RISK BASED DECISION MAKING APPROACH

DEVELOPED FOR INTERNATIONAL SHIPPING DOMAIN

BY ADAPTING FROM ASSET MANAGEMENT OF ENERGY INFRASTRUCTURES

ANIL KUMAR RAVULAKOLLU

TU Delft

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DEVELOPED FOR INTERNATIONAL SHIPPING DOMAIN BY ADAPTING FROM ASSET MANAGEMENT IN ENERGY INFRASTRUCTURES

By

Anil Kumar Ravulakollu

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Student number: 4510178

Thesis committee

Chairman:	Prof.dr. Y. (Yao-Hua) Tan
First Supervisor:	Dr.ir. R.A. (Rudi) Hakvoort
Second Supervisor:	Dr.ir. B. (Bert) Enserink
Third Supervisor:	Dr. B.D. (Boriana) Rukanova

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PREFACE

Some see what they believe and some believe what they see. In this report, I documented what I gathered and developed over last six months as a part of my thesis at TU Delft. The central idea of this report is to present the evolution of a decision making approach that is grounded in the principles of risk management and multi-actor study. The domain for which this approach is developed is the international shipping industry. The discipline from which this approach is inspired is asset management in the energy domain. Further, the approach developed is studied by placing it along the proposed large scale digital trade infrastructure of Data Pipeline. Therefore, this report covers general aspects of supply chain, risk assessment, energy infrastructures, actor analysis and digital infrastructures.

Since the thesis pans across different several topics, to aid the reader, the report is structured in a modular fashion. While each topic is dealt with separately, by providing just enough details, an attempt has been made to not let the reader stray from the line of argumentation. Further, the manner in which it is written, the reader can distinctly identify the specific chapters where different topics merge. Literature study, in Chapter 3, would give good amount of insights for those who are interested in gathering more information. But the report can still stand as a whole and be meaningful without the need for the reader to dwell too much in it.

As a part of thesis scope, a tool was developed using Visual Basic. Since the actual code could not be presented owing to its significant length, it might be that readers interested in coding and programming would find that missing. However, the functionality of the tool is detailed in the report and its interface is captured through screenshots to give a general idea of the tool.

Anil Kumar Ravulakollu
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A rock perching on top of a mountain is not any more significant than the one that is forming the base of that very mountain. I stand today, as I am, not without the support and influence of some important people in my life. Here is the chance to express my sincere gratitude to them and etch their contributions forever.

First and foremost, I would like to thank the members of my thesis committee individually beginning with my first supervisor, Dr.ir. Rudi Hakvoort. He was always crisp and clear in stating what was needed to be done and to what extent it needs to be done. He played a significant role in scoping my thesis and giving it a structure. As a second supervisor and also the programme director, Dr.ir. Bert Enserink was always there when needed. No matter what the issue was his smile gave an assurance and strength. Though she may be the third supervisor, Dr. Boriana Rukanova, played an immense role and been a mentor all along during my thesis. I can comfortably say that she was driving my work consistently. Finally and importantly, as the Chair of the committee Prof. Yao-Hua Tan was a guiding beacon by pointing me to the right direction at the right times and prodding me to think more critically. Thank you all for giving me a platform to express myself.

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Away from my course work, I find home among some amazing people. Yash, Chandru and Shrinivas were more like brothers than friends. The lousy cricket matches, long night chats, experimental cooking, guitar sessions, long cycle rides and foreign trips and much more are all recorded safely with me. No words for my close ones Raman, Vishal and Avinash for being there as always. Last but not the least, Roopasi was that one person who was there during the times of joy, sadness and even nothingness throughout these two years. Again, any words ascribed will fall short and let me leave it there.

I am not sure if this writing justifies the magnitude of gratitude that I bear within me for my family. Both my parents stood by me always even when I made some big decisions in my life and cannot thank them enough for letting me be and having trust in me. The other pillars of my life are my sister and my brother-in-law, and their being as pragmatic as possible when I go dishevelled with my thoughts helped me stay focussed. I also thank my aunt and uncle both paternal and maternal for being there when needed. Finally, my grandparents whose lessons and blessings have formed my core. Never a day has passed without me thinking of you all.

I thank you all once again, and all the others who in some or the other way went beyond their usual and helped me. I have missed several names, not intentional surely, but merely due to the trickery of my memory.

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EXECUTIVE SUMMARY

In an international trade, the process of shipping is initiated once the consignor procures the goods and begins packaging them for shipment. It ends after the shipment has been delivered at the designated location for the consignee to pick it up. Between these two events, numerous interactions occur and different players appear performing different roles. Broadly, the packed consignment is picked up by the freight forwarder at the export side, with the help of customs agent export clearances are obtained and consignment is loaded onto the carrier vessel. Once the vessel reaches the port of destination, similar activities occur until the freight forwarder brings the consignment to the pickup location. The export and import clearances involves inspections, scanning procedures and document verifications. In each of the several transactions occurring around the shipment, multiple flows of information happen. Today, shipping industry is a complex system involving multiple actors, multiple interests and intricate interactions occurring at different levels.

Like any other industry, international shipping industry is also feeling the strain of the rapid trends of globalisation and liberalisation. It would not be surprising if it is the one that is getting affected most owing to the increase in global trade. With the growing complexities and increasing pressure to modernize and streamline the shipping process is making the overall global supply chain scenario more vulnerable to inefficiencies. While all these happen, the concerns related to security and reliability continue to test the quality of the overall system. Any disruptions in the chain that occur in the shipping process could have high impacts on the process throughputs, time, and costs. Further, with a number of such events occurring there would be multiple impacts and accumulation of costs on individual actors operating in the system. There are number of ways in which disruptions could happen. However, in a dynamic multi-actor environment often actors themselves could be identified as both the source and the targets of these disruptions. In the literature, these disruptions are often referred to as operational risks. Unless these risks are well understood and prioritized based on the situational demands, the businesses will find it difficult operate in such complex actor-intensive system.

In energy industry, particularly in distribution sector, ***Risk Based optimization*** *(RBO)* approach has been in use to manage the large infrastructures and multiple assets. RBO approach has been effective in identifying and prioritising the risks affecting the performance of the assets. By employing this method, the electricity distribution companies have refined their decision making process pertaining to asset management. The decision are mainly investment decisions related to asset maintenance, upgradation and replacement. By using RBO approach, the electricity distribution companies have eventually been able to improve the quality of their business.

Similarly, in the shipping domain, if there is a process or a framework that can identify and prioritize the operational risks for each actor, it is highly likely that the quality of the shipping process would be improved. This thought conceived an idea of adopting the RBO approach from the energy domain to the shipping domain to enhance the decision making process of the businesses. One of the main challenges that was distinct at this stage was that RBO has not been applied before in a multi-actor setting. Clearly, RBO cannot be adopted directly as it is. It had to be adapted to fit the purpose of shipping industry. A research was thus taken up to investigate this idea and thereby to develop a risk based decision making (RBDM) approach for international shipping domain. In this regards, **the first research question** formulated was: *How can risk based optimisation approach, which is used in asset management in energy infrastructures, be adapted to improve the quality of international shipping?*

On the other front, it is well established in the literature and among the practitioners that global supply chain today suffers a considerable lack of visibility of critical data related to goods and events at different points along the shipping line. This issue of information fragmentation has several

implications among the actors in the system. For instance lack of information would lead to more inspections at Customs, while in the efforts of retrieving the data, thereby causing delays in the overall shipping time. As mentioned, these interruptions have cascading impacts in the shipping process. To tackle this issue, development of a large scale Digital Trade Infrastructure (DTI) called ***Data Pipeline*** is in progress under the project called CORE. The central aspect of this project is to enable all the authorized parties to have a digital access to the right information at the right time thereby making the process more transparent. By doing so, it is expected that the quality of overall operations along the shipping processes would be increased and eventually the quality of the supply chain to be enhanced.

If observed, the motivation for the development of both Data pipeline and the RBDM Approach is similar. Both of them aim to provide transparency to the parties operating in the field by providing the information of goods and events are different stages of the process. While one aims to make the system explicit by studying different operational risks, the other aims to connect the information systems of the different parties and organisation. Thus, it was interesting to explore the extent to which each of these concepts would corroborate each other in improving the overall quality of supply chain. In this regards, **the second research question** formulated was: *How can the quality of the global supply chain be further enhanced by integrating the developed risk based decision making approach with the data pipe line concept?*

Thesis Objectives

To answer first research question it is necessary to firstly to understand the core concepts of RBO methodology. Secondly, it is important to establish the extent to which the current risk management practices in the shipping industry are useful in facilitating decision making in a multi-actor context. Thirdly, it is essential to learn about the necessary multi-actor techniques that need to be incorporated in the process of RBDM Approach. And finally, the process that is developed has to be tested. In this research a prototype of the tool base on the developed RBDM Approach and validated.

The second research question, deals with realising the extent to which both RBDM Approach and Data Pipeline can work effectively towards achieving transparency in the shipping process and eventually improve the quality of global supply chain. They can achieve maximum efficiency not only working together but also by supplementing each other. In this regards, it is essential to identify the areas in which this can happen.

Thus, five objectives were identified and a sub-question was formulated catering to each objective to answer the two main research questions. They are shown in Table 1.

Thesis Methodology

To meet these objectives formulated at different levels, it is necessary to have a structured research methodology. Since the research is closely relate to the core aspects of information systems, a well-known **design science methodology** used in the domain of information systems research is adopted here. According to design science the need for research emerges if there is no immediate solution available to solve the problem in the practical *environment* where business operations occur. By conducting a *rigorous* research based on the available *knowledge base* available and through different *methodologies*, a *relevant artefact* as a solution to the problem is developed. The artefact is *assessed* and *refined* by conducting case studies and simulations. Once it is found that it meets the *business needs*, it is *applied* in the environment. Further, in the process of research if any new theories are developed then they are *added* to the existing knowledge base.

In this research the environment is the international shipping industry. The knowledge base comprises of the concepts of RBO method of the energy industry, the core concepts of risk assessment practices in shipping industry and the multi-actor theories. The methodologies to gather information from the knowledge base are the literature study and expert interviews. The artefact developed in this research is the prototype of RBDM tool based on the developed RBDM Approach process. This artefact was tested through face validation with the help of domain experts and by applying the tool on the trade lane of a fruit importing company called JamboFresh.

Table 1 Research Flow Summary

Research Sub-Questions	Objectives
a. *What is (are) the challenge(s) in using the current RBO approach of energy industry as-is in international shipping domain?*	To establish the shortcomings of RBO to be used as is in shipping industry
b. *What are the limitations existing in the current risk management practices used by the actors to improve the quality of their operations in the international shipping industry?*	To establish the shortcomings of the risk management practices in the context of decision making to improve the businesses
c. *What are the relevant multi-actor theories required to establish a sound process of RBDM Approach?*	To gather the required multi-actor theories to incorporate in the RBDM Approach
d. *How feasible is the developed conceptual framework of RBDM Approach to put to practice?*	To develop and test the prototype of RBDM Tool
e. *What are the potential ways in which RBDM and data pipe line can reinforce each other to aid the decision making process of the stakeholders in the supply chain?*	To study the manner in which both RBDM and Data Pipeline can supplement each other

Theoretical Foundation for RBDM Approach

The first three sub-questions of the research are answered by conducting a thorough literature study over three different topics and established a foundation for developing RBDM Approach. In the process of **answering the first sub-question,** study was conducted to understand the overall process of RBO method. It was observed that the energy companies usually as a part of RBO adopt the ISO 31000 framework of risk management to construct a risk matrix. It was identified that for making informed decisions related to asset management, it is essential to develop a well-designed risk matrix. However, to do so, there has to be a thorough understanding of the causes and the effects of risk events. One of the ways that aids this process is to follow the bow-tie framework. For development of RBDM Approach however, a mere adoption of RBO process is not enough. It has to be adapted for a multi-actor setting. Therefore, the main challenges for using the current RBO approach as-is in international shipping domain are that firstly, the process of developing risk assessment should incorporate relevant multi-actor concepts at every stage. Secondly, the framework of bow-tie has to be tailored to represent the dynamics of multi-actors. Thirdly, the risk matrix has to be actor-centric instead of asset centric.

The second sub-question was answered by exploring the different risk assessment frameworks practiced in the shipping industry. It was found that the risk management processes in general focus on specific areas of the industry. For instance, while some focussed on ship safety, some focussed on border security. However, most of them catered to the aspects of safety and health in shipping industry. Moreover, they were quantitative in nature and none of the risk assessment methods that were studied address the need for multi-actor considerations in the risk assessment process. With

regards to organisational decision making, most of the risk assessment practices recommend the treatment of risks through mitigation measures. However, since they only focus on specific areas for risk analysis, they fail to drive the decision making of the organisations in developing their businesses. Having said that, all the risk assessment frameworks had a similarity. They all recommend a step wise approach for identifying and managing risks. These steps were found to be similar as the process steps of ISO framework, as far as the activities and functions involved in the steps are concerned.

The third sub-question was answered by identifying the relevant multi-actor techniques required for developing RBDM Approach. It was found that often actor analysis techniques recommended in the literature explore multi-actor dynamics in four different dimensions, namely networks, perception, values, and resources. However, for a sound decision making particularly based on risks, it was realised that the system has to be explored in all the dimensions to certain extent. The network dimension gives the details about the actor interactions and interdependencies. The dimension of perception exposes the notions surrounding the risks at individual level. Through the dimension of values, the criteria to measure the risks can be established and through the dimension of resources, the strategies available to the actors to mitigate the risks can be identified. Thus it was concluded that by focussing on fundamental steps of actor analysis a more general approach is to be adopted into the RBDM Approach.

The following study dealt with exploring a typical shipping process along a trade lane. Several important actors were identified who were playing different functionary roles. The main actors are the consignor (the shipper), the consignee (the buyer), the freight forwarder, the international carrier, the shipping agents, the port authorities, Customs and the inland carriers. There were several interaction among these actors. At an international level, Incoterms determine the roles and responsibilities among the actors related to sharing of costs and risks. These terms are usually found in the contractual agreements between the shipper and the buyer. By knowing the nature of these terms, the interdependencies among the actors can be mapped.

Further, through the study on actor perceptions on risks in general, it was found that there are several psychological factors that influence the notions that the people construct around risk. Often the appearance of these influences or distortions depend on the way people feel towards risk and its outcome, the representation of the probability of occurrence of events, the presence of availability heuristics and the impact on the emotional levels of the people.

Development of RBDM Approach and the Prototype of the Tool

Taking leads from the findings of literature study, RBDM Approach was developed. The process steps of ISO framework were adopted to guide the development of RBDM Approach. Consequently, five phases identified similar to ISO framework were established. Within these phases the six basic steps of actor identification were incorporated as shown in Table 2. Each of the phases were discussed elaborately, by establishing set of guidelines based on the learnings from the literature. The outcome of the analysis phase is the risk centric bow-tie diagram and the outcome of the evaluation phase is the actor centric risk matrix.

To establish the process further, a working prototype of RBDM Tool was developed on Visual Basic platform in Microsoft Excel. The approaches followed to develop the tool were both top-down and bottom-up. Establishing the final objective of the tool as generation of a risk matrix at the decision making phase, a question of "what are the minimum requirements" was repeatedly asked till the system establishing phase. Once all the minimum requirements were identified, a bottom-up approach was used to build the code at every level to arrive till the evaluation phase where risk matrix is generated.

Table 2 Incorporating Multi-actor analysis in RBDM Approach

Phases of RBDM Approach	Multi-actor Analysis Steps
System Establishing Phase	1. Formulation of a problem
Identification Phase	2. Inventory of the actors 3. Exhibiting the formal chart
Analysis Phase	4. Mapping out the interdependencies
Evaluation Phase	5. Determining the actor perceptions
Decision Making Phase	6. Determining the consequences of the findings

The prototype developed, thus, uses several user forms to gather the data. The main components of the prototype are the dashboard to facilitate easy navigation, a risk analysis form for each risk with all the details of the risk event, an actor analysis form for each actor to capture the subjective data, risk register with a list of all risk events, and an actor register with a list of all the actors in the system and their functions. The main functions of the tool are generating a bow-tie diagram in a multi-actor context for each risk and generating a risk diagram in a multi-actor context for each actor.

Validation of the Prototype of RBDM Tool

The tool was built in a modular fashion process by process. At every stage of the tool development, the modules were tested with dummy data of varying nature. Once the tool was built as a whole, it was subjected to direct structure tests. This was done in two ways. First is the direct face validation with the help of domain experts of ICT (Information, Communication and Technology) and energy industry, who in this case were the thesis supervisors. Once confidence was gained regarding the functionality of the tool, the second stage of validation took place by testing it on the trade lane of JamboFresh.

As was mentioned, JamboFresh is a fruit trading company in Netherlands importing avocadoes from Kenya. It is an actor intensive trade lane. The key actors at the export side are the growers, the shipper, the freight forwarder, the inspection agencies, the international carrier and the export terminal. At the import side the key players are JamboFresh (the buyer), the import terminal, the Customs, customs agents and the inland forwarders. By interviewing the associates of JamboFresh and the expert form an international shipping company a list of 12 risk events with their causes and consequences were identified. Further, based on their information the interdependency map was developed. By feeding into the tool these inputs through its user forms, bow-tie diagrams for each risk event and risk matrix for each actor were generated. Later, the results were discussed with the associates of JamboFresh.

Several observation were made and recorded in the main sections of the report. They were helpful in answering the **fourth sub-question**. It was shown that employing RBDM Approach by the actors was feasible. However some critical features have to be in place for the tool to establish it effectiveness holistically. The tool should have feature related to ensuring data security, providing data connectivity, allowing access to only authorized personnel, and forming linkages with the real time data.

RBDM Approach and the Data Pipeline

The **fifth sub-question was answered,** firstly by analysing the features that Data Pipeline offers and studying the manner in which RBDM Approach can benefit from them. It was found that RBDM

Approach can be benefitted in three main ways. First, it can cope with the issue of information fragmentation that is prevalent in the shipping industry. Second, it can thrive by exploiting the piggybacking of the data. Third, is that the actors can pull the data without actually relying the other actors to provide that data.

Secondly, by following the converse approach, the benefits the Data Pipeline could have by linking with the RBDM Approach were realised. This can happen in three ways. First, RBDM Approach could facilitate the articulation of values of different stakeholder along shipping line. Second, through continuous processing of data, based on the flow of events along the bow-tie, an alerting mechanism could be established to the actors. Third, by prioritising the risk events RBDM Approach can improve the decision making related to synchro-modality. Thus it can be established that both RBDM Approach and Data Pipeline have capability in reinforcing each other and thereby work towards achieving an improved quality in global supply chain.

