UNCERTAINTIES IN DOCKING PROJECTS FOR OIL TANKERS

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Abstract. *The oil industry has substantially increased its investments in projects, given the importance of this sector to the country's development. The large number of projects has made their objectives progressively harder to achieve owing either to the competition for resources or to their high complexity, or even to interference among the projects themselves. In one of the links of this industry's production chain, the logistics area, more specifically shipping, the projects are related to the preventive maintenance of existing ships, known as docking, and to the building of new ships. A difference is noticed in the docking projects regarding objectives planned and those achieved, which indicates the need for improvements. As docking operations are considered projects, the concepts and tools of project and risk management can be used to meet such needs. This paper presents a study of risk events in docking projects for oil tankers and points out the most important ones, describes their causes and consequences and the methodology, tools and techniques employed.*

Keywords*: Uncertainty, Risk management, Docking, Risk assessment, Oil tanker*

1. INTRODUCTION

Uncertainties are inherent in human activity and can be found in any organization's routine projects and activities. When handling uncertainties likely to create technical risks, there are a number of tools available as well as databases concerning the likelihood and impacts with regard to risk events. For example, when calculating an automobile premium, an insurance company has tabulated data regarding incidents and thefts, and information on the driver such as: age, gender, marital status, home address, garage parking, and other details that define the likelihood of incidents and the respective impacts.

When managing risk events, the picture will be different, and as organizations are in their initial maturity stages, there are still no structured databases with information available to project managers, who will have to depend on information gathered by professional team members involved in projects, and certain precautions should be adopted in order for these data to be useful. Finally, there is a need to assess this information's quality.

This article's purpose is to point out the key risk events to which docking may be subjected, to examine and to rate them with the aid of the techniques and tools more commonly used by project management professionals, and to analyze the level of convergence among specialists' opinions in connection with impacts and the likelihood of risk events occurring.

2. THEORETICAL FOUNDATIONS

This section deals with the concept of uncertainties when docking oil tankers, as well as the analysis of opinions regarding risk events. It also discusses how the acquisition of specialists' knowledge takes place and how people position themselves when faced by risk. The conclusion will cover aspects on the application of Kendall's concordance coefficient.

2.1. Project uncertainties

A paradox in risk management has attracted interest and curiosity in the project management community: on the one hand, this field of knowledge is one of the most important and full of techniques and tools, and on the other, it is one of the least studied. A survey performed by Ibbs and Kwak (2000) shows that a lack of knowledge in dealing with uncertainties was detected in project managers in four of the different sectors under review: telecommunications, high technology manufacturing, information technology, and civil engineering. Absorbing concepts with regard to risks and uncertainties and knowing how to manage them is thought to be one of key considerations that project managers may learn from the survey.

One of the most valuable contributions to the understanding of risk concepts was provided by Wideman (1992) when defining the bounds of the field of uncertainties, including the opposing elements of the unknown and of certainty. In this respect, uncertainty may be considered a conceptual field confined between these two elements, which is the center of the concerns involved in risk studies. The risk versus uncertainty relationship adopted by the PMI (2004), for example, was considered, and a comprehensive risk definition was established as being “an uncertain event or condition which, when it happens, has a positive or negative effect on a project’s objectives.”

In this regard, project risks have their source in the field of uncertainties, which in turn are found in every project, in a more or less intense form (Perminova et al, 2008).

For Perminova et al (2008), the key difference between risk and uncertainty refers to the likelihood of establishing probabilities. Hence, risk is defined as a situation in which decisions are made under unknown probability conditions. This is not case with uncertainties. It is impossible to associate them with numerical probability values, and there is a lack of knowledge on the outcome of an event.

