s.n.

Hinrichs, J., Baldauf, M. & Ghirxi, K., 2010. Accident investigation reporting deficiencies related to organizational factors in machinery space fires and explosions. *Accident Analysis and Prevention,* 28 Diciembre, Volumen 43, p. 1187 1196.

Huber, G., 1999. *Toma de Decisiones en le Gerencia.* México(D.F.): Trillas, S.A. de C.V..

IMO, 2012. *International Shipping Facts and Figures – Information Resources on Trade, Safety, Security, Environment,* London: IMO.

L., Boisson, 1928. Editions du Centenaire. *Le Courrier,* Volume 1828-1928, p. 10.

Lakatos, I., 1978. *La Metodología de los Programas de Investigación Científica.* España: Alianza Editorial.

Martínez de Osés, X. & Blanco, R., 2003. *Metodología y Criterios para el Desarrollo de un Sistema Integrado de Información Meteorológica y Oceanografía para la Navegación,* Barcelona: s.n.

Maza, A. & Sarraga, R., 2000. *El Factor Humano en la Toma de Decisiones de los Oficiales de Puente en las Tareas de Navegación,* Barcelona: s.n.

MIT, T. B. o. M. A. I., 2012. *Costa Concordia,* Rome: Italian Ministry of Infraestructure and Transport.

Montes de Oca, R., 2013. Induced Accident & Slow Shipping. *RIDEPORT, RED INTERNACIONAL DE EXPERTOS EN PUERTOS Y COSTAS*, Noviembre, pp. 110 -20-25.

Montes de Oca, R. & Martínez Marín, J., 2013. Induced Accident & Slow Shipping. *Journal of Maritime Technology and Environment,* II(Maritime Technology and Environment), p. 122.

Organización Marítima Internacional, OMI, 2010. *Código de investigación de Siniestros y Sucesos Marítimos,* Londres: s.n.

Organización Marítima Internacional, 2011. *Documento GWGSP12-3,* Londres: Organización Marítima Internacional, OMI.

Perrow, C., 1999. *Normal Accidents.* New Jersey(NY): Princenton University Press.

Petroski, H., 2010. *Design Paradigms.* 14th ed. New York(NY): Cambridge University Press.

Psarros, G., Skjong, R. & Eide, M., 2009. Under-reporting of Maritime Accidents. *Accident analysis and Prevention,* 8 Octubre.pp. 619, 623 - 625.

Richard A, C., 2002. *Collisions and Their Causes.* 3rd ed. London: The Nautical Institute.

Rodríguez-Martos, R., 2006. *El Buque Mercante Un Análisis Sociológico.* 2da ed. Barcelona: Centre de Publicacions del Campo Nord, CPET.