Answering the Main Research Questions

First Research Question: RBO Approach was adapted by coping with the challenges posed by RBO approach of energy industry. It does so firstly by incorporating the relevant steps of actor analysis in the ISO framework. Secondly, by constructing the risk centric bow-tie diagram in a multi-actor context by analysing the interdependencies among the actors in the system. Thirdly, by generating an actor-centric risk matrix in a multi-actor context by establishing impact scales which are subjective to each actor.

RBDM Approach was adapted by narrowing down the limitations offered by current risk management practices that are employed by the actors in the international shipping industry. It does so in four ways. Firstly, it is not restricted a particular focus areas and can be applied to study risks beyond just safety and health. Secondly, RBDM Approach facilitates both qualitative and quantitative approaches in risk assessment process. Thirdly, RBDM Approach improves the operations of the business by encouraging them to identify the KPIs based on the organisational goals and interests. Fourthly, RBDM Approach is flexible in accommodating the other risk assessment frameworks.

RBDM Approach was adapted by incorporating the relevant multi-actor theories in its process. It did so in multiple ways. Firstly, it absorbed the six general steps of actor analysis to explore the dimensions of networks, values, perceptions and resources. Secondly, it focusses on understanding the formal and informal relations among the actors in the identification phase. Thirdly, it takes a precautionary approach towards gathering the distorted information around risks through influenced actor perceptions.

The feasibility of RBDM Approach was studied by developing a RBDM Tool that can be used by the practitioners in the shipping industry. Though it was found that it is possible to be used, the effectiveness on the overall decision making process of the organisation was not realised.

Second Research Question: It was established that both the concepts work towards improving the visibility of the supply chain. It was discussed earlier that both these concepts can reinforce each other and further enhance the overall quality of the supply chain. From the perspective of RBDM Approach, the main advantage is that the Data Pipeline offers an access to the real time data. This information availability enhances the capability of RBDM enormously, mainly because the main limitation of the Approach is to gather the reliable data. From the perspective of Data Pipeline, it can exploit the advantage of articulation of values of different actors across the shipping line. This articulation enables the actors to work towards minimizing risks that affect their organisational objectives. Thus having a link between Data Pipeline and RBDM Approach presents a strong motivation for the stakeholders to invest in the concept of Data Pipeline.

Recommendations

After identifying different limitations both in the research and in the RBDM Approach developed, few recommendations were identified. They are as follows.

- Companies, organisations and individual operators can adopt the RBDM Approach in its current form to study their internal processes more thoroughly and also identify risks both within their organisation and beyond to certain extent. The societal impact that RBDM Approach can have immediately depends on extent to which the actors incorporate the approach as a part of their organisational procedures.
- RBDM Tool has to be used to study the inputs from various other actors along the trade lane. This will help in exploring and realising the complete potential of RBDM Tool.
- There is a scope of exploring and demonstrating the capability of RBDM Approach to accommodate different risk assessment frameworks and techniques. This will allow the organisations to readily adopt the new approach without replacing their old methods of risk assessment entirely.
- RBDM could be integrated with other analysis techniques which are suitable to analyse the aspects of multi-criteria dynamics in a multi-actor context.
- The RBDM tool can be further developed to have improved data security features and computational ability. An advanced and capable programming platforms like Python and C++ can be used to accomplish this.
- It is highly recommended for the RBDM Approach to be linked with the digital infrastructures, like Data Pipeline, that are capable of gathering the real time data of the events and activities of actors across the shipping lane.
- RBDM Approach has a possibility of being industry independent and a standalone decision making tool. It would be worthwhile to develop it in this direction so that it can be applied to any multi-actors systems.
- Finally, to substantiate the current knowledge base, adapt and structure RBDM Approach according to the academic standards thereby to establish it as a comprehensive framework to facilitate an effective decision making based on risk assessment in a multi-actor context.

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1. INTRODUCTION

Supply chain, as we know today, is a series of interactions in the form of business activities, information exchanges, material flows, and financial transactions occurring around a product from its raw material stage to its finished and delivery stage (Mentzer et al., 2001). With the increase in globalisation and the countries movies towards more open markets for trade, international shipping lines are getting busier and complex. In such system of intricate linkages, any unplanned or an unexpected event, often can have a high impacts on businesses and operators participating in the trade lane (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007). Particularly, in the domain of international shipping, owing to its multi-actor setting, the impacts can vary depending on the roles, functions, interests, values and perceptions of the actors. Inadvertently, these impacts would lead to increased costs for the actors in the process of either recovering from the damages or setting up damage controls. These undesirable events result due to the factors associated with both the uncertainties prevailing in the domain and the human errors. At a broader level, these factors can be either external or internal (Kandakoglu, Celik, & Akgun, 2009; Pruyt, 2013). External factors refer to the uncertain and uncontrollable factors like disruptions due to harsh weather or a political turmoil. Internal factors refers to the ones which are caused by activities and events which are in control of one or more actors. Lack of providing valid documents about the goods for getting could be one of the internal reasons which can cause a delay in the shipping process. Unless these factors are identified clearly with respect to each actor in the domain, undesirable events keep occurring. Further, due to the inherent complex nature of shipping industry, several transactions lack visibility (Hesketh, 2010). This makes it also difficult to identify the actors involved in these events and thereby, making the distribution of the costs incurred, fairly among them, not simple.

These events when positioned between cause and consequence, can be familiarly categorized as operational risks (Lewis, 2003). Managing these risks, in international shipping industry as of now, is largely limited to the organizational boundaries of a particular actor. Perceiving an event as a risk is generally subjective, especially when there are different actors with diverse interests. However, with a prevalent interplay of several actors, an action (or a missed action) of a particular actor can trigger series of events impacting other actors downstream in the supply chain. The severity of impacts of such risk events can vary for different parties. For an actor, most of the decisions related to business sustenance and development are centred on managing costs. To improve such decision making in shipping industry today, it becomes essential to evaluate the risks based on the impacts and thereafter prioritize them. A promising approach to facilitate this could be learning from the risk based optimisation (RBO) method of the energy industry. It is a method to optimise resource allocations of a company and has been particularly effective in managing assets of the capital intensive energy companies (Wijnia, 2016).

RBO essentially deals with decision making process beginning with identifying the risks and prioritizing them based on a parameter. Risk identification, which includes identifying causes and consequences, takes place through a structured and deliberate process by closely observing the life cycle of the assets. The likelihood of occurrence of the identified risk events are usually estimated based on a statistical analysis of the historical data. Later, the impacts of the risks on chosen parameters, which are usually key performance indicators (KPI) of the company, are estimated. These impacts are graded according to established impact scale for each KPI. The risks are then placed in an x-y coordinated matrix called the risk matrix or the impact-likelihood matrix with level of impact and levels of likelihood of occurrence as the axes. This visualization facilitates in prioritizing the risks. There upon, a process optimization is achieved by focusing the resources on the risks that need immediate attention. In the case of asset management in energy infrastructures,

cost is considered as the optimization parameter and by targeting low cost-benefit ratio, risk matrices are employed (Wijnia, 2016).

In this regards, a similar approach can be employed in international shipping domain to make the system more explicit and thus providing clarity to the operators in the shipping line. Thus based on the prioritized risk events they can optimize or rather strategize their business operations thus making their decision making process more equipped. However, it can be clearly noted that RBO cannot directly be adopted and applied in shipping domain. The main reason is that energy industry is asset intensive and shipping domain is actor intensive. Therefore, this research deals with understanding the concepts of RBO used in energy industry and thereafter adapting it to shipping industry as Risk Based Decision Making (RBDM) Approach by incorporating a multi-actor dimension to the risk analysis.

Meanwhile, envisioning an efficient and secure system of shipping of goods globally, a consortium comprising of several public, private and research organisations are participating in the CORE Project[1]. It is funded by European Commission under the Seventh Framework Programme. As a part of this project, the effectiveness of a Digital Trade Infrastructure (DTI) called the Data Pipeline is being evaluated. The main objective of the pipeline is to enable more transparency in the shipping trade lanes and to increase the efficiency by eliminating the bottlenecks. It facilitates the collection of critical data required for different actors across the shipping lane. In other words, it would reduce the uncertainties prevailing in the international trade lane and thereby improve the quality of the shipping process (Klievink et al., 2012). Since, risk management also operates in the presence of uncertainties, it becomes interesting to see how RBDM if linked with data pipeline can enhance further the quality of the shipping process. This is the second focus area of this research.

To establish the context of the research more firmly, there is a need to have some insight on the three areas with which the research deals. Section 1.1.1 discusses more on the current state of Shipping Industry at a general level with regards to risks and their impacts. Section 1.2 highlights the association of two main discipline in the energy industry which are risk management and asset management. The third area related to DTI and data pipeline are introduced in section 1.3.

1.1.1 International Shipping Industry As-Is

The complexities of supply chains are intensifying under the influence of rapid globalization. Several countries are opening up the markets by embracing the policies of liberalization. To sustain in the such dynamic and competitive market, businesses and enterprises began developing various strategies like "outsourcing, supply-base rationalization, just-in-time deliveries and lean inventories" (Council, 2011). Though these strategies improved the effectiveness of the supply chains, they are also making shipping industry more complex and thereby making the supply chains vulnerable to breakdowns or failures (Council, 2011; Tummala & Schoenherr, 2011).

Shipping, as being referred to here, comprises of all the activities that take place around the shipment from the time the consignor (producer/supplier) packages the shipment to the time the consignee (consumer/customer) receives it. In other words, this industry encompasses all the processes that take place in the distribution phases of a supply chain (highlighted in Figure 1). The processes typically involve interactions among different actors in the form of physical transactions, financial exchanges, and information flows. Particularly at international level, these processes are associated with importing and exporting activities of goods.

As the supply chains are get lengthier, the reliance on international shipping keeps increasing. To facilitate efficient supply chain management, shipping industry has to cope with this growing dependence. One of the ways is to lower the vulnerabilities of the industry to the possible threats and risks that can impact the stakeholders. These impacts, based on their severity for each stakeholder,

[1] More info on CORE Project is given in Appendix C.

can determine the efficient working of supply chain. This means that not only an effective risk management system should be in place but also an effective risk based decision making approach should be adopted by the players operating in the shipping industry.

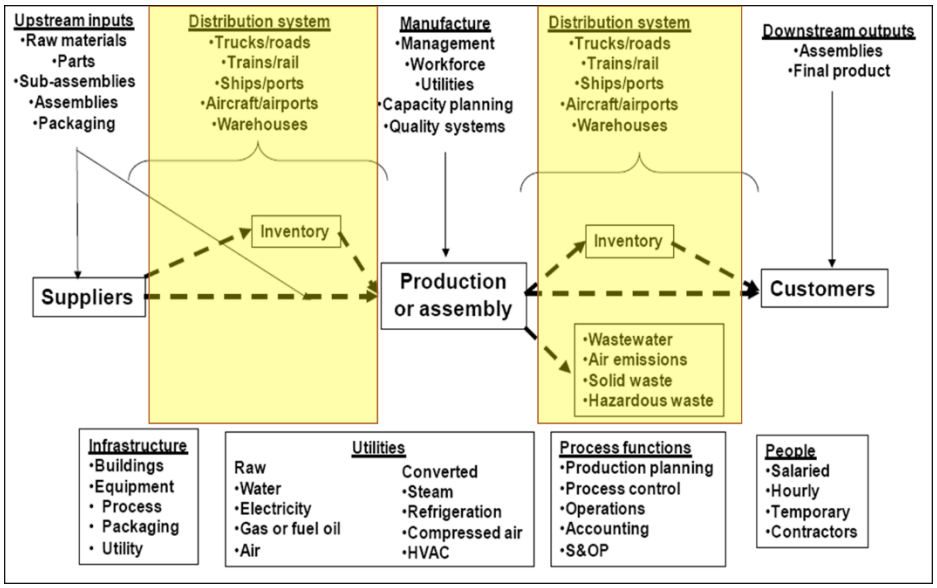


Figure 1 Notional Supply-Chain Process Flows (Council, 2011)

Tummala and Schoenherr (2011), in their paper, conceptualized supply chain risks by building upon various definitions provided by different authors. They identified a supply chain risk "an event that adversely affects supply chain operations and hence its desired performance measures, such as chain-wide service levels and responsiveness, as well as cost. Regardless of the area of interest, risk is associated with an undesirable loss, i.e. an unwanted negative consequence and uncertainty." Based on the works of Chopra and Sodhi (2004) and Schoenherr et al. (2008), they have listed different categories of risks along with their triggers (shown in Table 3). Though this list might not be exhaustive, it is comprehensive in providing an overall understanding of the vulnerability of supply chain. However, for the players in shipping industry, to make sound decisions regarding their business, it is important to realise the actors who are invloved in each of these triggers and the extent to which these risks could impact them.

The risks and threats leading to supply chain failures often arise due to the inherent dynamic nature of the shipping industry. With the presence of several interplays of actors, businesses and organisations, supply chain risks are not restricted to the organisational boundaries. A single risk event could have different impacts on different actors. Multiple such events could often lead to accumulation of costs on a single actor.

To illustrate, for instance if the information about the sea carrier vessel arriving either too late or too early was not conveyed to the freight forwarder (FF), additional costs are incurred at both FF and the company's warehouse for either waiting long or not being able to claim the shipment. The causes of this event can be a human error of not sending a notification on time, or a human error of not being able to receive the notification, or even may be that there is no system in place to send the notification. To reemphasize, a holistic approach needs to be taken to assess both the impacts and causes of a single risk event.

Table 3 Supply Chain System Risk and their triggers

Risk Category	Risk triggers
Demand risks	Order fulfilment errors
	Inaccurate forecasts due to longer lead times, product variety, swing demands, seasonality, short, life cycles, and small customer base
	Information distortion due to sales promotions and incentives, lack of SC visibility, and exaggeration of demand during product shortage
Delay risks	Excessive handling due to border crossings or change in transportation mode
	Port capacity and congestion
	Custom clearances at ports
	Transportation breakdowns
Disruption risks	Natural disasters
	Terrorism and wars
	Labor disputes
	Single source of supply
	Capacity and responsiveness of alternate suppliers
Inventory risks	Costs of holding inventories
	Demand and supply uncertainty
	Rate of product obsolescence
	Supplier fulfilment
Manufacturing (process) breakdown risks	Poor quality (lack of compliance standards)
	Lower process yields
	Higher product cost
	Design changes
Physical plant risks	Lack of capacity flexibility
	Cost of capacity
Supply (procurement) risks	Quality of service, including responsiveness and delivery performance
	Supplier fulfilment errors
	Selection of wrong partners
	High capacity utilization supply source
	Inflexibility of supply source
	Poor quality or process yield at supply source
	Supplier bankruptcy
	Rate of exchange
	Percentage of a key component or raw material procured from a single source
System risks	Information infrastructure breakdowns
	Lack of effective system integration or extensive system networking
	Lack of compatibility in IT platforms among SC partners
Sovereign risks	Regional instability
	Communication difficulties
	Government regulations
	Loss of control
	Intellectual property breaches
Transportation risks	Paperwork and scheduling
	Port strikes
	Delay at ports due to port capacity
	Late deliveries
	Higher costs of transportation
	Depends on transportation mode chosen

Further, during the course of shipping process it is likely that multiple risk events can be fired during a particular period. While it is good to have them all resolved, often it is costly and time consuming to attend to all of these. Considering that each risk event could have different levels of impact, to optimize the shipping process it becomes important to prioritize these risks and thereby, delegate the resources required for risk management accordingly. The question now becomes, for whom in the chain of shipping process these risks should be prioritized. This is in the view that sometimes in a particular process of shipping a high risk for an actor could be a low risk for another actor. At the same time, if shipping as a whole is considered, there are some risks that need to be given high attention. These can be risks leading to increase of overall carbon footprint or increase of delay time. This means risk assessment should be subjective to accommodate the values of each actor and at the same time objective to meet the norms and objectives of the shipping process as a whole.

In a multi-actor setting, risk events can often be triggered due to the causes which are outside the boundaries of operation of a particular affected actor. For example, in the case of this company, a risk event of missing info at customs could have been triggered by the shipper having not included the required documents in the shipment. This affected the actors like customs, FF both at export and import side.

As far as improving the businesses of operators in shipping industry is considered, the various risk assessment methods used fall short mainly on two fronts. Firstly, for long, risk management methods in the industry have been largely limited to assessing risks related to safety, health and environment. They have not been used effectively to identify and evaluate operational risks affecting the businesses through impacts on costs, time, reputation, and so on. Secondly, the context of multi-actor setting is neglected while assessing risks and correspondingly carrying out organisational decisions. Section 3.2 throws further light on these aspects by exploring different risk assessment methods used in the shipping industry.

1.2 Risk Based Optimization for Asset Management in Energy Industry

Energy industry here refers to electricity power industry which includes electricity generation, distribution and sales. This industry is asset-intensive and in particular the daily operations of distribution networks depend on the performance of their physical assets. These networks typically include large numbers of physical installations like overhead lines, underground cables, substations and transformers. With the growing requirements for environmental, safety and regulatory compliances, organisations are driven to optimize the performance of their assets using scarce resources (Deloitte, 2015). While taking decisions concerning assets Schneider et al. (2006) identified four key challenges for the distribution companies: "alignment of strategy and operations with stakeholder values and objectives; balancing of reliability, safety, and financial considerations; benefiting from performance- based rates and living with the output-based penalty regime". With physical assets and infrastructures making the core essential elements for an electricity distribution, asset management has become an important area of focus for organisations.

According to Publicly Available Specification 55 (PAS 55) developed by Institute of Asset Management (IAM) and British Standards Institution (BSI), asset management is a "*systematic and coordinated activities and practices through which an organization optimally manages its physical assets, and their associated performances, risks and expenditures over their lifecycle for the purpose of achieving its organisational strategic plan*" (BSI, 2004). This definition reflects the importance of achieving a balance among costs, risks and performance of assets throughout their life cycle.

Since around a decade, organisations have been adopting risk based approach to manage their assets. These approaches have been effective not particularly in reducing risks, but in achieving a balance between operational performance and life cycle costs of the assets. By rationalizing the levels

of exposure to risks that are acceptable to the stakeholders, asset managers are able to take better decisions related to their expenditures. In 2013, Deloitte Touche Tohmatsu Limited (DTTL) conducted a survey covering 40 different energy companies worldwide to understand their asset management strategies. They observed that around 95% of the respondents have incorporated at least partially the risk based optimisation approach in their asset management policies (Deloitte, 2015).