An interesting enough aspect regarding uncertainties, basic and at the same time supplementary to the studies of Wideman (1992) and which provides a broader view on the subject, was put forth by Meyer et al (2002) who proposed four types of uncertainties:

- Variability: random yet foreseeable and controllable changes around the known objectives of cost and term;
- Foreseeable uncertainty: a few known factors will affect a project in an uncertain manner, yet allowing contingency plans to be put in place in order to handle the consequences of any occasional events;
- Unforeseeable uncertainty: one or more significant factors that influence a project cannot be predicted, requiring the solution of problems as they occur;
- Chaos: completely unforeseeable factors totally invalidate a project’s objectives, planning, and approach, causing it to be repeatedly and completely redefined.

Conceptually, the field of uncertainties may be viewed as the core of managerial concerns. In this regard, Ward and Chapman (2003) uphold that any project risk management process should restrict its focus to managing uncertainties, as risks are always associated with threats (or opportunities) of uncertain events in projects.

In a previous study they showed that the traditional ways of treating risk tend to concentrate on variability events and makes little consideration of the ambiguous aspects existing in projects. To them, variability refers to a project’s elements likely to assume different and hence uncertain values, such as: terms, costs, and quality. On the other hand, ambiguity is associated with the lack of clarity in data, in detail, structures, among others, because biases, limited knowledge, and less clear situations will be found in the behavior of the persons involved.

The writings of Ward and Chapman (2003) may be seen as a continuum representing the spectrum of uncertainty management, which takes into consideration not only threats but also opportunities. The broad vision of risks, involving threats and opportunities, was ratified in the works of Hillson (2002). To this author, risks are related to uncertain events likely to affect a project’s objectives in a negative or positive manner. This manner of risk positioning creates different managerial strategies.

To the US Department of Defense (DOD, 2006), risk is understood as a measure of future uncertainties in achieving program objectives within the restrictions established for cost, terms, and performance. According to Modarres (2006), the term risk means not only the occurrence of an undesirable event, but also its likelihood and consequences, should it occur.

Risk management thinking puts forth additional alternatives to enable the management of those events defined up to now. Nonetheless, for Raz et al (2002) the subject of risk management is still in its childhood. Several studies (PMI, 2004; VALERIANO, 1998; Keelling, 2006) have shown risk management as a series of interconnected processes involving specific techniques and tools. The PMI (2004) proposed six risk management processes: Risk management planning, detection, qualitative assessment, quantitative assessment, response to risk, and monitoring and control.

Project risk management is intended to detect and deal with uncertainties likely to impact a project, yet there are a number of unknown uncertainties likely to affect a project and which are not given any consideration, and may affect their objectives. Those uncertainties that cannot affect a project, whether known or unknown, are not a source of concern to the persons involved in risk management. Figure 1 depicts this situation; the uncertainties known and unknown to the persons involved are shown on the horizontal axis, and the uncertainties likely to affect or not the project, on the vertical axis.

	Known Uncertainties	Unknown Uncertainties
Uncertainties that could affect	Scope of the risk management	Could be a risk
Uncertainties that could not affect	No need to be dealt with by risk management	No need to be dealt with by risk management

Figure 1 – Uncertainties matrix

Furthermore, an environment of uncertainties may be represented jointly with a project's environment, as in Figure 2, in which the environment of uncertainties is described by a certain degree of knowledge, varying from a limit close to zero to a limit close to one hundred percent of the uncertainties likely to affect a project. The project environment is broader, embracing the partially known environment of uncertainties and the environment unknown to the project team. There is also the environment unknown to the team, but which does not affect a project and are not a source of concern.

