The Implementation of Risk Management processes as a contributing factor to the minimization of shipping disasters through the study of previous shipping accidents

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Abstract: Environmental disasters can maliciously affect property, human lives and even entire ecosystems. The magnitude and extent of such a disaster can lead to uncertainty about who is liable and how the restoration of the environmental damage will be achieved. The implementation of Risk Management processes enables us to combine our available information and resources and learn how to avoid such problems in the future. In shipping industry, oil spills from tanker vessels constitute the most severe threat to local and global ecosystem. When an oil spill happens, it usually spreads rapidly and is affected by weather and sea currents. Without prompt treatment it can cause huge disasters in the local aquatic ecosystem and human property altogether. This paper will assess the famous accident of Exxon Valdez based on Risk Assessment Methods and more specifically with the method of Root Cause Analysis to identify and measure the effect of each contributing factor to each accident and with Failure Mode Effect Analysis to identify the best solutions to minimize such risks in the future.

Keywords: Oil Spills, Risk Management Methods, Maritime Accidents, Root Cause Analysis, Failure Mode Effect Analysis.

1. Introduction

In 1989 Exxon was the dominating company in the oil market and the tanker Exxon Valdez was the "pride" of its fleet. On his third year at sea, it was one of its newest and most well-equipped ships. Sadly, on March 24, 1989, when this tanker departed from the port of Valdez, it caused the largest oil spill in American history. The main issues that led to the accident were among others: i) the failure of the Master to perform his duties properly due to alcohol addiction, ii) the inability of the active Lieutenant to control the ship due to fatigue and lack of training, iii) the failure of Exxon Shipping Co. to manage its ship in the aspect of safety and security and iv) the lack of preparedness and organization by the competent stakeholders to contain the oil spill (Leacock, 2005).

This paper will assess the accident based on Risk Assessment Methods. The first section will therefore analyze the most crucial factors that led to the accident. The second section will identify the real causes that led to the accident, utilizing the Root Cause Analysis and in the third section the Failure Mode Effect Analysis will be implemented, to evaluate the best solutions to minimize such risks. Finally, the fourth section will assess the environmental impact of the accident and the actions to be taken to eliminate such incidents in the future. (Pasman et. al., 2017)

2. The most prominent factors that led to the accident.

The stranding of the "Exxon Valdez", resulted in the leak of 10.8 million gallons of oil at Prince William Sound, was the outcome of multiple serious incidents, some of which were caused even by the company itself and mismanagement.

After the completion of the investigation, these issues were, firstly, the irresponsibility of Captain Joseph Hazelwood to perform his duties properly during the critical navigation in the sea area of Prince William Sound. As demonstrated before the departure of the ship from the port, he was found to consume alcohol against the regulations of STCW95 (Section B-VIII/2 Part 5, paragraphs 34-36). When the ship departed and while under the control of the navigator, the captain had gone to his cabin and returned to the bridge shortly before the navigator departed. After the navigator disembarked on the radar screen, ice was shown on the path the ship would follow. Usually, when ice occurs within maritime traffic systems, the master has the option of either lowering the speed of the ship to pass the ice or changing sea lanes by first receiving approval from land. In the case of Exxon Valdez, the Captain requested permission from the USCG and after it was approved, instructed the helms man to change course and enter the opposite sea lane. He then instructed the Lieutenant to turn the ship back to its original course and left the bridge again in violation of STCW95 rules, leaving an uncertified, as will be mentioned in the next paragraph, officer alone at a critical navigation point (Leacock, 2005).

The captain's decision to leave the ship's bridge was the beginning of the "disaster". The Lieutenant who took control of the ship turned out to be tired of the consecutive hours of work with just 5-6 hours of rest within 24 hours. According to the MLC2006 Convention, rest hours in a 24-hour period must not be less than 10 hours. He was also not certified in accordance with STCW requirements as an officer on the watch to perform safe navigation duties on the ship's bridge. The result was that he was unable to judge when such a large tanker to safely return to its original course and its erroneous movements led to the ship's stranding on Bligh Reef (Ismail, 2019).

It also appeared that the ship's manning policy significantly affected crew fatigue. The U.S. Coast Guard had certified a minimum crew number of 15 people, while if a radio operator was not required, 14 people. For its part, the company had manned the Exxon Valdez with 14 crew instead of 24, which were required based on the vessel's size, to save money, so the ship lacked the required amount of trained crew to respond to emergencies properly.

Finally, it is worth noting that the accident was caused by the wrong actions of the ship's crew, but the magnitude of the spread of the oil spill was not only due to the unskilled and untrained crew but also to the lack of organization on the part of Alyeska Co, the company responsible to provide cleanup crews and equipment, for the immediate response actions required in case of pollution (Leacock, 2005).