The two international standards that practitioners use widely for their asset management are ISO 55000 series and PSA 55. ISO 55000 series consists of three standards on different aspects of asset management. ISO 55000 gives the overview and basic terminology of asset management; ISO 55001 lays down the requirements for an asset management system; and ISO 55002 specifies the guidelines related to application of ISO 55001. PAS 55 is divided into seven sections: (1) general requirements, (2) asset management policy, (3) asset management strategy, objectives, and plans, (4) asset management enablers and controls, (5) implementation of asset management plan(s), (6) performance assessment, and (7) improvement and management review. Both these standards assign high importance to risk assessment in the process of asset management. In ISO 55001, risk management methodology is detailed elaborately in section 6.1. PAS 55 dedicates sections 4.2 (d), 4.3.1 (e), 4.3.2 (h), 4.3.3, 4.3.4 (a) and (c), 4.4.1 (g), and 4.4.7 to risk management (Minnaar, Basson, & Vlok, 2013; Woodhouse, 2014).

Further, these standards not only encourage the practitioners to assess their risks, but also empower them to take well informed consistent decisions regarding activities "that impact asset-related risks, performance, and cost profiles" (Minnaar et al., 2013). Risk based optimisation for asset management is being mainly used in prioritizing the investment decisions (Deloitte, 2015). These decisions usually pertain to investments in maintenance, timing of upgradation or replacement, and making choices among the available technical alternatives. While each organisation has their own approach in devising decisions regarding investments based on risks, the broadly used tool in the industry is the risk matrix (Wijnia, 2016). After evaluating and quantifying the risks, they are placed in corresponding grid cells formed by scaling impact on one axis and likelihood of risk occurrence on another axis. The process of RBO is discussed in detail in section 3.1.

The intervention decisions over these risks follow the priority based on the region in which these risks fall. Typically four kinds of decisions are recommended based on the position of the risk: (1) transfer the risk (for example having an insurance scheme for the asset), (2) reduce the impact (for example by having emergency response plans in place), (3) reducing the likelihood (for example by investing in maintenance) and (4) accepting the risk if the impact is low (for example using the asset till the end of its life before replacing when there is no immediate impact).

1.3 Digital Trade Infrastructure of Data Pipeline

Research in information systems took off more than two decades ago. Propelled by the growth in technology, the research began focusing on developing digital infrastructures that can radically sway the societies at a large scale. Emerging initially as a concept during the process of modernizing infrastructures like electricity grids, digital infrastructures development has penetrated into other sectors (Tilson, Lyytinen, & Sørensen, 2010). Particularly in the domain of trade, concepts of Single Window, National Community Hub, and Data Pipelines have emerged as a part of development of digital trade infrastructures (DTI) (Henningsson, Henriksen, Rukanova, & Tan, 2016).

In international shipping industry the inefficiencies related to time, cost and security arise predominately due to the dearth of availability of timely information about transactions and actor interactions. In their paper Klievink et al., (2012) highlight that due to the complexities arising from extended supply chains, the stakeholders, particularly buyer and seller, endure the supply chain processes through second hand information which itself is usually filtered or even at times altered. The activities which led to the clouding of the actual information are often the outsourcing of shipping

process to third parties, consolidating the cargo, deploying multi-modal transport chains, assigning complicated contractual terms, and even non-disclosing the information due to commercial reasons. Moreover, for customs and border agencies, to regulate the flow of goods having supply chain visibility is a top priority. Currently most, if not all, of the information exchanges are paper based transactions. Typical transactions and requirements across the trade lane are depicted in Figure 56 in Appendix C.

In this context, the concept of data-sharing infrastructure in the form of data pipeline evolved to provide the actors better access to secure and quality data. The main motivation for data pipeline arises by observing the benefits of inter-organisational information sharing digital infrastructures like internet, extranet, and electronic data interchange (EDI) (Klievink et al., 2012). Currently, various parties operating in global supply chain already use some form of information systems (Overbeek, Klievink, Hesketh, Heijmann, & Tan, 2011; van Stijn et al., 2011). Data pipeline seeks to link these systems which are now operating in a fragmented manner to have "one integrated access point" (Klievink et al., 2012). Figure 2 shows different data from various sources in a trade lane. A data pipeline, thus, is a digital infrastructure that transcends the organizational boundaries, and facilitate the availability of information and thereby improve the efficiency of the international trade systems.

While discussing the concept of data pipeline, Klievink et al., (2012) identified following advantages it for the overall trade lane.

- As mentioned earlier, data pipeline increases the transparency across the supply chain. This increased visibility will benefit both the commercial operators and government organisations involved in the supply chain.
- Data pipeline facilitates the "piggybacking" of data, which means that data collected can be re-used for other purposes. This is particularly important for government actors to assess the risks, smoothen the process of customs clearance and inspections.

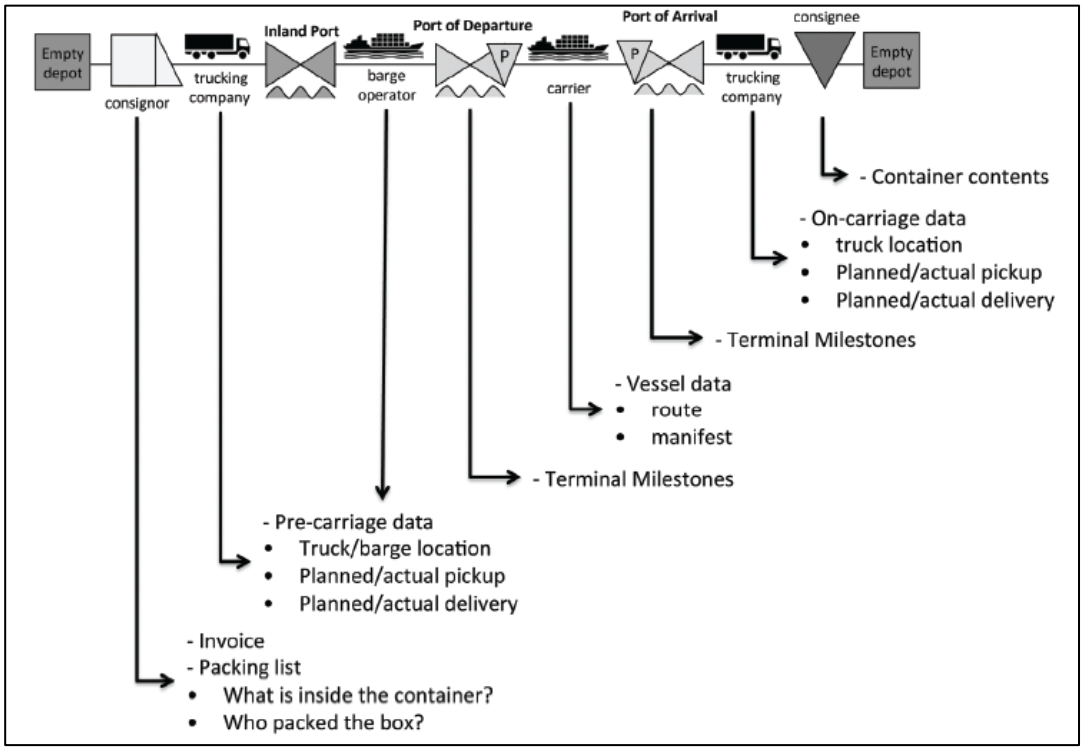


Figure 2 Different data from various sources in a trade lane (Klievink et al., 2012)

- The principles of system-based approach can be deployed where government agencies can assess the businesses of the operators by understanding their internal systems and procedures. With the current nature of document sharing philosophy, the information remains locked with a particular actor as long as that actor does not "push" the documents to another party. However by accessing the data directly, in other words through a "pulling" action, the government can study the businesses.
- Data pipeline can directly enable synchro-modality effectively. This means that by having the first hand timely information the operators can quickly make decisions on choosing the right kind of mode of transport based on the situational demands.

While proposing the Digital Trade Infrastructure (DTI) Framework, Henningsson et al. (2016) identified three dimensions along which framework is structured, namely architecture, process, and governance (see Figure 4). Architectural component describes the DTI schematic at a meta-level. Process component identifies the phases through which the process occurs. The Governance component lays down the contextual rules, regulations and the rights. In this regards, as proposed by the authors, the architectural component of the proposed data pipeline infrastructure would compose of two components. One being thin data pipe line and the other being thick data pipelines, depending upon the nature of exchanges that occur. Thick data pipeline deals with the actual physical exchange, whereas thin data pipeline deals with the information about the events of these occurrences (Henningsson et al., 2016).

According to Tilson et al. (2010), development of large scale socio-technical digital infrastructures through research is laden with inherent paradoxical natures of both change and control of these infrastructures. In their words, on one hand paradox of change emerges from the "characterization of digital infrastructures as unbounded, evolving, shared, heterogeneous, and open installed bases of capabilities". On the other hand, the paradox of control follows from the notion that for the evolution of digital infrastructure, "opposing logics of centralized and distributed control (or individual autonomy)" play equal roles. This discrepancy is highly relevant for the development of digital trade infrastructure of data pipeline. Paradox of change in data pipeline concepts can be noticed by realising the disturbances caused by evolving technologies in the information systems like block chain technology. Paradox of control can be seen from the requirements of having overall visibility at the same time having increased security. Though the advocates of the data pipeline concept point out that the access to information would be granted only to authorised operators, having central control point is vulnerable to cyber threats (Klievink et al., 2012). Further, for data pipeline to materialize, an effective market driven approach has to evolve. This is so mainly because for the governments to extract funds to deploy such infrastructure at global scale is impractical. Unless the stakeholders are actively involved, adoption of data pipeline would remain as an abstract possibility.

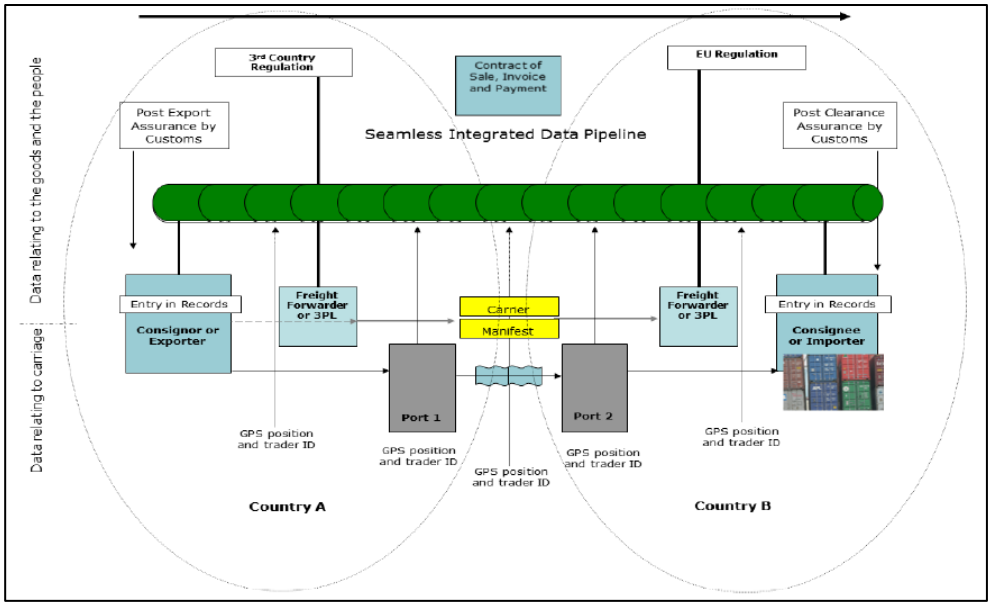


Figure 3 Concept of data pipeline across shipping lane (Klievink et al., 2012)

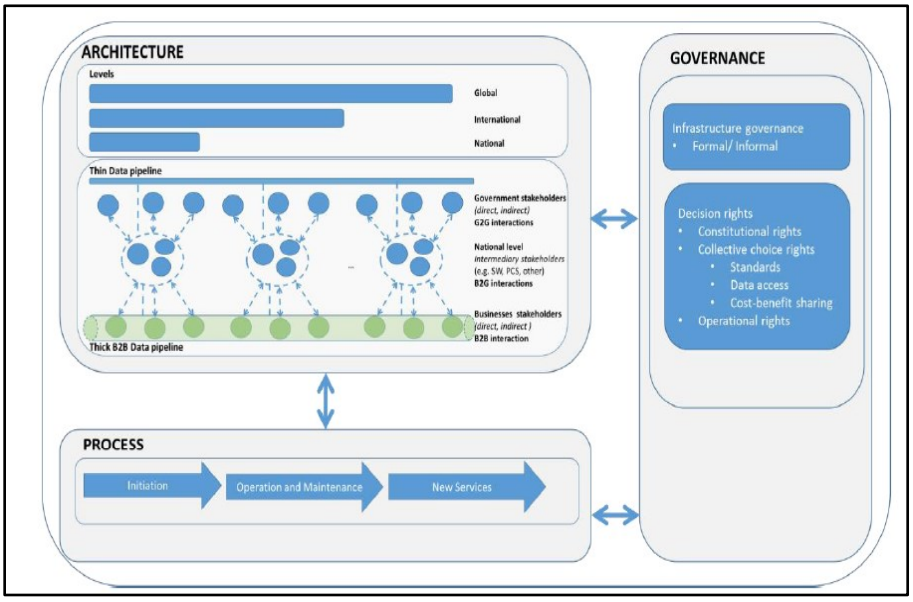


Figure 4 Visualization of DTI Framework (Henningsson et al., 2016)

2. THESIS DEFINITION

In the introduction it was stated that this thesis is an attempt to learn risk based optimisation approach from the energy industry, and to employ it in shipping industry to improve the decision making of the actors regarding their business and operations. In the previous sections an overview of three different topics that form the context and motivation for this thesis have been discussed. This section establishes the connection between these three topics and formulates the objectives for the thesis.

2.1 Thesis Objectives

It was discussed (section 1.1.1) that in international shipping domain, risk events when triggered, would have implications beyond organizational boundaries of a single actor. These events not only accumulate costs for dependent actors but also make the decision making of actors regarding business development more complex. The following section 1.2 shifted the focus to asset management in energy industry and highlights the importance of risk based optimisation approach in lowering the organisational costs. The step wise risk assessment processes offered through RBO method aid in identifying, structuring and prioritizing risks. In energy industry it is facilitating the decision making of organisations largely pertaining to investing in either equipment maintenance or equipment upgradation. In shipping industry also, decision making tools related to businesses development are needed to improve the quality of supply chain. The difference between the two industries is that decisions are taken based on performance of assets in energy domain while they are based on the events and actions predominately by other business and parties. In other words, the environment is more dynamic in shipping industry with interplay of different actors. Though lowering overall costs is the main driver for both the industries, in addition to that time factor also plays an important role in shipping domain. Therefore, the existing RBO has to be modified to develop a different RBDM Approach to address the complexities of international shipping domain in improving the quality of supply chain. In this regards, the first research question to drive this thesis is:

1. ***How can risk based optimisation approach, which is used in asset management in energy infrastructures, be adapted to improve the quality of international shipping?***

This question cannot be answered satisfactorily without having a holistic approach in understanding the context. Firstly, the gaps posed while deploying the RBO as-is in the shipping industry have to be exposed. This shall determine the extent to which it can be adopted and establish the additional features and aspects that would be required to adapt the concept to shipping domain. The sub-question that shall drive this objective is formulated below.

a. *What is (are) the challenge(s) in using the current RBO approach of energy industry as-is in international shipping domain?*

Secondly, it is necessary to realise the manner in which the risk management practices used in shipping industry currently fall short in facilitating sound decision making related to development of businesses and operations of the parties in the industry. This is relevant because for RBDM Approach to be adapted it has to meet the short comings of these practices and also to a certain extent be flexible in incorporating these practices. In this regards, the second sub-question is formulated as follows.

b. What are the limitations existing in the current risk management practices used by the actors to improve the quality of their operations in the international shipping industry?

Based on these findings, a ground work could be laid developing for a RBDM. However, it does not answer the main research question entirely. It was mentioned that shipping industry is actor intensive and the methodology that needs to be developed has to be applicable in a multi-actor setting. Therefore, for the method to be comprehensive it is important to explore the theories related to actor analysis.

c. What are the relevant multi-actor theories required to establish a sound process of RBDM Approach?

Adaption means that the Approach is capable of being incorporated by the operators in their organisational decision making process. Therefore, in addition to the above question, it is also essential to check the feasibility of putting the concept to practice. In order to do so, a prototype of RBDM tool is to be built and demonstrated. The following sub question helps in doing so.

d. How feasible is the developed conceptual framework of RBDM Approach to put to practice?

In the previous section, the concept of data pipe line was briefed upon. It was highlighted that by introducing data pipe line infrastructure in supply chain the issue of information fragmentation would be mitigated and thereby the visibility of supply chain to the actors would be improved. In other words, data pipeline is aiming to lower the uncertainties in the supply chain and thereby improve its performance. If observed closely, the objective of RBDM Approach that is being developed in this thesis is converging with one of the objectives of data pipeline that is to provide visibility to the actors and aid in improving their organisational decision making. Based on this coherence between these two concepts the second research question driving the thesis further can be formulated.

2. How can the quality of the global supply chain be further enhanced by integrating the developed risk based decision making approach with the data pipe line concept?

Further, if RBDM Approach is linked with Data Pipeline, it is possible that both of them can supplement each other. Data pipeline is needed for RBDM Approach because, risk analysis depends heavily on the actor and event information. Once the information is quickly available, the organisations can take well informed decisions using RBDM Approach. Thus, by realising the advantages the Data Pipeline would offer to the stakeholders in the shipping lane, they would be interested in investing in the development of Data Pipeline. On these lines it is necessary to identify the potential areas where both can supplement each other. Therefore the sub question that is formulated in this regards is:

e. What are the potential ways in which RBDM and data pipe line can reinforce each other to aid the decision making process of the stakeholders in the supply chain?

The research proposed in this paper has two main components. First component deals with modifying the existing RBDM method commonly used in the energy infrastructures to suit the international shipping domain. The second component deals with integrating the modified RBDM with the data pipeline that is being developed as a part of CORE EU project. Table 4 summarises the objectives of this thesis.

Table 4 Thesis Objectives

Research Question		Objectives
Question 1	***How can risk based optimization approach, which is used in asset management in energy infrastructures, be adapted to improve the quality of international shipping?***	To Adopt RBO form energy industry and to adapt it to shipping industry as RBDM Approach
Sub-Question a	• *What is (are) the challenge(s) in using the current RBO approach of energy industry as-is in international shipping domain?*	To establish the shortcomings of RBO to be used as is in shipping industry
Sub-Question b	• *What are the limitations existing in the current risk management practices used by the actors to improve the quality of their operations in the international shipping industry?*	To establish the shortcomings of the risk management practices in the context of decision making to improve the businesses
Sub-Question c	• *What are the relevant multi-actor theories required to establish a sound process of RBDM Approach?*	To gather the required multi-actor theories to incorporate in the RBDM Approach
Sub-Question d	• *How feasible is the developed conceptual framework of RBDM Approach to put to practice?*	To develop and test the prototype of RBDM Tool
Question 2	***How can the quality of the global supply chain be further enhanced by integrating the developed risk based decision making approach with the data pipe line concept?***	To study the manner in which both RBDM and Data Pipeline can together improve the quality of the global supply chain.
Sub-Question e	• *What are the potential ways in which RBDM and data pipe line can reinforce each other to aid the decision making process of the stakeholders in the supply chain?*	To study the manner in which both RBDM and Data Pipeline can supplement each other

2.2 Thesis Methodology

The outcome of an endeavour depends on the manner in which it is executed. This is highly relevant to any research activity. For effectively meeting the objectives formulated in the earlier section within the stipulated time, a well-planned and structured research methodology is to be followed. Hevner et al. (2004) developed a well acclaimed and highly cited research methodology of design science for the domain of information systems research.