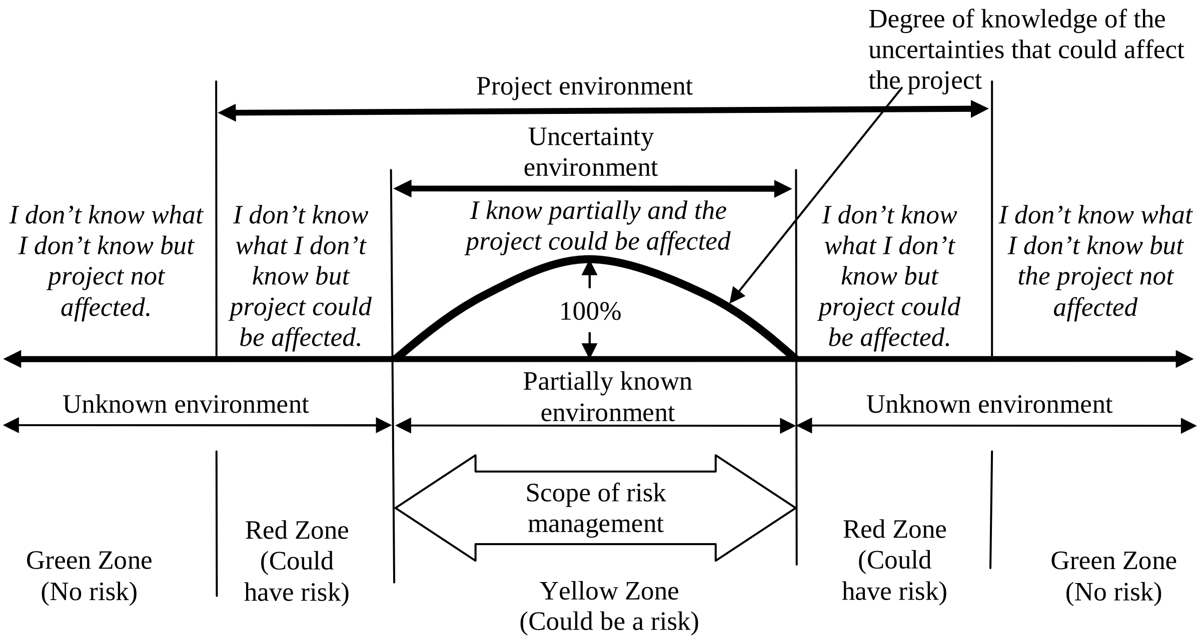


Figure 2 - Project and uncertainty environment

2.2. Docking

The development and application of a risk management methodology for ship maintenance projects, this paper's objective, has not been covered yet by literature specialized on this topic. Nonetheless, the concepts and nature of this type of project should be explored.

According to Transpetro's System for the Economic Monitoring of Projects (TRANSPETRO, 2000), a ship maintenance project is an extremely important event in its operating life, and takes place every two and a half years by means of compliance with rules and regulations, one of which is intermediate and one intended to close a five-year cycle. The deadline for concluding each project is defined in each ship's certificate, and therefore, unless an accident happens, or in the event of a technical recommendation or restriction, planning should be based on these dates.

In general terms, maintenance of an oil tanker means placing it in a dock or dry-dock (facilities intended to build or repair ships) performing the required repairs, and putting it back in operation. This procedure in the shipping area is known as docking. Santos and Gonçalves (2006) explain that from an operator's viewpoint, maintenance may be divided into four stages: Preparation of the repair specifications, inspection and acceptance of the services provided, approval of the shipyard's invoice, and preparation of the final project report. Hence, maintenance of oil tankers is a generic term for the period during which a ship is handed over to a shipyard for repairs (TRANSPETRO, 2000).

During these projects, work takes place including those repairs that could not be performed during a ship's operating cycle. This could take place owing to the lack of time or to the need for special cleaning preparations and elimination of gases from hydrocarbons, employed in a ship's vital systems and which would cause its downtime. This special preparation will allow work in an environment healthy for people, known as "free for fire" or "free for man."

Specifying the services to be provided and defining the shipyard selected for the repairs should take place before beginning a ship's downtime and is part of the project planning stage. This stage is complex, as in order for it to be successfully executed, removing a ship from operations has to be discussed with all the interested parties, reconciling the outcomes arising from this downtime. It is also necessary to list all the services to be provided and to select the shipyards capable of meeting the requisites.

Removing a ship from operations will affect the rest of the fleet's programming, often requiring a temporary replacement of this equipment, which is not always available in the market. Correctly detecting the service will also be adversely affected, as with a ship in total operations it is not possible to perform a detailed inspection throughout the ship. In conclusion, the selected shipyard may reject or postpone receipt if a ship is not available for maintenance on the agreed on date, as normally demand for shipyard services is greater than the supply.