3. Utilization of «Root Cause Analysis».

The Root Cause Analysis method is a way to respond to problems that occur. This method provides guidance to identify possible causes, then collect and analyze the data and ultimately identify the real causes of the problems. As far as safety is concerned, it is used for accident investigations where the purpose to be used in this report is. The previous section mentioned the problems that led to the accident. However, to find the real causes, consideration must be given to how these problems were created, what was the issue with the company's management of the ship and the coast guard's response to emergencies (Mullai, 2006).

The first problem mentioned above is the captain's consumption of alcohol a few hours before the ship's departure. The reason Hazelwood did not reflect on the impact of his actions on the performance of his duties was his alcoholism problem. Exxon was aware of this weakness after it had also mediated his rehab treatment, and although incidents had been reported before, from testimonies from his associates that he was still drinking quantities of alcohol, the company continued to utilize him on its ships. The real cause of this problem is therefore the company's wrong decision to re-hire Captain Hazelwood without properly assessing the implications of that decision (Okes, 2019).

The next thing to consider is crew fatigue. The Lieutenant who was on the ship's bridge at the time of the accident was tired as he had worked more hours than the law stipulates. The reason is that the company at the time was trying to save money so decided to reduce the crew to the minimum so that the 14 people who remained on board worked longer hours and with additional responsibilities.

Regarding the incidents of violation of the regulations by both the seafarers and the company, for example the absence of the Master from the bridge, the extended working hours, the uncertified and trained crew are all the result of poor management by the company, which had not taken care to hire a certified crew, to ensure that international rules are respected by all and to undertake the training of the crew in order to be able to respond to emergencies (Rausand et al., 2020).

The late response of Alyeska Co. contributed to the uncontrolled spread of the oil spill. According to the center's response plan, the response team, cleaning equipment and boats that will take them to the pollution site should be on standby at any time within 5 hours of the call for help. However, in recent years there had been a reduction in staff and there was no 24-hour readiness and on the day of the accident the vessel that would transport the equipment to the site of the pollution was for repair. The confusion over who was obliged to undertake the clean-up of pollution also delayed the response to the issue. By the time the cleanup vessel was finally arriving at Exxon Valdez, it had been 13 critical hours. Evidently, the reason for all these delays was the lack of organization to deal with marine pollution from coastal states as well as the lack of cooperation and communication between ship and land.

4. Risk Minimization measures - FMEA (Failure Mode Effect Analysis).

Failure Mode and Effect Analysis (FMEA) is a qualitative, systematic, and very structured technique used to investigate how a system or parts of the system can lead to performance problems. (Mullai, 2006). The FMEA identifies possible failure functions, i.e., what is not working properly, the results of these failures, how to avoid them and/or even measures to minimise the impact of these failures on the system (Jahanian et. al., 2020).

In the Exxon Valdez accident, from what has been said in the previous two sections, what was not working properly was the management of the company's ships and their crews in terms of ship safety, cargo handling, and the response environmental threats and finally the lack of an organized response to reduce pollution from the port of Valdez and Alyeska Company.

The results of these failures were to result in 10.8 million gallons of oil at sea, which contaminated 2,100 km of oil. coastline, to kill thousands of birds and marine beings and cause huge economic disasters in the wider region (Barron et. al., 2020).

Therefore, considering all the above measures that should have been taken to minimize the risk are:

1. Compliance with STCW regulations on the prohibition of alcohol consumption by crew during the performance of safety tasks.
2. Compliance with STCW regulations on the certification and training of safety officers for the safe navigation of the ship as well as their duties in the event of an emergency.

3. Compliance with MLC 2006 regulations on crew working and rest hours.
4. Creation of emergency response plans, both by the company for its ships and for itself, and by the coastal States so that they are ready to respond in a timely and methodical manner to combat and minimize the risk.

In the end of this paper, FMEA is applied, using an appropriate table (Appendix 1).

5. Environmental Impact of the accident. Aims that should be achieved.

An ecosystem consists of plants, animals and other organisms interacting with each other and with their environment, such as water. When everything is in balance, ecosystems are self-sufficient. Ecosystems generally change slowly over time, but a disaster can suddenly change an ecosystem. That is the case with the Exxon Valdez accident on Prince William Sound. (Leacock, 2005).
The environmental impact of the Exxon Valdez oil spill has been devastating and you estimate that 250,000 seabirds, nearly 4,000 marine otters, 300 sea seals, 250 bald eagles, more than 20 Orca whales as well as billions of salmon and herring eggs were killed. The result of these effects was also the economic destruction of the region as the losses of local fishing reached $286.8 million (Barron et. al., 2020).
In order to eliminate such accidents, appropriate milestones should be set. It is important that every ship-handling company harmonizes its policy based on the ISM Safe Management Code. These objectives should provide safe practices for the operation of vessels and a safe working environment. Also, all recognized risks should be assessed regarding the ship, human life and the environment and establish safety measures. It is important to continuously improve the skills of both land and ship personnel to enhance the operational efficiency, effectiveness and safety awareness (Ismail, 2019).
Also based on SOLAS regulations and by extension STCW and MARPOL it is mandatory to conduct training drills on board ships to prepare the crew in emergency situations.