This research is closely related to information systems, involving interactions of several actors and oriented towards business development across supply chain. Further, the motivation and objective of this thesis aligns with the core characteristic of design science paradigm which is "knowledge and understanding of a problem domain and its solution are achieved in the building and application of the designed artefact". Therefore, this thesis adopts the conceptual framework recommended by design science paradigm (shown in Figure 5).

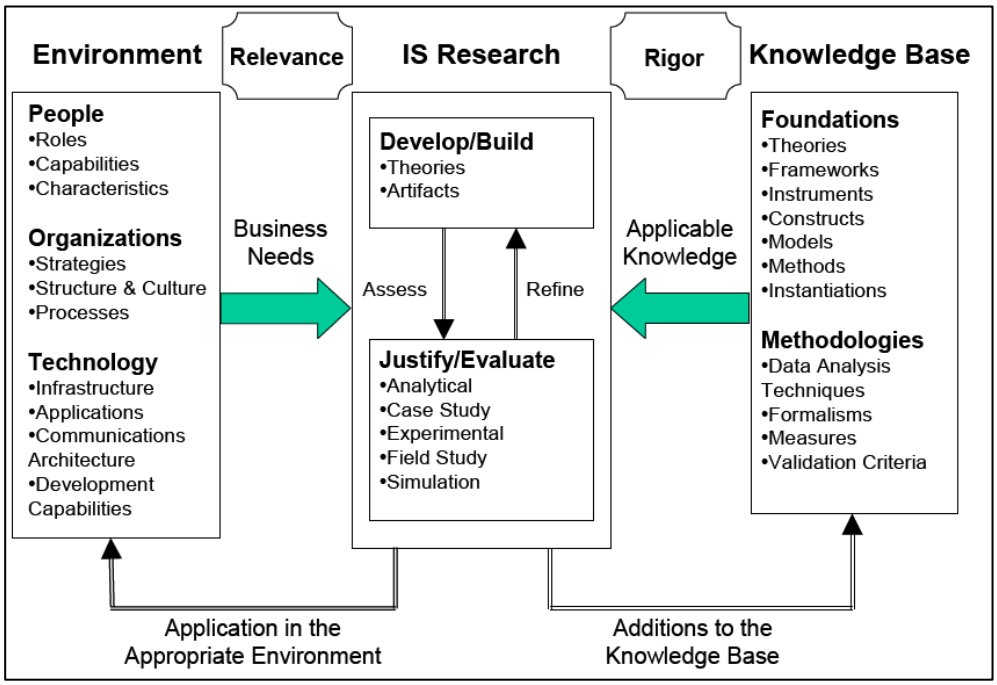


Figure 5 Design Science Framework for Information Systems Research (Hevner et al., 2004)

2.2.1 Design Science Research Methodology

Hevner et al., (2004) emphasize that design science is a nothing but a problem solving process. The framework is constructed such that through the process the problem is well understood, and an innovative solution in the form of an "artefact" is developed based on the existing knowledge base. They lay down seven guidelines "to assist researchers, reviewers, editors, and readers to understand the requirements for effective design-science research". They are briefly mentioned below.

Guideline 1: Design an artefact

This guideline emphasizes that outcome of any design science research should be a viable product in the form of a model, a method or an instantiation.

Guideline 2: Problem Relevance

The solution that emerges out of the research, which could be the artefact itself, should be technology-based and should cater to the needs of the problem field.

Guideline 3: Design Evaluation

The viability of designed artefact should be well demonstrated and tested using appropriate evaluation methods.

Guideline 4: Research Contributions

Since the artefact is solving the problem by introducing an innovative concept, the design research process should also be contributing to advance the existing knowledge base

Guideline 5: Research Rigor

The word rigor here addresses the manner in which the research is carried out. This guideline stresses that the methods deployed during construction and evaluation of the artefact should be rigorous.

Guideline 6: Design as a Search Process

This guideline highlights that the design process is in itself an iterative and cyclic process. The developers and researches must search for an effective and optimal solution and produce it in the form of an artefact.

Guideline 7: Communication of Research

The final step of the research process is to effectively communicate the results to both technical audience and the end users or the practitioners.

Table 5 Design Science Research Guidelines (Hevner et al., 2004)

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

The guidelines, as originally presented, are reproduced in Table 5. Figure 5 illustrates the framework of design science research. The main objective of the design science research which is to build an artefact, is positioned at the centre-top of the research. This effectiveness of this artefact

depends on how relevant it is to the problem field and how rigorously is it built upon the existing theories. In this regards, the problem field, which includes all the people, organisations and technologies in that particular domain, occupies the left side in the framework as "environment". The relevant grounding theories, concepts and research analysis tools are placed to the right under "knowledge base". Located at the centre-bottom is the important step of evaluating and validating the artefact using different techniques. Finally at the bottom two process arrows emerge from the centre block. One feeds back into the "environment" block assessing the extent to which the artefact developed was effective as being a solution. The other arrow revisits the knowledge base to infuse into it the novel concepts, methods and findings realised during the artefact development.

2.2.2 Application of Design Science to Thesis

Applying the design science research framework to this thesis not only streamlined the research process but also assisted in structuring this report. In this section, the research methodology undertaken during the course of this thesis is mapped onto the design science research framework, to provide a clear understanding to the readers.

As formulated in the objectives section, one of the goals of this research is to develop the concept for RBDM Approach and based upon that to build a prototype of RBDM tool. This tool along with its conceptual framework becomes the end artefact of the thesis. This artefact is developed to improve the decision making process of the players acting in the international shipping domain and thereby increasing the overall quality of the supply chain. Further the feasibility of linking RBDM Approach with the data pipeline technology would also be studied in this thesis. The idea of developing a RBDM Approach emerged from observing the effectiveness of RBO used in the energy industry. Therefore for this research the concepts of RBO form part of knowledge base. The other theories used to build RBDM Approach are existing risk assessment methods in shipping industry and the multi-actor analysis methodology. Finally one the tool was developed, it was validated by demonstrating it on a trade lane of an avocado importing company located named JamboFresh. This report concludes by revisiting the environment block and the knowledge base block of the framework to evaluate the relevance of the RBDM tool and the rigour of the research. Figure 6 illustrates the research methodology of this research by mapping it onto the design science framework.

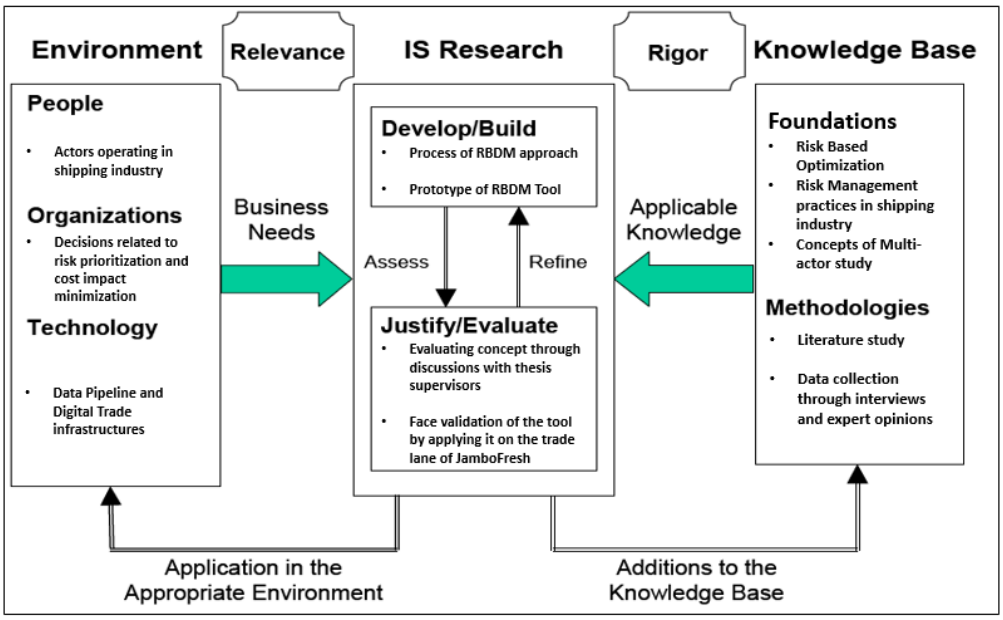


Figure 6 Mapping of thesis methodology on Design Science Framework

2.3 Thesis Report Structure

In Chapter 1, the environment and the problem context was presented. It was mentioned that shipping industry in its present form ails from risks and disruptions leading to negative impacts on the businesses. RBO approach being effective in asset management seemed like a promising tool to improve the operations across shipping industry. It was also highlighted that Data Pipeline concept is a large scale project targeting to increase the information visibility of the supply chain. Therefore, it seemed viable to link RBDM Approach with the pipeline. In this regards, previous sections of this Chapter 2 laid down the objectives for the research. Further, design science methodology provided the logic of the research. This section discusses flow of the research and the manner in which the report is complying it. To aid the understanding of research progress a process flow was constructed and is shown in Figure 7.

By observing the objectives laid out through sub-questions a, b, and c, it can be realised that they prompt the need for more information on three different areas respectively. This calls for a deeper study to understand the main underlying concepts of RBO, the existing gaps in the risk management techniques and the useful theories for multi-actor analysis. In this regards, Chapter 3 deals with the literature study in these three different areas. The findings of the study would then set a stage for developing RBDM Approach. This process of developing a conceptual framework of RBDM process is detailed in Chapter 4. However to answer the fourth question, i.e sub-question d, it is not enough to just build a conceptual process but also study to what extent it can be put to practice. In this regard, a prototype of RBDM tool was developed and later applied.

Chapter 5 deals with the development of the prototype on Visual Basic platform of Microsoft Excel application. Later, for applying the tool to a real case, it is necessary to first gather the relevant data. The understanding of concepts from the literature study narrowed down the kind of information that need to be gathered for risk analysis in a multi-actor context. Based on this knowledge, preparation for semi-structured interview process was done and interview was conducted. Thus, the information gathered was fed into the tool developed and an analysis was conducted. Chapter 6 deals with the application of the tool. Further, the domain experts, who were in this case the supervisors of this research themselves, were consulted and their views were gathered. Thus Chapter 6 also deals with the discussion that was carried out with the experts. Later the results were also presented to associates of JamboFresh and the overall discussion regarding RBDM tool is presented in Chapter 7.

Following Chapter 8, deals with closing the circle of the research by reverting to the research questions. Each of them are answered sequentially. Chapter 9 discusses the limitations of both the process of research and the RBDM Approach developed. Finally with the stage set, Chapter 10 lays down the main recommendations and future scope of work.

In Figure 7, the four main blocks of the research according the design science methodology can be observed. They are the literature study block or the knowledge base block, the artefact development block, the artefact evaluation block, and the final deliverable block which can be considered as the additions to the environment and the existing knowledge base. The blocks which are discussed in this report main sections specifically are coloured in blue. Green block refers to the expert consultation step and the orange block refer to the research process steps associated with the data gathering through interviewing JamboFresh.

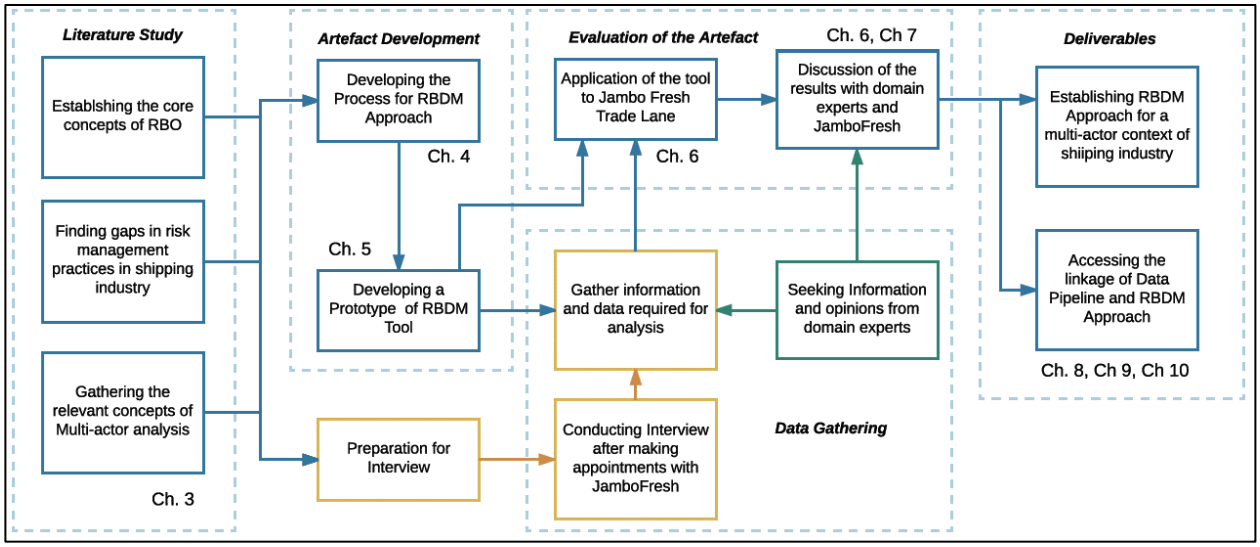


Figure 7 Flow of the research and corresponding report chapters

3. LITERATURE STUDY FOR RBDM APPROACH

There are three main areas where more light has yet to shine before proceeding with the development of RBDM Approach for shipping industry. First is to gather enough understanding of the concepts of RBO methodology as used by the energy companies. Based on the learnings, the limitations of using RBO as-is would be discussed. Second area is the need to gather the main short comings of the risk assessments methods in improving the decision making capability of the operators in shipping industry. To do this different risk assessment methodologies used in shipping industry are explored. Third area of focus required for this research is to gather the principles of multi-actor analysis relevant for developing a holistic RBDM Approach. All these three areas were explored by studying the literature available. The process of literature study conducted for this thesis is elaborated in Appendix A.

One these lines, Section 3.1 of this chapter explores the underlying concepts of RBO method and its application in managing assets in energy industry. Later, section 3.2 draws the attention to different risk assessment practices used in shipping industry. Following section 3.3 introduces the relevant concepts of multi-actor analysis and discus their relevance for shipping industry. Finally section 3.3.5 lays the theoretical foundations for developing RBDM Approach based on the findings of the literature review.

3.1 Concepts of RBO as used in Energy Industry

Ype Wijnia, through his doctoral research, established that a formal RBO process is both effective and feasible in managing assets of infrastructure for energy distribution. He arrived upon this conclusion by conducting several experiments in an energy company called Enexis and studying the results. The effectiveness of RBO was noted when the company was able to reduce their costs related to assets by 20%. The feasibility, on the other hand, could be achieved by incorporating subjectivity in the risk assessment process (Wijnia, 2016).

It was showcased in his research that in the presence of uncertainties, a *well-designed risk matrix* can be used to effectively organize and prioritize the risk. By well-designed he means that the construction of the matrix needs to be sensitive to the value systems and interests of the practitioner. Since value systems vary considerably across the actors and organisations, there is no rigid framework dictating the process of RBO and the development of a risk matrix. However, a general risk assessment framework offered by the international standard of ISO 31000 is used to structure the RBO process in energy industry (Wijnia, 2016).

3.1.1 ISO Risk Management Process

Titled formally as "Risk Management- Principles and Guidelines", ISO 31000:2009 is an international standard in the field of risk management. This standard resulted through series of deliberations and discussions among experts from over 20 countries over a period of several years. It was developed with the intention that it can be used by all kind of practitioners in any organisation regardless of the industry, operation and the complexity. ISO 31000 recognises that all organisations are affected by various internal and external factors while working towards achieve their core objectives. On these lines, it identifies risks as effects of uncertainty on the organisational objectives (Gjerdrum & Peter, 2011; Purdy, 2010).

The standard emphasises that the risk management should be an integral component of an organisation. It assures that, by incorporating the guidelines outlined in the framework, "the corporate governance, financial reporting and stakeholder trust" could be improved significantly. Further, this process can also become a reliable basis for making decisions related to allocation of

resources. By linking risk management to the organisational strategic objectives, ISO stands out from the traditional operational risk management practices (Gjerdrum & Peter, 2011).

Risk management process of ISO 31000:2009 is both stage wise and iterative. The schematic as represented by Purdy (2010) is shown in Figure 8. The process flows over five basic blocks. They are establishing context, assessing risks (which includes identifying risks, analysing risks, evaluating risks), treating risks and the two key interventions in the form of "communication and consultation" and "monitor and review". Incorporation of the these two interventions has made ISO standard unique among all the other formal risk assessment processes (Gjerdrum & Peter, 2011; Purdy, 2010).These blocks are briefed below.

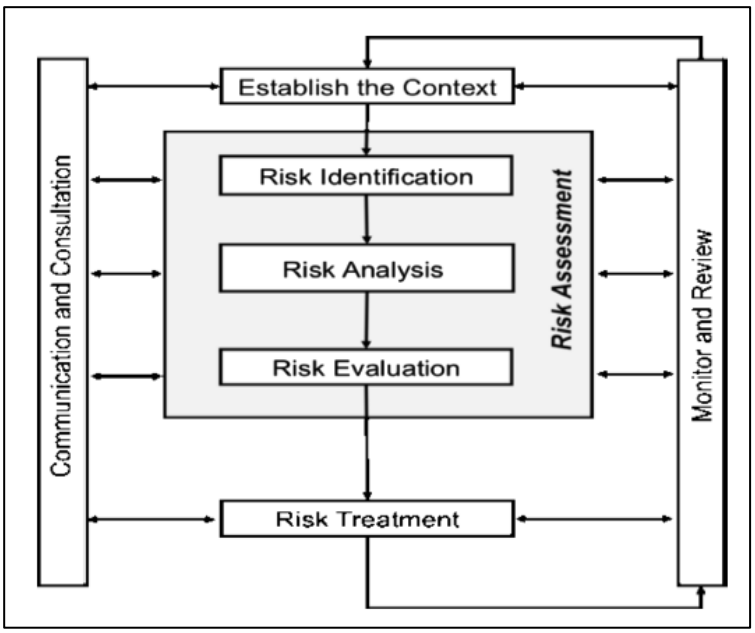


Figure 8 Risk Management Process as per ISO 31000:2009

Block 1: Establish the context

The structure and goals of organisations vary widely across the sectors. This step establishes the needs and objectives of the organisation, the scope of risk assessment process and value based criteria to carry out decision specific to organisations. In other words, the risk management process begins with identifying both the internal and external success factors of an organisation in which it is being carried out.