2.3. Risk perception

Risk analysis is a rational assessment procedure that may contribute significantly to the decision making process, if values and limitations are borne in mind in a realistic manner. There is a trend to accept assessments as an exact measurement, when in fact there is a lot of subjectivity involved (SKJONG; WENTWORTH, 2001). Subjectivity is related to perception by people, and which pursuant to Kunreuther (2002) is affected by biases in their judgments.

According to Slovic (1987), research on the perception of risk events has brought to light a set of mental or heuristic strategies that people employ to find some meaning in a world of uncertainties, and though these rules are valid in several circumstances, in others they may lead to biases with strong implications in the treatment of risks; there is much evidence that the perception of risk events is affected by biases in their judgments (KUNREUTHER, 2002). In general, these heuristics are easy to use, but they may lead to serious systematic errors (TVERSKY; KAHNEMAN, 1974).

Difficulties in understanding probability processes, media coverage, personal experiences and anxieties cause uncertainties, badly assessed risk events, and the judgment of facts lacking credibility by the public in general. Specialists are also subject to the same biases, in particular when they are forced to give an opinion on subjects not covered by their field of knowledge (SLOVIC, 1987). For this reason, specialists should be consulted only on events in connection with their specialties; in addition, they should be questioned on what experience and relevant information contributed to their assessment, as although specialists are very knowledgeable, they may have difficulties in attributing probabilities (SKJONG; WENTWORTH, 2001).

Slovic (1987) studied risk perception by people in the United States. The author wanted to discover how people perceived risks in thirty activities and technologies, such as for example: Nuclear energy, motor vehicles, small firearms, tobacco, motorcyclists, alcoholic beverages, private aviation, police work, pesticides, and surgery. Each of the persons interviewed was requested to consider the risk of death in society as a whole, arising from these activities and technologies. The survey was applied to four different groups: forty members of the League of Women Voters, thirty university students, twenty-five professionals who were members of the Active Club, and fifteen professionals chosen for their involvement in risk analysis, including among others a geographer, an environmental policy analyst, an attorney, an economist, a biologist, a biochemist, and a member of a government regulatory agency for hazardous materials.

The authors concluded that perception by specialists with regard to the risks in the thirty items was very much associated with the annual background of casualties, though it was only possible to confirm twenty-five items from which the background was obtained. In the case of laymen, however, only a moderate relation was noted between perceptions and the casualty background. In particular, the risk perceived in the nuclear energy activity was exceedingly high when compared to its casualty background, in addition to being considered the most risky by two groups of laymen, while specialists deemed it in twentieth place only.

The survey by Slovic (1987) contributes to risk management by demonstrating that specialists are able to get close to the values found for background data, while laymen have no sensitivity to deliver an opinion on risk events.

2.4. Positioning in the face of risk

In addition to perception, another factor that deserves to be borne in mind in risk management is the behavior of people.

In fact, people position themselves differently in the face of risk; according to Lefley (1997), personal attitude is influenced by past experiences, and when young, people tend to assume greater risks than when they are older or more experienced. A survey with fourteen hundred and eighty-four project managers found a strong negative correlation between a manager's age and the acceptance of risk, in other words, the older they are the less risk acceptance there is (VROOM; PAHL, 1971).

A simple tool to understand risk tolerance is the utility curve, which according to Kwak and LaPlace (2005), and Von Neumann and Morgenstern (1953 apud NEPOMUCENO FILHO; SUSLICK, 2000), shows the aversion to risk for a concave curve, the propensity to risk for a convex curve, Figure 3 and in the case of a decision maker indifferent to risk, the utility curve appears as a straight line.