6. Conclusion

Nowadays, where 11 billion barrels of oil are consumed daily, oil spills have become a very familiar incident. Environmentalists worldwide are trying to reduce our dependence on oil, but scientists have identified at least 500,000 different uses of oil and its derivatives. With our dependency on oil as a fact, the only course of action is to find a way to minimize environmental costs and avoid and minimize the frequency of oil spills, aiming to a gradual elimination of those incidents.
After the Exxon Valdez disaster, governments and businesses realized how poorly prepared they were to deal with such a disaster. As a result, in 1990 the Oil Pollution Act 1990, passed by Congress, was revised with a stronger set of regulations to prevent, and deal with oil spills. Additionally, Conventions such as CLC, and BOPC were initiated, guidelines such as International Safety Guide for Oil Tankers and Terminals (ISGOTT) were drafted and Associations, such as P&I Clubs, became more aware and involved actively in prevention, enhancement of safety measures and other pro-active and reactive policies. Additionally, guides
Unfortunately, history shows that to establish and implement a set of rules and practices for the protection of human life, the environment and property, a huge disaster must come first. A very efficient practice that has been developed is the study of previous incidents to find the root of the cause and utilize measures to prevent those incidents for happening in the future, through the implementation of risk assessment methods. In this paper, we used the root cause analysis and failure mode effect analysis to assess the most prominent factors that led to the accident, evaluate their effectiveness to the outcome and propose measures to avoid similar incidents in the future.
As for Prince William Sound, it has been 30 years since that disastrous night and its ecosystem has not recovered yet. A more recent example is the oil spill caused by the explosion on the oil extraction platform, Deep Horizon in 2010 where in this case the company mismanagement played a major role in the cause of the accident. It is evident that the environmental disaster of “Exxon Valdez” has not become a lesson yet, but many steps have been taken to the avoidance and minimization of damage of similar incidents.

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Annex 1: Failure Mode Effect Analysis

PROCESS	Potential failure mode	Potential effect of failure	S	Potential causes of failure	O	Current process controls	D	RPN	Recommended actions	Responsibility and completion date	Reviewed by and date
Crew Service- The second lieutenant in-service lacked proper training and was unfit for service (fatigued) The captain has suffered from alcoholism	Loss of life, property and environmental pollution	Likelihood of Accident	5	Improper crew management and awareness of responsibilities by company and by ship master.	4	Captain and crew unfit for service and unaware of action in case of force majeure	5	100	Better training and awareness of crew responsibilities and safety processes and company actions to avoid similar cases in the future. Stricter company policies in case of master//officers/crew noncompliance with company QMS.	General Manager, Safety Officer, Crew Manager	Daily
New Result*			2		2		2	8	ACCEPTABLE		
Crew Training and Experience	Loss of life, property and environmental pollution	Decreased crew productivity, leading from near miss accidents to environmental hazards	4	Lack of experience and proper training	3	Crew members unaware of their responsibilities and of basic safety processes.	5	60	1.Proper and adequate training of the crew from certified training centers and by experienced staff. 2. Regular training through seminars and information programs. 3. Constant on-board training and awareness of the crew, pursuant to QMS Company Manual.	1. Crew training from certified training centers. 2. Constant training of the company's fleet be company executives while on-board or even before embarking.	Weekly
New Result*			2		1		2	4	ACCEPTABLE		
Manning of Ship (Required number of seafarers on board, fit for action)	Loss of life, property and environmental pollution	Improper ship operation and untimely execution of required tasks	4	Decrease of company expenses	3	1. Lack of Crew 2. Failure of the company to comply with the MLC 2006 & STCW rules 3. Failure in risk assessment	4	48	Proper crew manning and constant officer and company control if each member of the crew is fit for service.	General Manager, Crew Dept., Captain and Officers on-board	At start and during each voyage
New Result*			1		2		2	4	ACCEPTABLE		

*After implementing the recommended actions

S=Severity rating	**O=Occurrence rating (Frequency)**	**D=Detection rating (adequacy of present controls)**	**RPN=Risk category percentage**
5. high severity 4. Moderate severity 3. Low severity 2. Severity almost non existent 1. No severity exists	5. Very high chance of occurrence 4. moderate chance of 3. low chance of 2. very remote chance of 1. No chance of	5. Very low chance the control will detect a potential `cause/mechanism and subsequent failure mode 4. low chance the control will detect a potential `cause/mechanism and subsequent failure mode 3. Moderately high chance the control will detect a potential `cause/mechanism and subsequent failure mode 2. High chance the control will detect a potential `cause/mechanism and subsequent failure mode 1. Control will almost certainly detect chance the control will detect a potential `cause/mechanism and subsequent failure mode	100-91% High Planned response within one month 90-61% Medium Planned response within twelve months 60-20 Low Monitor only 20 > Very low No action required