Block 2: Risk Assessment

Risk assessment block of ISO standard comprises of three main sub-steps which being risk identification, risk analysis and risk evaluation. **Risk identification** deals with understanding the causes of risk, areas of impact, and potential consequences. This is a rigorous step of creating a comprehensive list of possible risks (Gjerdrum & Peter, 2011). According to ISO 31010:2009, the risk identification methods include the following (ISO, 2010):

- "evidence based methods, examples of which are check-lists and reviews of historical data
- Systematic team approaches where a team of experts follow a systematic process to identify risks by means of a structured set of prompts or questions
- Inductive reasoning techniques such as HAZOP
- Various supporting techniques can be used to improve accuracy and completeness in risk identification, including brainstorming, and Delphi methodology"

It is important to note that risks can have both downside and upside consequences. That means that unlike the traditional practice, risks are not to be seen as being associated only with negative consequences. Sometimes they can yield benefits and can be differentiated as being opportunities.

Risk analysis step deals with developing a thorough understanding of each risk identified. This involves developing understanding of causes, consequences and their likelihood of occurrences. The standard does not dictate the manner in which the results are obtained. They can be qualitative, semi-quantitative, or quantitative. It however stresses that representation of results should be consistent with the risk criteria established in the first step of the risk management process. Further, the confidence in determination of these have to be communicated to the stakeholders and the decision makers. A well-known technique that can be employed to understand the risks is the application of bow-tie framework. This is discussed in following section 3.1.2.

Risk Evaluation follows from the analysis step and it deals with prioritizing the risks. The risks are measured or evaluated with respect to the organisational criteria identified while establishing the context of the risk management. The objective of this step is to identify those risks which need immediate attention. Usually, this is the stage where risk matrices are developed. More discussion on risk matrix is captured in Section 3.1.3.

Block 3: Risk Treatment

The risks once prioritized have to be treated by taking appropriate decisions. The decisions depend on the control options that the organisations have at their disposal. Risks, as mentioned could have either negative or positive implications. ISO lists out general options that can be used to treat the risks. They are listed below (Purdy, 2010).

- "Avoiding the risk by deciding not to start or continue with the activity leading to the risk
- Taking or increasing the risk in order to pursue an opportunity
- Removing the risk source
- Changing the likelihood
- Changing the consequences
- Sharing the risk with another party or parties (including contracts and risk financing)
- Retaining the risk by informed decision"

Based on the resources available and the urgency of treating the risks, the appropriate decisions are to be taken by the organisations.

Block 4: Communication and consultation

This element is acting always throughout the risk management process. ISO emphasises that the stakeholder involvement is necessary for a holistic risk management process. Their objectives and values are to be understood before establishing the scope and criteria of the process.

Block 5: Monitoring and Reviewing

ISO recognises that at every stage of the risk management process a continuous feedback mechanism has to be in place. The progress has to be reviewed, the effectiveness of the control options have to be monitored and appropriate intervening actions have to be taken whenever necessary. This way, the organisation would remain both resilient and flexible to both internal and external changes.

3.1.2 Bow-Tie Framework

As discussed, risk analysis step in risk management deals with mapping down the causal links between the causes of risk event and the consequences. Wijnia(2016) in his research refers to this process as development of a risk diagram. He reflects that the concept employed is same as that of a typical bow-tie framework. Therefore, to establish a firm foundation, it is necessary to have a good understanding of this framework. Basically, bow-tie diagram is a graphical illustration of events

surrounding risk where causes *focus* onto risk and consequence *project* from the risk (Mokhtari, Ren, Roberts, & Wang, 2011).

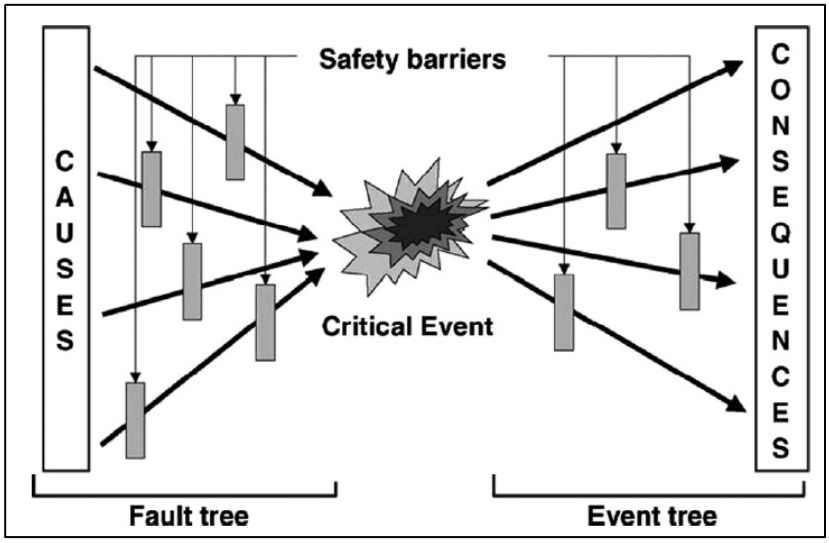


Figure 9 Bow-tie framework (de Ruijter & Guldenmund, 2016)

De Ruijter & Guldenmund (2016), while reviewing and formalizing the bow-tie framework, established that there are four essential elements in a bow-tie diagram namely top event, threats, consequences, and barriers. **Top event** is the moment when the control is lost. In literature this event is referred to by different terms like critical event, central event, or risk event. **Threats** are the different causes that can trigger the top event. There can be multiple threats with several interdependencies. They are placed on the left side relative to the central event in the bow-tie. **Consequences** are the sequence of implications fired after the top event is triggered. There can be multiple consequences for a single top event. They are places on the right side relative to the central event in the bow-tie. **Barriers** are the controls placed either between the threats and the top event (left side) or between the consequences and the top event (right side). Their placement depends on the function they are performing. They are placed to the left if they are eliminating or reducing the probability of top event occurring. They are placed to the right if they are mitigating the impacts or providing means to recover from the impact. Mokhtari et al.(2011) termed the earlier ones as *preventive actions* and the latter ones as *corrective actions*.

From the lens of Safety Science, bow-tie analysis can be looked at as a combination of Fault Tree analysis and Event Tree analysis[2] (de Ruijter & Guldenmund, 2016; Khakzad, Khan, & Amyotte, 2012; Mokhtari et al., 2011). The manner in which threats are leading up to the top event can be analysed by following **fault tree** technique. The manner in which the outcomes of the top event propagate can be analysed by deploying the **event tree** technique.

3.1.3 Risk Matrix as a Decision Making Tool

Risk evaluation stage of ISO 31000 framework deals with the evaluating the risks against the established criteria and thereby prioritizing them. A tool often used to represent this prioritization and facilitate the decision making process is the risk matrix. Though the decisions are taken in the latter stage of risk treatment, a risk matrix determines which risks are to be attended to. Risk matrix is a simple two dimensional tool across which the risks are positioned. The first dimension is related to the likelihood of occurrence of a risk event and the second dimension is related to the level of

[2] Fault Tree Analysis and Event Tree Analysis are briefed in0.

impact on a chosen criteria. The identified and analysed risk events are placed in the grid cells formed by the axes.

Wijnia (2016), in his research discusses different underlying features of a risk matrix. To gather reasonable inferences from the results obtained, it is important to understand the notions associated with these features. Each of them are listed and discussed below.

Notion of risk: Risk is defined by ISO as being an event which can lead to negative consequences. This definition indicates that risk is considered as an entity. On the other hand, if the notion of risk as a measure of negative consequences is considered, risk is impact times the likelihood of occurrence.

Risk measuring criteria: As mentioned before, risk is an event which can have negative impact. However, unless it is clear on what a risk can have a negative impact, it cannot be established as a risk. In other words, risk measuring criteria have to be established in the first step of the risk assessment process. Usually Key Performance Indicators (KPI) are chosen based on the value systems of the organisation. They can be quantitative (like financial losses, delays, and number of damaged parts) and qualitative (like reputation, human injuries and loss of business opportunities).

Scaling Level of impact of a risk event: The impacts are scaled from very low level of impact to very high level of impact. Usually scaling quantitative criteria is easier. For example a loss of a million euros is unacceptable whereas a loss of couple of euros is acceptable. Further, it is convenient to use order of magnitude of the impact within specific ranges like 1 to 10^2 euros, 10^2 to 10^4 euros and so on. However, scaling qualitative criteria is difficult especially when the order of magnitude is considered. Therefore, for such criteria each tolerance level has to be descriptive clarifying what the corresponding stands for.

Scaling likelihood of occurrence of a risk event: The basic requirements mentioned for establishing the levels of impact on quantitative risk criteria are also applicable while scaling the likelihood of occurrence of risk events. The approach of order of magnitude within a specific range has to be used. The value of likelihood of occurrence of a risk event is usually obtained from historical data and by consulting the experts or the practitioners themselves. If in case fault tree analysis is used, the probability (or likelihood) of occurrence is calculated through Boolean operations.

Colour coding for Risk Matrix: The tolerance levels of the risks are often used to express the seriousness of the risk. The two extremes of the scale are a risk is acceptable or risk is unacceptable. The number of intermediate scales can vary depending upon the operation. They can vary from being very high risks (i.e very low tolerance towards them) and very low risks (i.e. very high tolerance towards them). Each tolerance region is colour coded to provide quick visualization of the scenario.

A typical risk matrix used by the companies in the energy industry (in this case by Enexis), to manage their infrastructure assets is shown in Figure 10. The KPIs chosen as the criteria to measure the impacts are finance (costs), safety, and reliability. Both finance and reliability are quantitative, while criterion of safety is qualitative. The impact levels are calibrated on y-axis starting from being negligible to extreme. Along x-axis, the probability or the likelihood of occurrence of a risk event is measured. Each cell is colour coded according to the severity of the risk event. In this case, black cells refer to unacceptable risks (U), purple as very high risks(VH), red as high (H), orange as medium (M), yellow as low(L), and green as negligible (N).

Potential consequences				Likelihood					
				Unlikely	Remote	Probable	Annually	Monthly	Weekly
Severity class	Finance	Safety	Reliability	<0,003	0,003-0,03	0,03-0,3	0,3-3	3-30	>=30
Extreme	> 10 M€	Several fatalities	> 20 M cml	M	H	VH	U	U	U
Serious	1-10 M€	Single fatality or disability	2-20 M cml	L	M	H	VH	U	U
Considerable	100k-1M €	Serious injuries and significant lost time	200k-2M cml	N	L	M	H	VH	U
Moderate	10k-100k €	Lost time incidents	20-200k cml	N	N	L	M	H	VH
Small	1k-10k€	Near misses, first aid	2-20k€ cml	N	N	N	L	M	H
Negligible	<1k€	Unsafe situations	<2k cml	N	N	N	N	L	M

Figure 10 Risk Matrix used by Enexis, (Wijnia, 2016)

The risks identified and measured by the company would then be placed at respective grid cells in the risk matrix. Once all the risks are placed, the management would get an overview of the vulnerabilities of their systems. The immediate strategies for them should be to develop measures that can push the risks lying on the top right side of the matrix to the bottom left (i.e from unacceptable and high risk regions to acceptable and low risk regions). These measures could be either preventive actions or corrective actions depending upon the capabilities and resources that the company has.

It can be noticed that by allocating resources to the priority risks, the operations related to asset management have been optimised. However, often there may be more than one risk in the high risk region or there may be more than one control option available to mitigate the risk. In both these cases a simple cost-benefit analysis can be useful.

3.2 Risk Assessment Processes in Shipping Industry

Risk assessment practices in shipping industry have evolved considerably over last two decades. Most of the major developments taken towards establishing formal risk assessment methods were reactionary measures to major accidents, security breaches, and hazards related to health and safety. For instance, disaster of Piper Alpha causing serious environmental and human damage led to introduction of framework of Safety Case in 1992. Later with the dreadful September 11 attacks in several nations were forced to ramp up the security and regulatory measures.

Consequently, several forms of risk assessment frameworks and procedures have emerged globally. Most of them are however restricted to particular regions and organisations. To search, identify and study each of them is firstly a highly time consuming task. Secondly and importantly, gathering information about all the risk assessment procedures is out of scope for this research mainly because the focus of this research is at international level. It is important at this stage to identify and study those procedures which are widely accepted and used in the shipping industry. Therefore approach adopted in this research is to identify the relevant literature focussing on identifying different risk assessment methods practiced in the shipping industry.

The search engines used for the literature survey were Google Scholar and Scopus. After operating through several combinations of relevant key words[3], it was found that except two publications not much literature discussed about the various risk assessment procedures and techniques being practiced in the shipping industry. First one is a publication titled "Risk Management System– Risk Assessment Frameworks and Techniques" authored by Arben Mullai in 2006 as a part of DaGoB project. The project was partially funded by European Union within the BSR INTERREG III B programme. The second one is a paper reviewing and critically analysing the risk-based models in shipping. It is titled "Security and Risk-Based Models in Shipping and Ports: Review and Critical Analysis" authored in 2008 by Khalid Bichou who was associated with Centre for transport Studies in Imperial College, London. Most of the other literature search results yielded various risk assessment techniques which were either the proposals for new methods of assessment or the applications of exiting methodologies to different case studies. More information on the process of literature study conducted is documented in Appendix A.

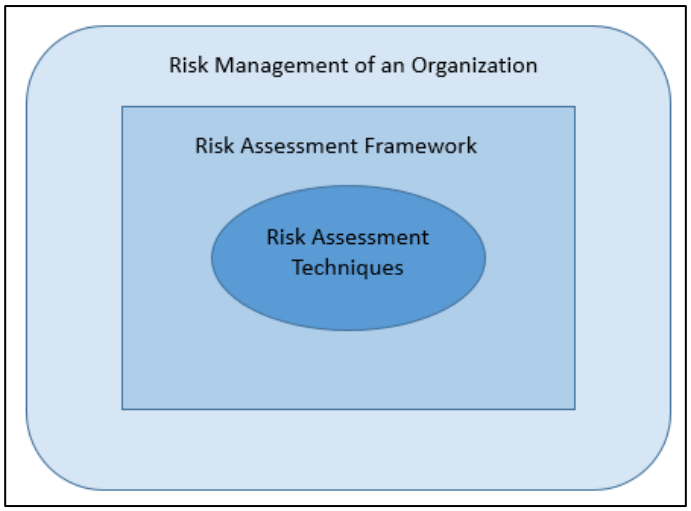


Figure 11 Notions of Risk Assessment

[3] Refer Appendix A for more information related to key word searches.

Though both Mullai (2006) and Bichou (2008) discussed different risk assessments methodologies, Mullai (2006) was more systematic in differentiating between frameworks and techniques. The notion of framework as considered in this resarch is that it is a general outline laying out guidelines on how the process of risk management has to be conducted. The role of risk assessment framework extends from the point of identifying risk to the point of being able to make decision regarding risk mitigtaion. A risk assessment framework could invoke several risk assessment techniques at different stages in the process. Figure 11 illustrates these notions. Different risk assessment techniques are mentioned in Appendix D.

On these lines, the following sub sections study different risk assessment frameworks practiced in the shipping industry. Though cues are taken from the works of Mullai (2006) and Bichou (2008), each of the framework is further reviewed by doing relevant literature study. Further, the framework offered through AEO Compact Model which was not discussed by both the authors is also reviewed here in section 3.2.1.

3.2.1 Risk Mapping as per AEO COMPACT Model

Customs for long have been the main actors regulating the movement of goods and shipment across the nations. With the rapid globalization and expanding supply chains, these movements have increased immensely. Consequently, the responsibility of Customs in handling the shipments entering and leaving the borders, got intensified. One of the main tasks of Customs is to assess the risks involved during the trans-border movement of goods. But considering the quantity of goods flowing it is both tedious and many times an unnecessary process. In this context, World Customs Organization (WCO) introduced the concept AEO (Authorized Economic Operator) based on "Customs-to-Business" partnership in order to meet one of the mutual objectives of ensuring supplying chain security (Commission, 2006, 2016) .

According to WCO, AEO is "a party involved in the international movement of goods in whatever function that has been approved by or on behalf of a national Customs administration as complying with WCO or equivalent supply chain security standards" (Papa, 2013). For a party operating in shipping industry and belonging to a member state of WCO can apply for AEO status at the respective Customs administration (Commission, 2016). However, before granting the status customs authorities have to perform an audit and evaluate the applicants business to assess the risks which might affect the customs objectives. The framework that is employed by the authorities is called Compact Model (Compliance Partnership Customs and Trade) (Commission, 2006). Refer Figure 49 for illustration of the Compact model framework.

The integral part of this model is the risk mapping process. This methodology is employed to systematically assess the risks involved for customs during the business operations of the applicant. The framework of the Compact Model recommends the authorities to employ the following five steps (shown in Figure 12) to evaluate the applicant's eligibility for AEO status (Commission, 2006).

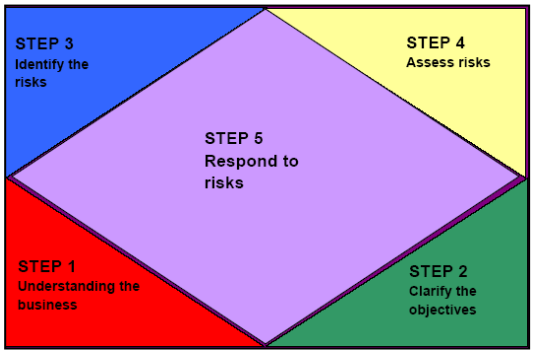


Figure 12 Steps for Risk Mapping as per AEO Compact Model (Commission, 2006)

Step 1: Understanding the business of the operator

The essential part before identifying and assessing the risks is having a clear understanding of different aspects of business of the operator. These include (but not limited to) the revenue models of the business, the logistics, the origins and destinations of goods being shipped, and the procedures that govern the business processes. Customs can gather information in three ways.

1. Use internal sources like information from tax services, Intrastat databases, historical data like earlier audit reports, and even from intelligence data bases.
2. Use external sources like statistics published in annual reports of Chambers of Commerce or other third party agencies.
3. Obtain the information directly from the Operator through interview and scanning through the documented proof of operators transactions.

Step 2: Clarifying the objectives of the Customs

This step is important to filter out risks which are irrelevant as far as the requirements of Customs are considered. These requirements are centred on fiscal and security aspects of the business operations. In this regards, the objectives of AEO process have to be clarified to the operators, by working closely with them.