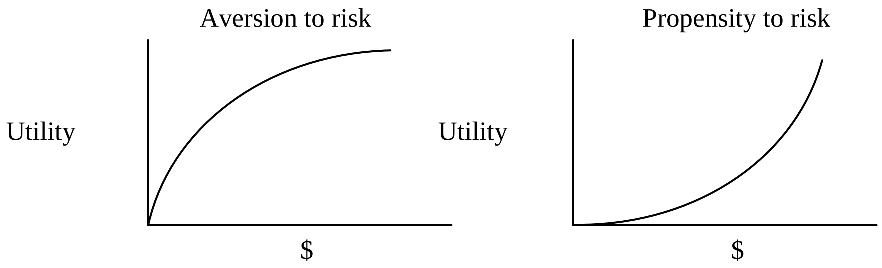


Figure 3 - Utility curve
Source: Kwak and LaPlace (2005)

Hence, it is important that the tolerance level should be very well defined so that project managers, other persons involved, and companies invest in their projects adequately.

2.5. Knowledge acquisition

Human knowledge acquisition is the process of extracting, structuring, and organizing the knowledge of specialists in order to capture problem-solving expertise (LIOU, 1992b). To Dhaliwal and Benbasat (1990), knowledge acquisition is the name given to the process of broadening, acquiring, and representing knowledge through the description, relationships, and procedures in the selected area of activity.

According to Liou (1992b), there are three concerns that should be applied in the process of knowledge acquisition: involvement with the appropriate persons, the use of adequate techniques to broaden knowledge and a structured approach. To make this effective, it will be required to prepare a methodology composed of four stages: planning, extraction, analysis, and verification, which will serve as a guide for those conducting the process (LIOU, 1992). The planning stage is the first and most important, and its purpose is to understand the problem's extension in order to define scope and identify specialists. The extraction stage has as its key activity the acquisition of knowledge from specialists by means of sessions in which different tools may be employed in support of the technique selected. The data should then be analyzed and organized. Finally, the verification stage will serve to assess the work performed with the specialists (LIOU; WEBER; NUNAMAKER JUNIOR, 1990).

The concepts proposed by Liou (1992) were employed in this survey. First, the surveys were planned and their objectives, techniques, and tools to broaden knowledge, survey forms were clearly identified, and specialists were selected. Subsequently, group work and personal interviews took place, which created a large volume of information which was then organized and analyzed; the specialists were then called on to review the results.

2.6. Kendall's Coefficient

To make sure of the quality assurance with regard to the information obtained in the interviews, an analysis of the replies will be required in order to confirm the alignment among the specialists. The opinions provided by the persons interviewed depend on their sensitivity in assessing future situations, defining the probabilities of events occurring and the impact that the latter may cause to a project, if any. It is impossible to know which is the correct or more precise forecast, as these are opinions on facts that have not occurred yet, and which may or may not take place. Despite this limitation, the degree of alignment or agreement among the specialists may be confirmed, by comparing their order of risk priorities.

One of the ways for measuring alignment among specialists' opinions is by employing Kendall's correlation coefficient (MARKOWITSH; PRITZEL, 1977; SCHMIDT, 1997; CONOVER, 1980; SIEGEL; CASTELLAN, 2006; MARTINS, 2001). Okoli and Pawlowski (2004) state that there are different forms of measuring orders of priorities, but Kendall's concordance coefficient (*W*) is broadly recognized as the best.

The International Maritime Organization (2002) and Kontovas (2005) propose this coefficient's systematic use when performing risk studies of accidents with ships.

The W statistical test, known as Kendall's concordance coefficient was submitted independently by Kendall & Babington-Smith, and Wallis in 1939 (CONOVER, 1980), and measures the distance between opinions (KONTOVAS, 2005).

In order to calculate the W coefficient, in which k specialists rate priorities of N risks, employing natural numbers varying from 1 to N, a second formula is used, in which Rj is the sum of the posts for each item assessed, in a k by N matrix:

$$W = \frac{\sum\left(R_j - \frac{\sum R_j}{N}\right)^2}{\frac{1}{12}k^2\left(N^3 - N\right)}$$

The difference between each Rj and the sum of the Rjs divided by N cannot be considered the deviation based on the average. The numerator is the sum of the squares of the deviations, and may vary from zero to the maximum possible value, which would occur in case of a perfect concordance between the k sets of posts, in this case equal to the denominator, for which reason W will vary between zero and one only.