Step 3: Identifying risks that can impact the objectives of the Customs

Risk according to AEO Compact Model is defined as "the likelihood of an event occurring, in connection with the entry, exit, transit and end-use of goods moved between the customs territory of the Community and third countries…" Further, the model differentiates between the risks specific to an organization and the risks which are general for all organizations. They classify the latter ones as "potential risks". Both these kind of risks are important to Customs as long as they have affect their objectives.

Step 4: Assessing the risks

The model recommends the operators and Customs authorities to assess the risks by prioritizing them based on their impact on Customs objectives and their likelihood of occurrence. Construction of a "risk map" (as shown in Figure 13) is suggested to segregate the risks identified.

The model acknowledges that "although the assessment of the risks is not always quantitative, the risk map will provide a certain degree of transparency into the risk environment of the operator in relation with the customs facilitation." Further, the model specifies that the risk mapping is done in two stages.

1. Mapping the risks internally within the Customs administration
2. Mapping the risks by coordinating with the operator

The model highlights four reasons for employing this two stage process. Firstly, it is convenient to make up one's own judgement without going through all the process steps. Secondly, an iterative process that takes place would facilitate in arriving upon a common comprehensive risk map. Thirdly, it increases the performance of the officials, by giving them experience on conducting risk mapping. Fourthly, this two stage process encourages transparency and partnership.

Once all the risks are mapped, discussion takes place on assessing the operator's strengths and weaknesses. Based on the outcome a common risk map is constructed. In this process often, risks which could not be either sufficiently identified or there could not be a mutual consensus on classifying them. Such risks are to be categorized separately as "remained risks".

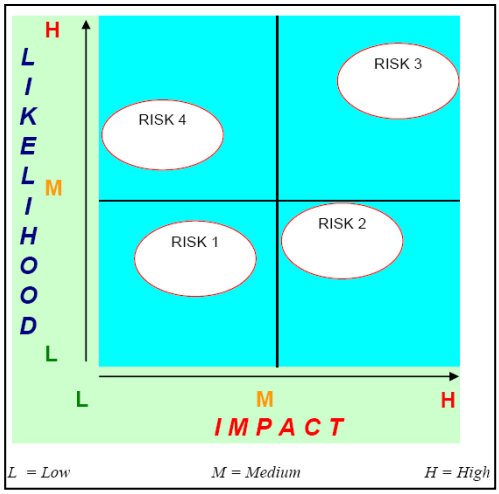


Figure 13 Risk Map as per AEO Compact Model (Commission, 2006)

Step 5: Respond to the risks

The AEO status is granted based on the decisions the operators take based on the risks identified. The four common strategies employed to tackle the risks identified and mapped are discussed below.

1. **Take:** Due to practical and feasibility reasons, often there will be risks which cannot be avoided. There will remain to some extent the impact of these risks. Such risks are usually accepted. However, "they should be explicitly stated, understood and approved by an appropriate level of management."
2. **Treat:** The aim of this strategy is to either reduce the likelihood of occurrence of a risk or lower the impact. The model explains that significant number of risks can be treated by facilitating "specific administrative or audit measures carried out by Customs".
3. **Transfer:** Transferring risks to third party is not uncommon. However, it should be made clear to the Customs, in a transparent manner regarding the kind of agreements the operators make with the third party.
4. **Terminate:** Some risks can be avoided by undertaking extreme measures by having intensive checks and controls in place. One of the measure could also be not granting an AEO status at all.

The model stresses that the strategies developed must be on the lines of "fit for purpose".

3.2.2 Formal Safety Assessment (FSA)

In 1995, Maritime Safety Committee (MSC) of International Maritime Organization (IMO) formalized the safety related rules by adopting the concept of Formal Safety Assessment (FSA). Rosqvist & Tuominen (2004) highlight that, prior to this, for the parties operating within the regulatory frameworks of international maritime, the concepts of risks are largely associated with safety and security aspects of the operations. The rules and guidelines established to mitigate or avoid risk events have largely been prescriptive and quite often derived as a reaction to a major incident at sea in order to prevent similar accidents from occurring again. A number of separate rules created, remained inconsistent among different parties (Rosqvist & Tuominen, 2004). Further, as pointed out by Lois et al. (2004) , the stakeholders operating in maritime transportation felt that "marine safety may be significantly improved by introducing a formal 'goal-setting' safety assessment approach so that the challenge of new technologies and their application to ship design and operation may be dealt with properly".

FSA is basically a rule making and decision making process based on risks. It has been appreciated to be more rational and systematic for not only for assessing risks, but also for evaluating the costs and benefits associated with options identified to reduce those risks (MSA, 1993; Peachey, 1997, 2002; Rosqvist & Tuominen, 2004). According to IMO (2002) which offer guidelines to execute FSA , the main objectives of FSA are to:

i. "Enhance maritime safety including life, heath, the marine environment and property protection;
ii. Help in evaluation of new regulations;
iii. Provide a basis for making decisions in accordance with objectives of the IMO;
iv. Enable appreciation of the effects of proposed regulatory changes in terms of benefits and related costs incurred for the industry;
v. Facilitate the development of regulatory changes equitable to the various parties."

The FSA methodology is usually applied by the member states of IMO, the organizations in consultation with IMO or the IMO committee itself. According to guidelines, FSA is not intended to be applied in all the situations. They are relevant only when the rule making proposals or decisions "have far-reaching implications in terms of either costs or legislative and administrative burdens." (Mullai, 2006). The five main steps of FSA methodology (Figure 14) are discussed below.

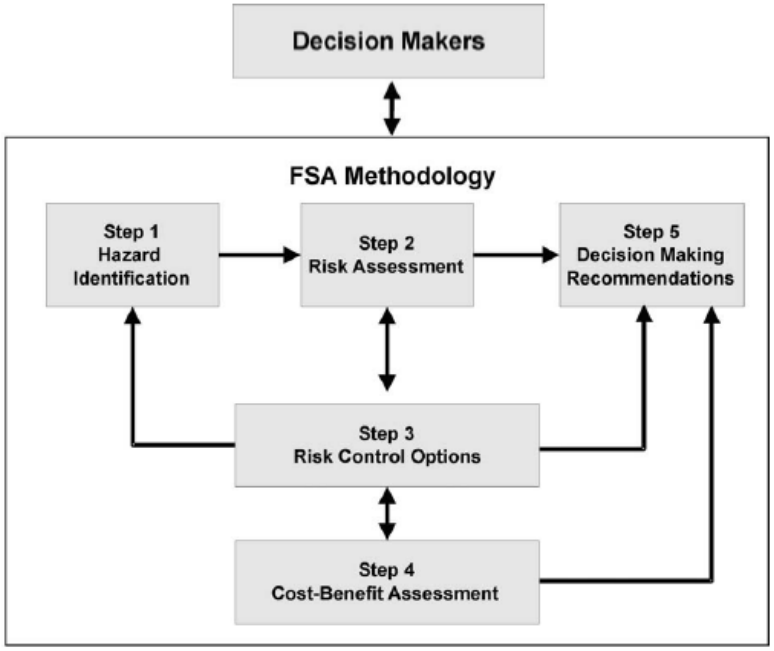


Figure 14 Steps of the FSA method according to IMO (Rosqvist & Tuominen, 2004)

Step 1: Hazard identification

Hazard can be simply defined as a "source of a potential harm or a situation with a potential harm"(Rosqvist & Tuominen, 2004). The objective of this step is to create an inventory of hazards. While several methods exists, the well-known ones are Hazard and Operability Studies (HAZOP) and Failure Mode and Effects Analysis (FMEA). The other techniques include brain storming(Lois et al., 2004; Rosqvist & Tuominen, 2004), interviewing stakeholders and experts, creating "hazardous-

system states (risk scenarios)" (Rosqvist & Tuominen, 2004) , analysis of historical data (Mullai, 2006).

Step 2: Risk analysis

This step deals with establishing the functional and stochastic relations among the hazards and the consequences. The techniques usually used are fault tree and event tree analysis (Mullai, 2006), constructing influence diagrams (Lois et al., 2004), and expert judgements (Rosqvist & Tuominen, 2004).

Step 3: Risk control options

Through this step, the practitioners devise measures to regulate, and reduce the risks estimated. These measures or the control options have three characteristics as per Wang & Foinikis (2001). Frist feature is related to reduction of risks like the preventative and mitigating measures. Second is related to type of action required, which can be either procedural or technical. Third is related to the level of confidence that can be place on the measure based on the extent to which it is "active, passive, redundant or auditable".

Rosqvist & Tuominen (2004) identified control measures or as they call countermeasures, as being the interventions involving people, procedures, or equipment. They break down the potential hazard to represent as "causal chain" as shown in the Figure 15.

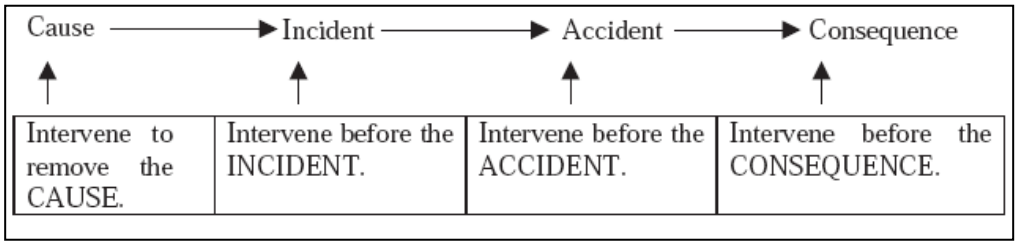


Figure 15 Representing hazard as a causal chain

Step 4: Cost-benefits assessment

A well-known technique that is employed at this stage is cost-benefit analysis (CBA) (Lois et al., 2004; Mullai, 2006; Rosqvist & Tuominen, 2004). The control options identified are evaluated using CBA approach. However, Wang & Foinikis (2001) point out that CBA as suggested as a part of FSA is not to be used mechanistically as it is only a way of evaluation and has to regarded only as a consulting tool for decision making.

Step 5: Recommendations for decision-making

This final step generates recommendations based on the analysis conducted in the previous steps. The control options identified are evaluated against the chosen "risk criteria", which has to be done by considering different values and perceptions. A rigid risk criteria would make the decision making process inflexible. Therefore, Wang & Foinikis (2001) suggest that ALARP (As low as reasonably possible) principle be used to arrive upon balanced decisions.

Though, the FSA is a highly generic framework and is not intended for application in all circumstances, the literature review several studies on maritime risks have used this framework (Gasparotti, 2010; J.-O. Lee, Yeo, & Yang, 2001; Lois et al., 2004; Rao & Raghavan, 1996; Trbojevic & Carr, 2000). Further, a thorough review of the IMO's guidelines (IMO 2002) done by Mullai (2006) show that the FSA does not adequately help in assessing the risks which are related to dangerous goods. He emphasizes that "the FSA does not contain a single term describing essential concepts related to risks of dangerous goods, such as "dangerous goods, substances, chemicals or hazardous materials", "toxic", "spill", "dose", "exposure" and many more".

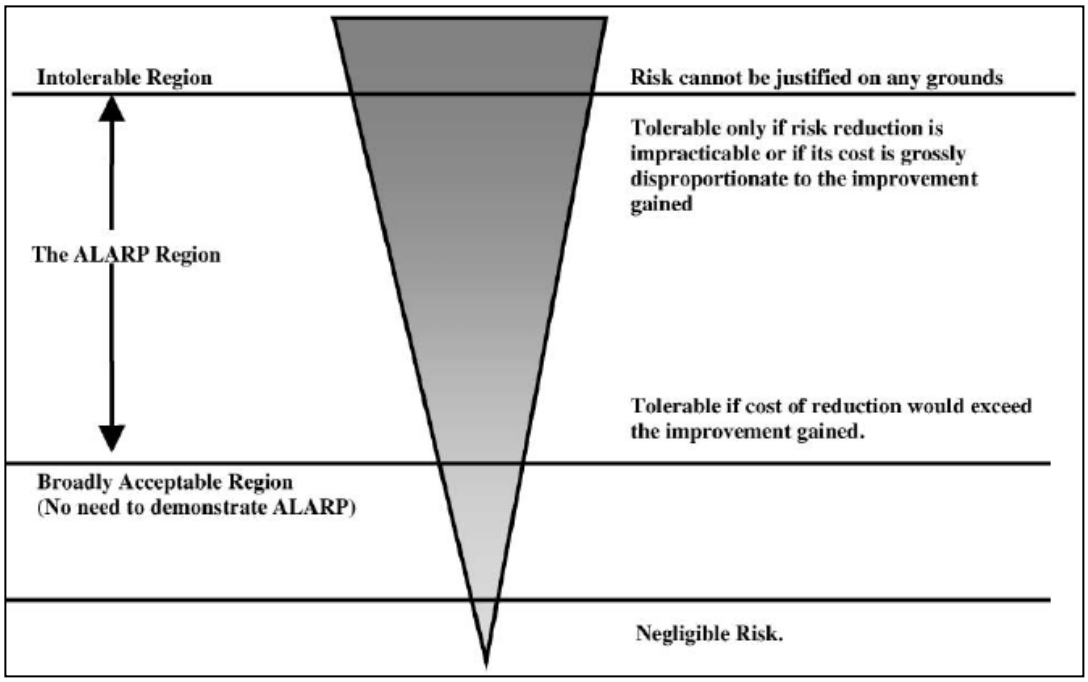


Figure 16 Concept of ALARP as a part of risk based decision making

3.2.3 Quantitative Risk Assessment (QRA) technique

Quantitative Risk Assessment (QRA) technique was developed by DNV Technica Ltd in United Kingdom for Health and Safety Commission (HSC) as a part of study on risk in British waters. This approach was initially applied to assess the risks during the transport of dangerous goods. Subsequently, the in the maritime transport, the framework was restricted to assessing risks affecting people during the shipment of dangerous goods in bulk (Mullai, 2006). However, in other industries, methodologies were developed based on QRA principles. These include Probabilistic Risk Assessment (PRA) for nuclear power reactors, space systems, incinerators of chemical ammunitions and Performance Assessment in waste repositories (Apostolakis, 2004).

According to Apostolakis (2004) QRA essentially answers three questions in a top-down manner– (i) what can go wrong? , (ii) how likely is it? (iii) What are the consequences? In order to do so, it follows following key steps (David & Gollasch, 2010; Mullai, 2006):

Step 1: Listing the end states

QRA process begins by attempting to answer the third question related identification of undesirable consequences. All the probable adverse end states affecting costs, safety and health are listed in this stage.

Step 2: Identifying the initiating events

Based on the philosophy that each end state must have a triggering event or events, this step traces back from each end state identified to their initiating events.

Step 3: Mapping the sequence of events

Fault tree and event tree analysis are usually deployed to establish the sequence of events leading to end state starting from the initiating events identified. Further, at the end of this stage accident scenarios are constructed thereby answering the first question.

Step 4: Estimating the probability of scenarios

From the evidence identified, with the help of expert judgements, the probability of occurrence of these scenarios are evaluated. This step focuses on answering the second question.

Step 5: Ranking accident scenarios

Finally, based on the frequency of occurrence of these scenarios, they are ranked. This step facilitates the decision making related to mitigating the risks**.**

QRA process was largely used to assess risks associated with transportation of dangerous goods such as flammable liquids and oils. This method was refined and used for different applications like assessing risks related to dangerous cargoes in the ports (Mullai, 2006).

3.2.4 Safety Case

The disaster of Piper Alpha oil platform in 1988 in North Sea, was instrumental in introducing the Safety Case to UK offshore industry in 1992. It was later adapted to shipping industry to assess risks associated with ships. A safety case is considered to be a documented evidence that an application, a system or a process is safe to be used in a particular environment. Though the methodology of a safety case varies from application to application across industries, it is built on three fundamental principles (Bishop & Bloomfield, 2000; Kelly, 2004). Figure 17 below depicts the flow of logic from a safety evidence to a safety claim or requirement.

Safety Requirement (or Safety Claim): A safety case should clearly establish that all the requirements or objectives for a system to function safely must be well supported. These requirements could be a property of a system or a functionality.

Safety Evidence: The claims that a system is safe should be well grounded with evidences. These evidences are usually facts, assumptions or sub- claims based on scientific principles or research.

Safety Argument: Argumentation forms the linkages between the evidence and the requirements. The nature of an argument is usually of probabilistic, deterministic or qualitative.

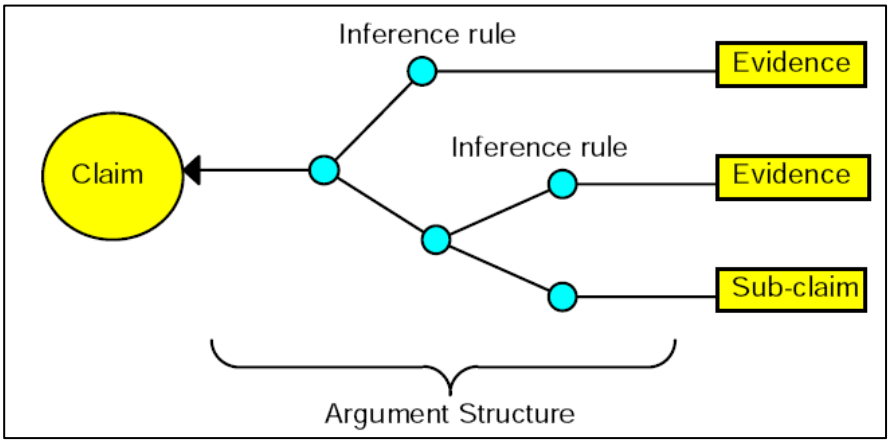


Figure 17 Fundamental elements of a Safety Case

A safety case as mentioned is a report with established structure and layout. Different standards prescribe different report structures, Kelly (2004) identifies that the general format of a safety case follows the outline shown in Table 6.

Though it was a legal requirement for offshore installations, in the case of shipping its application is voluntary. Based on the safety case the shipping companies adapt their safety management procedures. The effectiveness of the system in place is monitored through audits and inspections. However, one main drawback of the safety case approach is that it demands each and every ship to have detailed documentation by undertaking all the steps of analysis.

Table 6 Outline of a Safety Case document

Outline of a Safety Case	Core aspects of Safety Case	Conventional Techniques Used
• Scope	Context	
• System Description		
• System Hazards	Requirements	Preliminary Hazard Analysis (PHA)
• Safety Requirements		HAZOP
• Risk Assessment	Evidence	ALARP
• Hazard Control / Risk Reduction Measures		Hazard Risk Index
• Safety Analysis / Test		Fault Tree Analysis
• Safety Management System	Argumentation	
• Development Process Justification		
• Conclusions	-	

3.2.5 Marine Accident Risk Calculation System (MARCS)

A consortium called SAFECO (Safety of Shipping in Coastal Waters) was set up in 1998 under the supervision of European Commission. The objective of this consortium was to lower the risks of marine accidents during shipping activities by studying the underlying triggering factors. To analyse risks, SAFECO developed a quantitative risk evaluation framework called Marine Accident Risk Calculation System (MARCS). By statistically analysing the historical data, MARCS plots the frequency distributions of the risk causing factors. Based on the interrelations of the factors the probability of occurrence accident is determined. The fault tree analysis method is incorporated to evaluate the interrelations (Fowler & Sørgård, 2000). A typical block diagram of MARCS is shown in Figure 18. The main steps involved in MARCS framework are:

Step 1: Conducting historical statistics

This step involves gathering historical data and analysing it through statistical analysis. At this step both risks and risk causing factors are identified. Through analysis their frequency distributions are derived.