According to Conover (1980), if there were to be a perfect concordance among priority ratings, in other words, if all the priority ratings were exactly equal, the W coefficient's result would be 1; in the case of a perfect discordance or a total discordance among priority ratings, the W coefficient would be zero or close to zero.

Okoli and Pawlowski (2004) inform that there is a strong concordance among the opinions expressed by specialists in case W shows values above 0.7. Schmidt (1997) submitted Table 1 with an interpretation of the W values, which also shows a strong concordance for values above 0.7. The International Maritime Organization (2006) and Kontovas (2005) state that in the case of W values above 0.7, there is a good concordance. Table 2 shows the level of concordance suggested by the International Maritime Organization (2006), according to the W coefficient's values.

Table 1 - Interpretation of Kendall's coefficient
Source: Schmidt (1997)

W	**Interpretation**	**Confidence in the priority rating**
0.1	Very weak concordance	None
0.3	Weak concordance	Low
0.5	Medium concordance	Moderate
0.7	Strong concordance	High
0.9	Strong concordance (not usual)	Very high

Table 2 - Interpretation of Kendall's coefficient
International Maritime Organization (2006)

Concordance coefficient	
$W > 0.7$	Good concordance
$0.5 < W < 0.7$	Medium concordance
$W > 0.5$	Poor concordance

3. METHODOLOGICAL APPROACH

First a review was made of risk management and docking literature, for theoretical support, and then Transpetro's and the regulating bodies' specialists' and technical documents were selected. Subsequently, previous interviews were held with these specialists in order to make researchers familiar with oil tanker docking practices.

This initial stage is supported in the proposals of Liou (1992), who recommends planning as part of the knowledge acquisition process with a view to becoming acquainted with the extension of the problem, selecting specialists and defining the appropriate tools.

A method of research was then prepared and a Project Analytical Structure (EAP) was proposed with the specialists' assistance, which served as a basis for risk detection by employing a brainstorming technique.

This brainstorming lasted one day, and had the participation of professionals largely from technical engineering areas. They drew up a list of items that may be defined as risk events, causes or affects arising from these events. The specialists participated in organizing the material arising from the brainstorming session, and the end result was a list of deliverables with the risk events and their causes detected.

A Risk Analytical Structure (EAR) was prepared with the rating suggested by the Project Management Institute (2004): technical risk, organizational risk, external risk, and managerial risk, with the addition of one more class, that of HSE risks.

Once the risk events were rated, a questionnaire was prepared to specify the two variables in each risk event, their likelihood and impact. By virtue of the large number risk events detected, the specialists preferred to respond to a questionnaire containing likelihoods and impacts, in other words, which did not assess impacts on each project objective (time, cost, quality, and scope). According to the Project Management Institute (2004), an organization may rate risks separately in accordance with objective or may develop ways of determining a general rating for each risk.

The questionnaires were answered and a list was prepared rating the priority of the seventy-five risk events.

This priority rating listed the eight main risk events that were assessed above or equal to thirty-six, the product of likelihood times impact, on a scale from 0 to 10 with regard to likelihood as well as to impact.

In order to undertake a more detailed investigation of these eight risk events, a second questionnaire was prepared in order to verify the likelihood and impact in each of the project objectives: such as time, cost, quality, and scope.

The specialists completed the questionnaires in individual interviews, and based on the likelihood and on a further impact assessment on the project objectives, a priority rating was prepared of the eight risk events surveyed.

An alignment was also detected among the specialists who assessed the eight key risks.

A model was proposed and the conclusions were issued. Figure 4 represents the research model adopted.

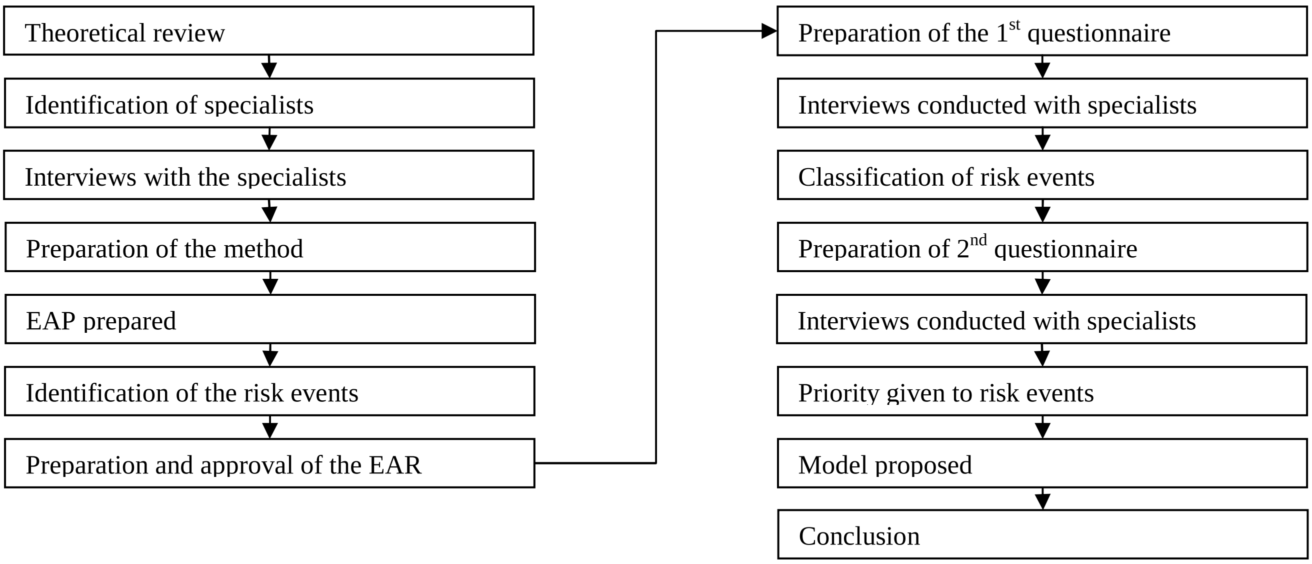


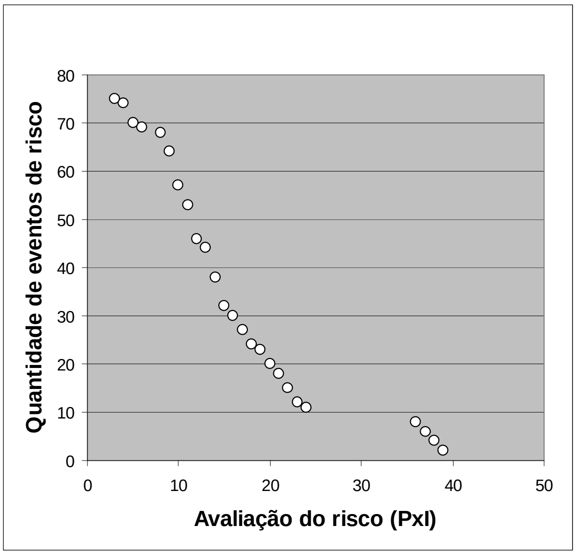
Figure 3 – Research model

4. RESULTS

Seventy-five risk events were detected and, after being analyzed and attributed their likelihood and respective impacts, were rated according to nature as well as to severity.

In order to assess likelihood as well as impacts, the geometrical average was employed instead of the mathematical average, as in accordance with Fischhoff, Slovic, and Lichtenstein (1978), the latter tends to be unnecessarily influenced by any occasional extreme values.

Graph 1 displays the number of risk events in relation to risk magnitude; for example, seventy-five events were assessed as above or equal to three, eight events were assessed above or equal to thirty-six. It will be seen in the graph below that there is a group of risk events separated from the rest, clearly indicating a boundary line for a rating; these are the eight risk events that obtained an assessment above thirty-six and were rated as high.