Step 2: Conducting Fault Tree analysis

Structured break downs of different accident causing factors and the conditions in which they act is established through fault tree analysis.

Step 3: Carrying out event tree analysis

Through this step, the probability of different consequences are identified based on the conditions in which the risk event was triggered.

Step 4: Seeking Expert Judgement

At this step the calculations and causal maps constructed are reviewed through expert opinions and judgement. Based on the input the inconsistencies of any are adjusted. The models developed are validated based on the statistical data of the risk events and their consequences.

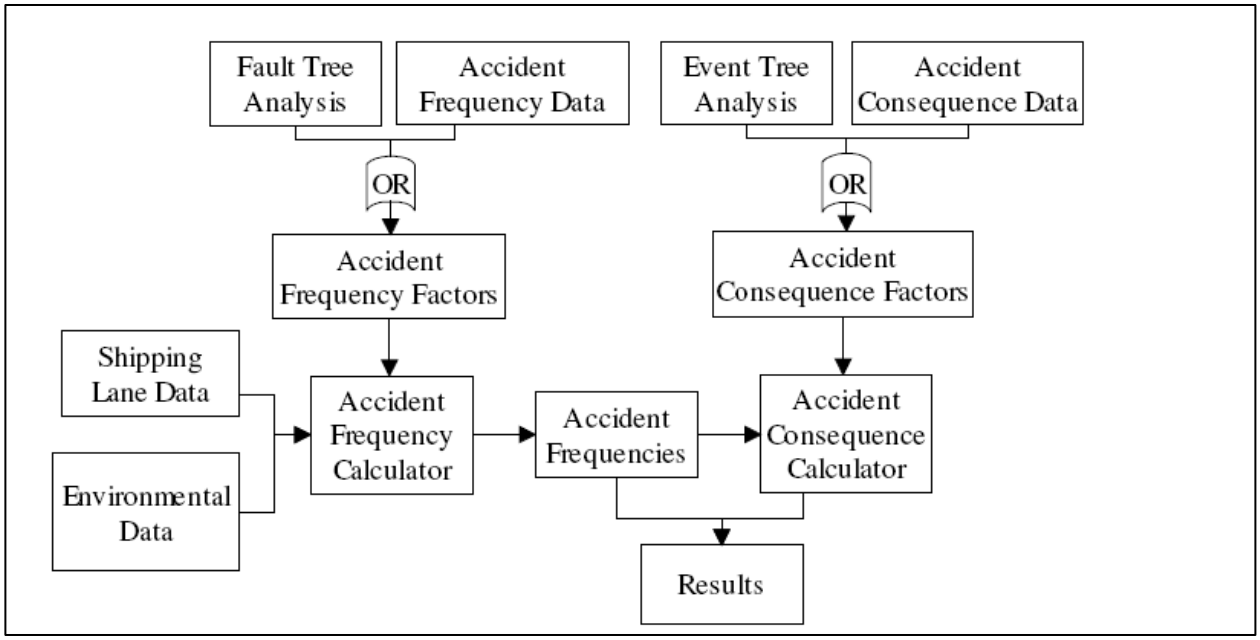


Figure 18 Block diagram of MARCS -(Fowler & Sørgård, 2000)

3.2.6 Reflection on Processes and their Relevance to the Research

Having panned across different risk assessment practices a stage is set to paint the overall picture of risk management in the shipping industry. It can be observed that risk management as a discipline is in its evolving stage. There is no one general risk assessment framework which can cater to all the issues related to different risks listed in Table 3.Considering that the nature of risks are diverse, it is easier for the practitioners to adopt specialized risk assessment practices focussing on particular areas of application.

Generally, risk assessment in shipping industry would immediately divert attention to assessing risks related to ship safety and maritime transportation. All the frameworks studied except AEO Compact model focus primarily on the aspects relating to safety and health. They techniques they recommend are more quantitative in nature. Further, frameworks do not emphasize much on the operational risks leading to delays and financial losses. The focus areas of the risk assessments are identified in Table 7.

Moreover, it is also evident that not all the actors participating in a trade lane have a formal risk assessment practice as a part of their organisational procedures. There is no international requirement or regulation enforcing the operators to adopt a forma risk assessment procedure. However, if operators desire to obtain a certification or are part of an international consortium they are forced to oblige by the agreement rules. This inference can be drawn from the mandatory risk assessment requirements laid down by WCO to obtain AEO certification.

One similarity in all the processes is that they all adopt a step wise approach in assessing risks. However, the number of steps involved vary across frameworks. By and large they can be generalized as context establishing step, risk identification step, risk analysis step, risk evaluation and treatment step. Further discussion on classifying the steps of these different risk assessment frameworks is done in section 3.3.5.

As far as the relevance to the current research is concerned, two aspects play an important role. First one is related to the extent to which they accommodate the human factors and actor interactions. The second aspect is related to the extent these frameworks are effective in facilitating

the organisational decision making to improve the businesses. The last two columns in Table 7 throw light on these two aspect of each framework.

As far as the first aspect goes, it can be noticed that none of the risk assessment methods address the need for multi-actor considerations in the risk assessment process. Frameworks like FSA, QRA, Compact Model and MARCS highlight the need for expert judgements while gathering information about the risks. They stress the need for considering stakeholder interests while establishing risk criteria. However, they do not mention the need to identify the risks caused by other actors or the impacts their organisation can have on other actors. Further, with less consideration of human elements, one of the implications could be that most of the techniques in the risk assessment process tend be more quantitative in nature. By moving away from being qualitative, the organisations will overlook the importance of intangible criteria like human loss, dents on reputation or impacts in the form of lost business opportunities.

With regards to second aspect related to decision making, it can be seen that most of the risk assessment methods recommend measures to mitigate the risks. The underlying process that can be observed is the prioritization of risks before the risks are treated. In other words, most of the risk assessment frameworks seek the process of optimisation by diverting the attention of the operator to the risks with high priority instead of treating all the risks. The Compact Model recommends 4Ts – take, treat, transfer, and terminate. FSA identifies the counter measures in the form of interventions at different stages of causal chain of risk propagation. Further, some frameworks also employ techniques that can facilitate decision making like cost benefit analysis.

Table 7 Reflection on risk assessment frameworks practiced in shipping industry

Framework	Focus Areas	Actors that adopt the framework	Consideration of multi-actor interactions and trans-organizational risks	Relevance to organizational decision making
AEO COMPACT Model	• Border Security • Supply Chain Security	• Operators applying for AEO status	• Focus is on those risks which have impacts on Customs objectives	• Risk treatment strategies are recommended based on risk map • Decisions are taken to meet minimum requirements to obtain AEO status
FSA	• Marine accident risks • Safety and health • Marine environment • Evaluation of rules and regulations	• Member states of IMO • The organizations in consultation with IMO • the IMO committee itself	• Highly generic and does not focus on actor interactions	• Recommends choosing interventions and control measures to treat risks using CBA • Suggests ALARP principle to establish allowable limits of impact on risk criteria
QRA	• Safety and health • Marine environment • Transport of dangerous goods • Marine accident risks	• Shipping and transportation companies	• Very specific to hazards related to the organization • No emphasis on multi actor representation	• Accident scenarios are ranked based on the frequency of their occurrence. • Decisions are taken based on the ranking.
Safety Case	• Ship Safety • Personnel Health	• Shipping and transportation companies	• Only restricted to ship safety and accidents	• Decisions related to ship safety and maintenance could be taken
MARCS	• Marine accident risks • Marine environment	• Shipping and transportation companies	• Highly quantitative. Falls short in accommodating actor perceptions	• The model developed does not prescribe any decision making strategies

3.3 Multi-Actor Analysis for RBDM Approach in Shipping Domain

In the book titled Policy Analysis of Multi-Actor Systems, Enserink et al.(2010) define an actor as "a social entity, a person or an organization, able to act on or exert influence on a decision". In an interconnected and a multi-actor system, an action of an individual would often have implications on several other actors in the system. If the interlinkages among the actors, their actions and their decisions are not identified, the implications can go unnoticed and add up to the overall costs along the trade lane.

One of the main focus of the research here is to have a clear understanding of the roles of different parties operating across the shipping lane. Thereafter, an actor interdependency map could be developed to realize the flow of cost impacts in the system. The other focus of the research is the development of a multi-actor approach in risk assessment.

In this regards, in this chapter, the first subsection gathers an overview of largely used actor analysis techniques and discusses the methodology that is appropriate for the current research. Second subsection deploys the chosen methodology to identify actors in the shipping domain across a trade lane. Third subsection discusses the development of an actor interdependency map to realize the cost flows across a trade lane. Fourth subsection attempts to fit in the multi-actor approach in risk assessment process. Finally using the concepts developed in the chapter, the fifth subsection studies the particular trade lane of Jumbo Fresh.

3.3.1 Actor Analysis Methodologies

In the literature, actor analysis is commonly referred to as stakeholder analysis and it is often carried out while managing projects involving several stakeholders. While literally a stakeholder can be defined as the one who has "an interest, financial or otherwise, in the consequences of any decisions taken" within a system (Macharis, Turcksin, & Lebeau, 2012). However, for a holistic approach and to avoid ambiguity, actor here refers an individual (or group of individuals) who is (or are) either influenced by the system or influences the system. Typically, the outcome of a stakeholder analysis is the identification of powers and interests of the involved actors. However, owing to the flexibility of these methods, stakeholder analysis techniques can be applied in diverse situations and domains (Enserink et al., 2010).

3.3.1.1 Conceptual Dimensions of Actor Analysis

Hermans and Thissen (2009) point out that in the context of policy analysis actor analysis methods like social network analysis, cognitive mapping and conflict analysis are employed, each focusing on different aspects of multi-actor scenarios. While studying different actor analysis methods (shown in Figure 19), they observed that most of them are centred on four conceptual dimensions. They are highlighted below, along with their relevance to this particular research.

Networks: The analysis deals with the clustered structures of actors where the activities in the system are determined by the social rules and institutional contexts. Exploration of this dimension, in the scope of this research, reveals the kind of interdependencies and the transactional relations among the actors.

Perceptions: Here the analysis reflects the images the actors have of the system around them which includes the actors, prevailing networks and the issues. This dimension is particularly helpful in understanding the risk perceptions of different actors. Risk perceptions are highly subjective in nature and realizing them for a particular actor would help in identification of risks, their different causes and their impacts.

Values: This dimension maps the motivations very specific to the actors at an individual level. They deal with relative preferences, goals, and targets. While the dimension of perceptions helps in

understanding the system around an actor from his or her point of view, the dimension of values reveal the personal interests at the core of the individual. This dimension can aid in scaling the impact levels for a particular actor.

Resources: Through this dimension, the instruments that the actors can control and operate to influence the system are made explicit. In the case of risk based decision making, an acute understanding of available resources with different actors can help the actors to strategize their actions in either preventing a risk or mitigate its impacts.

In figure 1 shows some of the prevailing actor analysis techniques which focus on particular values as identified by Hermans and Thissen (2009). As discussed earlier, for this research, each of the dimension would divulge a part of the information and data required for the RBDM tool development.

METHOD	FOCUS	REFERENCES
Network analysis	**Networks**	
Social network analysis	Structural characteristics of actor networks	Kenis & Schneider, 1991; Scott, 1991
Stakeholder analysis	**Resources and interdependencies**	
Stakeholder analysis	Stakeholder environment to maximize cooperative potential and minimize threat of obstruction	Freeman, 1984; Bryson, 2004
Game theoretic models	**Resources and interdependencies**	
Metagame analysis	Structure of policy 'game' to help identify stable outcomes and advise on strategies for negotiation and coalition building	Howard, 1971, 1989; Fraser & Hipel, 1984
Hypergame analysis	Structure of policy 'game' and role of (mis) information and strategic surprise	Bennett et al., 1989
Transactional analysis	**Resources and interdependencies**	
Transactional process models	Potential for exchange of control between different actors, to facilitate policy process	Coleman, 1990; Timmermans, 2004
Vote-exchange models	Predicted shifts in actors' positions and outcomes of collective decision-making	Stokman, 1994; Thomson et al., 2003
Discourse analysis	**Perceptions of groups of actors**	
Argumentative analysis	Different chains of reasoning used in policy debate and underlying values and assumptions	Toulmin, 1958; Mitroff, 1983
Narrative policy analysis	Opposing views of controversial problems and possible meta-narratives to reformulate those problems	Roe, 1994; Van Eeten, 2006
Q-methodology	Groups of actors with shared perspectives and their underlying basis	McKeown & Thomas, 1988
Cognitive mapping	**Perceptions of individual actors**	Axelrod, 1976
Self-Q interviews	Possibilities to address policy problems through actors' rationale	Bougon et al., 1990
Dynamic Actor Network Analysis (DANA)	Perceptions of actors to enable comparative analysis of agreement, conflict, etc.	Bots et al., 2000
Preference elicitation	**Values of actors**	
Analytic Hierarchy Process (AHP), multi-attribute assessment	Structure and hierarchy in various attributes and alternatives	Saaty, 1990; McDaniels & Thomas, 1999; etc.

Figure 19 Actor analysis methods (Enserink et al., 2010; Hermans & Thissen, 2009)

3.3.1.2 Fundamental Steps in Actor Analysis

Extracting from various actor analysis methods, Enserink et al.(2010) listed six fundamental steps at the core of a general actor analysis in policy domain. The choice of the method and the level of detail depends on the objectives of the analysis. The prime essentials important for this research is to obtain an inventory of several actors involved along a shipping line and to understand the cost transactions and impact flows among them. Therefore these steps are studied in this context below.

Step 1 deals with establishing a problem to serve as a starting point to carry out the actor analysis. The problem formulated could change during the course of analysis. However, for this research the main problem is that there are several implications in the form of mainly cost impacts to the actors

as a consequence of the risk event that occur across shipping line. These causes of these implications are often not clear and thereby result in uneven cost distributions among the parties.

Step 2 focuses on listing the parties that are operating along the international trade lane. The different actor identification techniques mentioned in the book by Enserink et al.(2010) are reproduced in Table 8

Table 8 Actor Identification techniques

Approach	Description	Relevance to the Research
Imperative	Identifies actors who feel strongly enough about the problem to act on their feelings	This approach will not yield the entire actor network, though it may be helpful in identifying the most impacted actors in the supply chain
Positional	By reviewing the existing formal legislations, procedures, and policy pieces this approach identifies the actors with formal positions	This could be an effective approach in identifying the formalized actors by reviewing the research papers and publications on international supply chain
Reputational	This approach identifies the important actors by taking the leads from the key informants related to the problem. Thereafter, a 'snowballing' effect can be exploited by asking the identified actors themselves to identify other parties	This approach can be effective in identifying the informal actors with the help of identified formal actors in the shipping line
Social Participation	The actors identified aid the process by actively participating in the discussions and meetings	This approach can be exploited to particularly identify the needs and improvements in the RBDM tool that has been developed. However, for the initial actor identification, this approach would shoot out of the boundaries of the research.
Opinion Leadership	This technique focuses on identifying the actors who are influential in affecting the opinions of other parties in the system	The research aims to gather the perceptions of the actors with regards to risks. Opinions though will give a sneak into possible causes and consequence, it would be helpful in determining them exactly.
Demographic	This approach identifies actors by such characteristics as age, sex, occupation, religion, level of education, residence and so on	One way this approach can be helpful is to identify the actors based on the roles they play and functions they carry out along the shipping like. This can be helpful in determining the general set of actors along the shipping line.
Causal Map	Causal mapping technique gives an insight of the system factors that are operating within the system and thereby help in identifying the actors involved in stimulating these factors.	This approach could give details about the impact flows and the causal relations. However, this approach demands a careful construction of a causal map by operationalizing outcomes of different events, which is a lengthy exercise altogether.

Of the methods mentioned above, three of them stand out in aiding the preliminary identification of actors. They are positional, reputational, and demographic approaches.

Step 3 of the process is to organize the identified actors according to their formal positions, their tasks and responsibilities. In this case, this step focuses on identifying the formal relations among the actors in the trade lane. This lays the ground work for mapping the interdependency chart required for analysing the flow of impact.

Step 4 of the process deals with realizing the interests and perceptions of the actors. In doing so, the key performance indicators for each actor can be identified. Based on these indicators, the risks affecting them due to different events along the trade lane can be listed. Further, the levels of their impacts of a risk for a particular actor on the respective indicators can be evaluated. In this research, the chosen indicator is cost and through this step the level of cost impacts of risks for each actor are identified.

Step 5 maps the interdependences among the actors. This includes the flow of responsibility and the flow of cost impacts in this case. Based on this map, the RBDM tool can prioritize the risks for each actor in the system.

Step 6 closes the circle by re-examining the problem posed in first step and asses to what extent it was solved. From the actor analysis the main findings for this research would be the list of actors, the list of risks for each actor which occur due to the reasons beyond their control and the level of impacts of these risks. By incorporating the outputs gathered from the actor analysis, RBDM tool can be well equipped to be used in a multi-actor scenario.

3.3.2 Actors along a Trade Lane

In order to identify important actors along an international trade lane, as a preliminary step, a desk research was conducted. In this regards, the first phase dealt with understanding the processes and operations in a supply chain at a meta-level. As mentioned before, supply chain is a series of interactions and transaction that occur around a product from its production stage to its finish and delivery stage. Shipping is a part of supply chain process, and it deals with the transactions and logistics that operate from export stage to the import stage. The main events that that occur along a shipping process are discussed below.