Graph 2 - Number of risks according to the assessment
Source: Prepared by the author.

Two ratings were prepared in this survey for risks, one in connection with nature – HSE, technical, organizational, external, and managerial, and another in connection with risk magnitude – low, medium, and high.

A combination of these two ratings is shown in Table 3, for a clearer vision of the risks likely to affect docking performance. It will be noted that thirty risk events were detected, which represent forty percent of the total and rated as: technical, organizational, or managerial, internal to the ships' operator and hence more likely to undergo immediate action. Please note also that four of these risks are rated as high and represent one-half of those rated as high.

Table 3 - Risk ratings

Rating	External	Managerial	Organizational	HSE	Technical	Grand total
High	3	1	-	1	3	8
Medium	17	2	9	2	6	36
Low	18	-	7	4	2	31
Grand total	38	3	16	7	11	75

Source: Prepared by the author.

The eight main risk events rated as high are: One for safety, environment and occupational health (HSE), three technical, three external, and one for project management.

These risks are:

- Delays in service provision owing to climate conditions (external);
- Deficient contractual technical specifications (technical);
- Contracted company has defaulted on agreed on term (external);
- Lack of qualified labor (external);
- Faults on compliance with program (managerial);
- Incorrect estimates for structural repairs (technical);
- Labor accidents in shipyard (HSE);
- Incorrect estimates for services in tanks (technical).

Once the key risk events were detected, it was decided to perform a new assessment, this time in greater detail, taking into consideration the impacts in each objective: such as time, cost, scope, and quality.

In order to consolidate results, the risk assessment was deemed to be a product of the likelihood of each risk times the greatest impact in objectives. For example: a risk had its likelihood of occurrence assessed as five, and the impact on cost assessed as two, six for quality, four for time, and three for scope.

Risk assessment = 5 x 6 = 30.

The rating priority shown in Table 4 was prepared based on the specialists' assessments, and number one represents a risk event deemed by a specialist as being the most severe and number eight as the least severe.

Table 4 - Priority ratings of key risk events

Risk event		Specialist						
Item	Description	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	Delay in service provision owing to climate conditions	5	6	7	7	7	6	6
2	Deficient contractual technical specifications	7	7	1	3	3	4	3
3	Contracted company has defaulted on agreed on terms	1	1	2	1	5	3	4
4	Lack of qualified labor	3	4	4	6	2	2	2
5	Faults on compliance with program	4	5	6	5	6	7	7
6	Incorrect estimates for structural repairs	2	2	3	2	1	1	1
7	Labor accidents in shipyard	8	8	8	8	8	8	8
8	Incorrect estimates for services in tanks	6	3	5	4	4	5	5

Source: Prepared by the author.

Kendall's coefficient was employed to measure alignment among specialists, resulting in 0.731 which in accordance with the International Maritime Organization (2002), means a good concordance level, and according to Schmidt (1997) there is strong concordance and great reliability in the priority rating.

5. FINAL CONSIDERATIONS

The survey was conclusive. The more relevant risk events for docking oil tankers were detected, their likelihood of occurrence was analyzed, with the respective impacts on the project objectives.

With these data in hand, the risk events were assessed bearing in mind the product of probability times impact, and the events deemed to be critical were given priority, permitting an assessment of the alignment among the specialists interviewed. A good alignment was found, meaning a good survey quality.

The survey was restricted to the initial risk management stages, in other words, to risk detection and assessment, and was not intended to prove that risk management may improve the performance of docking operations and to cover the response planning and risk monitoring stages. These stages, which were not covered in this paper, are the responsibility of each company and are strongly influenced by environmental factors.

As a suggestion for future studies, the development of a methodology could be submitted for the remaining risk management stages, their real case implementation, and the assessment of the results obtained in order to assess the risk management impact in ship docking projects.

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5. RESPONSIBILITY NOTICE

The authors are the only persons responsible for this paper’s contents.