Usually, the buyer places an order for a product and the seller, who is often the exporter, procures the material required for the product locally and then packs it. The shipment is sealed usually at this stage. Later the documents required for the export clearances are prepared, and the formalities are done to obtain export clearance. Meanwhile, a booking is done for a container to carry the shipment and the shipment is loaded onto the container. Inland transport modes are used at this stage. Once the container is loaded, it is brought to the chosen terminal at a designated location in the port and is loaded on the carrier vessel of particular shipping line. Once the clearance is obtained for the vessel, the transport by the sea takes place. At the import side, similar transactions occur. Once the vessel reached the port, export documents are verified by the authorities and the container is allowed to unload at the terminal. Here, the container is taken for scanning process. Once a clearance is obtained, the container is picked up by the inland transporters and taken to the warehouse of the buyer where the shipment is unladed. The process ends once the empty container is returned back to designated location at the terminal. Figure 20 summarizes the processes involved during a typical internarial shipping

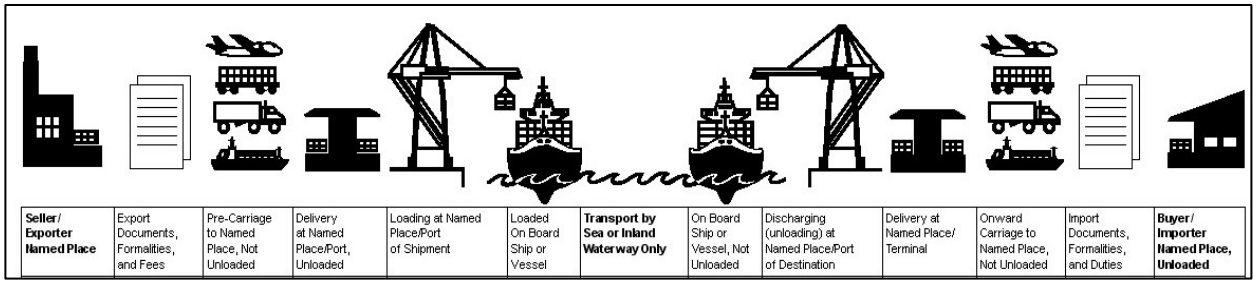


Figure 20 Processes involved during international shipping (AtoZ World Trade, 2017)

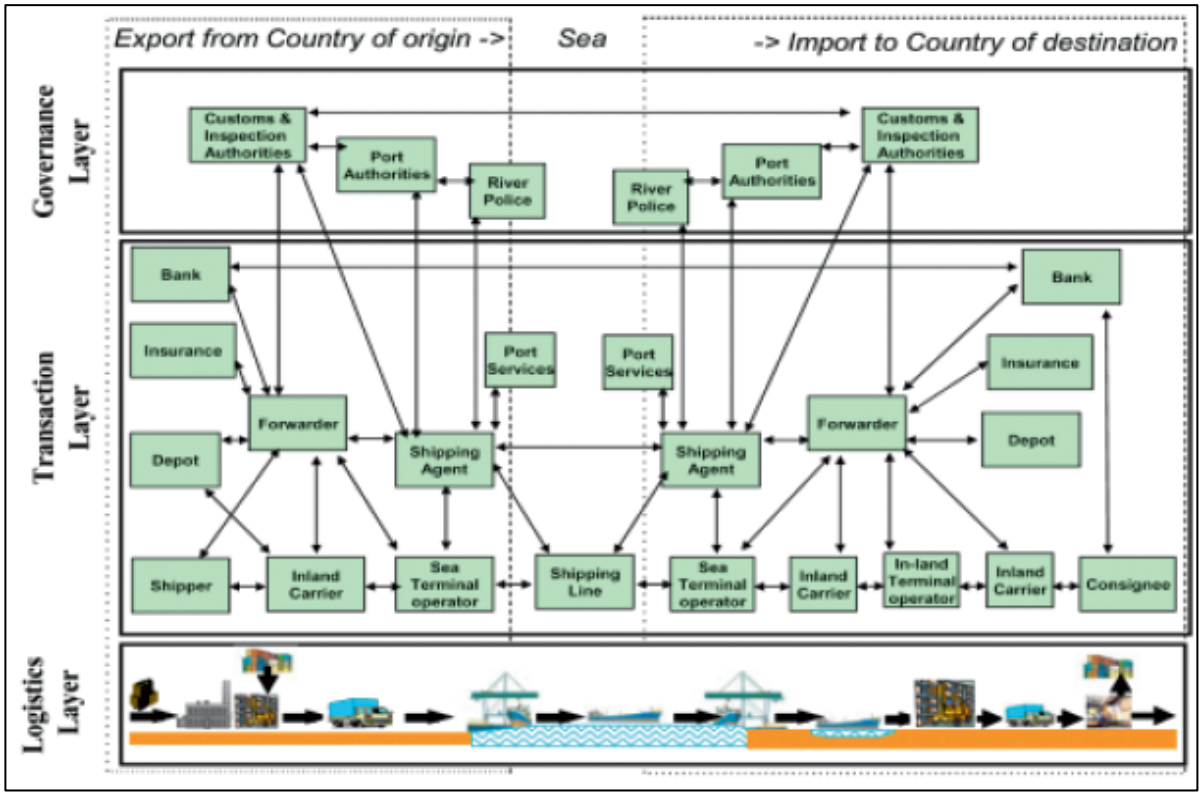


Figure 21 Three layers as identified by van Oosterhout (2008)

In his article "who packed the box", Hesketh (2010) refers to the work of van Oosterhout (2008) and distinguishes three different layers based on the functions and operations the actors perform: the Logistics Layer, the Transaction Layer, and the Governance Layer (shown in Figure 21).

The physical movement of objects and goods happens in the logistics layer. Transaction layer deals with the interactions and information exchanges between the B2B parties. Governance layer on the other hand deals with the interactions and information exchanges between the B2G parties. For actor analysis here, transaction and governance layers are particularly important to gather the required data for the risk based decision making. Some of the main actors operating in these layers are discussed below.

1. **The Consignor:** Hesketh (2010) identifies a consignor as the person who originally "packed the box" or, in other words, who "consigned the goods". Broadly, a consignor can be the shipper, the exporter or the supplier. Though the definitions of different terms can vary at a subtler levels, as used here a consignor refers to an individual, a party or an organisation that initiated the shipping process at the export side and has complete information of the nature of the goods being sent.

The Consigner may not necessarily be the producer of the goods. He or she can procure them from different local growers or manufacturers.

Once the consignment or the shipment is packed, it is sent to be loaded into the container. Once loaded, the consignor receives from the carrier the bill of lading (BOL). It is a document of receipt conveying that the consignment has been loaded in the vessel. BOL also serves the purpose of providing evidence of the kind of contract existing between the shipper and the carrier. Further, the consignor is also responsible to make the export declarations to the Customs authorities at the origin.

2. **The Consignee:** The buyer, the importer or the end customer of goods can be labelled as consignees. A consignee is a person, a group or a company that has placed the procurement or purchase order with the seller. Based on the requirements placed through the order, the consigner procures the goods and ships them. The consignee and the consignor usually have a negotiated sales contract. It should typically include details of the goods, the price per unit, the contract terms (Incoterms), payment details and scheduled or estimated dates.

   Often, the nature of the contract terms determines the responsibilities and obligations of seller and buyer towards sharing of costs and risks along the trade lane. Incoterms are widely used formal contract terms in the setting of international shipping. Based on these terms, the two parties contact the intermediaries like freight forwarders, carriers, agents and brokers (Malfliet, 2011). Further, the consignee is responsible to produce the BOL at the import customs to obtain authorisation to unload the goods (or receive the goods).

3. **International Carriers:** Carriers are responsible to transport the containers, loaded with the consignment, from export side to the import side. They can do so in all the three modes of land, sea, and air. However, today over 90% of the international trade is carried out by the sea (Heaver, Meersman, & Van de Voorde, 2001). Carrier is an umbrella term used to refer to the vessel operated by a shipping company or a ship owner.

   The main obligation of the carrier as per the international admiral law is to provide BOL to the shipper. By doing so, the carrier notifies that the shipment has been loaded safely in the vessel. The contract with the carrier is done either by the buyer or the seller based on the contractual terms. Often, freight forwarder can also establish the link between the seller and buyer via contacting the carrier company. The major container carriers operating are A.P. Moller–Maersk Group, China Ocean Shipping (Group) Company (COSCO), Mediterranean Shipping Company S.A. (MSC) and CMA CGM Group.

4. **Freight Forwarders (FF):** Freight forwarders are the intermediary agents operating under contract for either seller, buyer or for both. Though they are predominately associated with arranging the logistics for shipping. Their main roles include arranging for documentation related to shipping, obtaining licenses required for loading and unloading, clearing customs, and transporting the goods. Sometimes they are also associated with value added services like packaging and even advising the shipper regarding the selection of the trade terms (Murphy & Daley, 2001; Özsomer, Mitri, & Tamer Cavusgil, 1993).

   Today, the services offered by freight forwarders is increasing rapidly. Particularly with regards to international FFs, Murphy & Daley (2001) through their literature review identified different functions they perform. The extensive list of functions from their work is reproduced here as Figure 22. Owing to the growing complexities in providing these diverse services and to have an advantage in these competitive times, many of the FFs are becoming “one-stop” service providers. Further, the leading carrier like Maersk and Sea-land are also providing comprehensive freight forwarding services (Özsomer et al., 1993).

Functions	Source(s)
Quoting steam ship rates	[1,7]
Obtaining necessary vessel space	[1,2,5,6,9]
Preparing commercial invoices	[1]
Obtaining export licences	[1]
Issuing export declarations for the shipper	[1,2,5,6,7,8]
Preparing certificates of origin	[1]
Obtaining and preparing consular invoices	[1,2,5,6,7]
Compiling ocean bills of lading	[1,2,6,7,8]
Compiling air waybills	[2,6]
Obtaining insurance	[1,2,5,6,7,9]
Paying freight charges	[1]
Obtaining dock receipts	[1]
Presenting documents to the bank	[1,2,6]
Obtaining port warehouse space	[1,2,5,7]
Tracing and expediting shipments	[1]
Collecting and submitting money for shipments	[1,5]
Advising shipper as to selection of terms of sale	[6]
Acting as general consultant on export matters	[2,6,7,8]
Provide for transport from exporter to final destination	[2,5]
Legal counselling	[1,9]
Export packing	[5,8]
Shipment consolidation	[5,9]
Make routeing recommendations	[5]
Break bulk	[5]

Figure 22 Functions of International FFs- an extract from the work of Murphy & Daley (2001)

5. **Customs Authorities:** Customs is an agency of the government administration which enforces the laws and regulations of a country related to movement of goods, animals and plants across the borders. They are the main actors who are responsible to ensure the security of overall supply chain. They do so by executing wide range of policies formulated over areas like health, revenue, intellectual property, and illegal trade (Denktas-Sakar & Karatas-Cetin, 2012; Hesketh, 2010). The focus however is subjective to the country in which the agency is operating. For instance, for a developing country the revenue depends significantly on the trade inflows through taxes such as import duties, excise duties, value added tax (VAT), and tariffs. For a developed country on the other hand, there is a more focus on ensuring the border safety by enforcing restrictions on movement of certain goods and objects. Further, with the rising concerns of international terrorism, particularly since the 9/11 attacks, security imperatives have increased globally (Widdowson, 2007).

   The evolving nature of Customs operation is driven by increased focus on trade facilitation. Through the Revised Kyoto Convention of WCO, introduced in 2006, the governments have started to promote commercial activity of businesses across the countries. This forced the Customs to lowering the intensity of their procedures by embracing modernisation through technological sophistication (Gordhan, 2007).

6. **Inland Carrier:** These are the actors operating from the corridors of the ports at the interfaces between the sea and land, and between the sea and inland waterways. Trucks are major transport

modes carrying the containers from the ports to the destination point. Barges are the dominant carriers operating along the inland waterways connecting major cities, ports and industrial areas. Unlike other modes of transport the advantages the inland waterways offer are lowered energy consumption, lowered emissions, and decreased congestion of road and rail traffic. The containers transported by the vessels have to be transhipped to be transported through inland water ways. The process of transhipment is however undesirable mainly due to the activities like moving goods, relocating them, re labelling them and waiting till the carrier is loaded (T. Notteboom & Rodrigue, 2009; Roeleven, Kokc, Stipdonk, & De Vries, 1995).

7. **Shipping Agent:** Like any other agent, shipping agents carryout functions on behalf of the principal operators across the shipping line. Based on the company they represent and the activities they execute, shipping agents can be port agents, cargo agent, charterers' agent, and customs brokers. They possess expertise in carrying out the specific tasks effectively.

   Port agents act on behalf of the owner of the vessel and organises the port calls which includes booking berth at the port for the vessel and carrying out the required paperwork. A cargo agent is primarily responsible to secure cargo for the ship operator. Customs brokers are licensed induvial or agencies having expertise in preparing clearance documents, evaluating tariffs and taxes as per government norms, and carrying out scanning and inspection procedures required by Customs. For their services, the principal parties pay them agency fees.
8. **Terminal Operator:** Terminal operator or the port operator could be the port authority or a company hired by port authority to handle the movement of cargo and containers in the port area. Port management is the main responsibility of the terminal operator. The efficiency of the port operator is dependent on the "speed of container handling and the vessel turnaround time" (Tongzon & Heng, 2005). Operations at port are highly capital and asset dependent. With the growth of globalisation and liberalisation the roles of terminals is rapidly changing. This led to the creation of international terminal networks where different private company operate together in a joint venture with local partners in order to improve the efficiency of the port. These local partners include inland carriers, network of freight forwarders, shipping agencies, and even other port operators (T. E. Notteboom, 2004). The leading private terminal operators today are Hutchison Port Holdings, Port of Singapore Authority, DP World, and APM Terminals (T. Notteboom & Rodrigue, 2012).

3.3.3 Actor Inter Dependencies

It can be learnt from the discussion that shipping industry is actor-intensive. For a shipment to arrive at the customer since the time the purchase order is placed with the producer, several people come into play throughout its journey. Though the roles of the actors are well defined, to determine the responsibilities they bear regarding the costs and risks associated with a particular process, the nature of the contracts existing between the actors has to be understood. This is rooted in the notion that every transaction is built upon a contract. By identifying the contract, the responsibilities of the actors can be realised and an inter-dependent relation can be mapped between them.

In a shipping process, especially at an international level, contract include trade terms specifying the responsible party undertaking the costs associated with transportation, insurance, documentation and other formalities (Jimenez, 2008; Ramberg, 1997). Well known and widely used trade terms between the seller and buyer in international shipping industry are the Incoterms (International Commercial Terms). They are published by International Chamber of Commerce (ICC) as a part of its codified publications related to international trade (Malfliet, 2011). The latest revised publication in this regards is the Incoterms 2010. The following section discusses these terms briefly to understand the nature of contracts related to costs and risks among actors across shipping domain.

3.3.3.1 Incoterms

Bergami (2013) emphasizes that since Incoterms are not a body of law or a statutory, they must be specifically mentioned in the contract of sales for the rules to be applicable. Based on the rules specified, the appropriation of rights, duties, obligations and responsibilities between the seller and the buyer takes place. This appropriation happens on a "mutually exclusive basis" and is related to activities associated with the physical movement of the shipment from the place of origin to the point of delivery.

Currently there are 11 terms specified in Incoterms 2010. Malfliet(2011) in his overview of the terms, categorizes these terms into four groups based on the balance of obligations between the buyer and the seller. They are discussed below.

Category E: There is only one term under this category which is EXW (Ex-works).

1. **EXW:** Under Ex-works, the goods are placed at seller's premises and the buyer comes to collect them. The seller is under minimum obligation under these terms. The buyer sustains all the risks associated with shipping of the goods to the final destination.

Category F: In this category, broadly the buyer takes the obligation of bearing costs and risks of the international carriage. According to the seller, the main carriage is unpaid. There are three terms under this category.

2. **FCA (Free Carrier):** There are two ways of specifying FCA terms – one at seller's premises and the other at other place. *FCA seller' premises* means that the buyer arranges the collecting vehicle to the seller's place. *FCA at other place* means that the seller delivers the goods at an agreed place in his/her vehicle. Usually, the buyer arranges the international transport, or sometimes if the seller arranges it, the buyer will bear the costs and the risks. The latter can also be sometimes considered as *FCA additional service*.

3. **FAS (Free alongside Ship):** Under these terms the seller is responsible for costs and risks till the goods are unloaded at the vessel prior in the port. However, the seller is responsible to clear the export formalities and customs. However, *FAS additional service* is also applicable where the seller arranges for the international carrier, but the buyer bears the costs.

4. **FOB (Free On Board):** These terms are intended specifically during the transport on sea or through inland waterways. These terms extend FAS till the consignment is loaded onto the vessel. Here too the seller is responsible to clear the export formalities and customs. The notion of *FOB additional service* is applicable where the seller arranges for the carrier and the costs and risks associated are borne by the buyer.

Category C: Terms under this category specify that the seller is obliged to only pay for the international transport, but not bear the risks. According to the seller, main carriage is paid. There are four terms under this category.

5. **CPT (Carriage Paid To):** The shipping charges of the carrier are included in the selling price of the seller. However, once handed over to the carrier the additional expenses if occurred due to risks associated with the transportation, are borne by the buyer. In other words, CPT means that *Carriage is paid to* and not *Costs are paid to*.

6. **CIP (Carriage and Insurance Paid to):** According to these terms the seller is responsible to obtain an insurance package for the shipment while it is in transit. This package should have a minimum cover as prescribed by clauses (C) of the Institute Cargo Clauses.

7. **CFR (Cost and Freight):** Similar to CPT, however the risks are borne by the seller till the shipment is loaded appropriately onto the vessel. Further, according to CPT the seller must

be responsible to bear the costs till the shipment reaches the designated spot at the import side. However, under CFR, the designated spot is the import port itself.

8. **CIF (Cost, Insurance and Freight):** These terms are similar to CFR, with an addition that the seller is obliged to buy an insurance package for the cargo while it is in transit. This package should have a minimum cover as prescribed by clauses (C) of the Institute Cargo Clauses.

Category D: According to these terms the seller bears both the costs and the risks associated with transportation of goods from the origin point to the destination point. There are three terms under this category.

9. **DAT (Delivered at Terminal):** The goods are handled by the seller till the point of delivery at the designated location at the terminal. Once the goods are unloaded, the buyer is responsible to clear the customs.

10. **DAP (Delivered at Place):** As the name suggests, the goods are delivered at the place agreed upon. The costs and risks are transferred at this point from seller to the buyer. The costs that the seller bears are port charges at import and export side, the carriage charges, and the inland transport costs. However, the buyer pays for all the import clearances and the required duties.

11. **DDP (Delivered Duty Paid):** This is extreme side, and an extension to DAP. Here the seller also pays for the import clearances, taxes and required duties. Maximum obligation to the seller and minimum obligation to the buyer is reflected through these terms.

Malfliet(2011) further classifies these categories based on the notions of them being either arrival contract or departure contact. To summarize in his words, "E-, F- and C-terms are all departure contracts, because delivery occurs at the agreed place of departure, and only the D-terms are arrival contracts".

Table 9 Classification of the Incoterms 2010 in E, F, C and D-terms (Malfliet, 2011)

Departure			Arrival
Category E	**Category F**	**Category C**	**Category D**
EXW	FCA	CPT	DAT
-	FAS	CIP	DAP
-	FOB	CFR	DDP
-	-	CIF	-

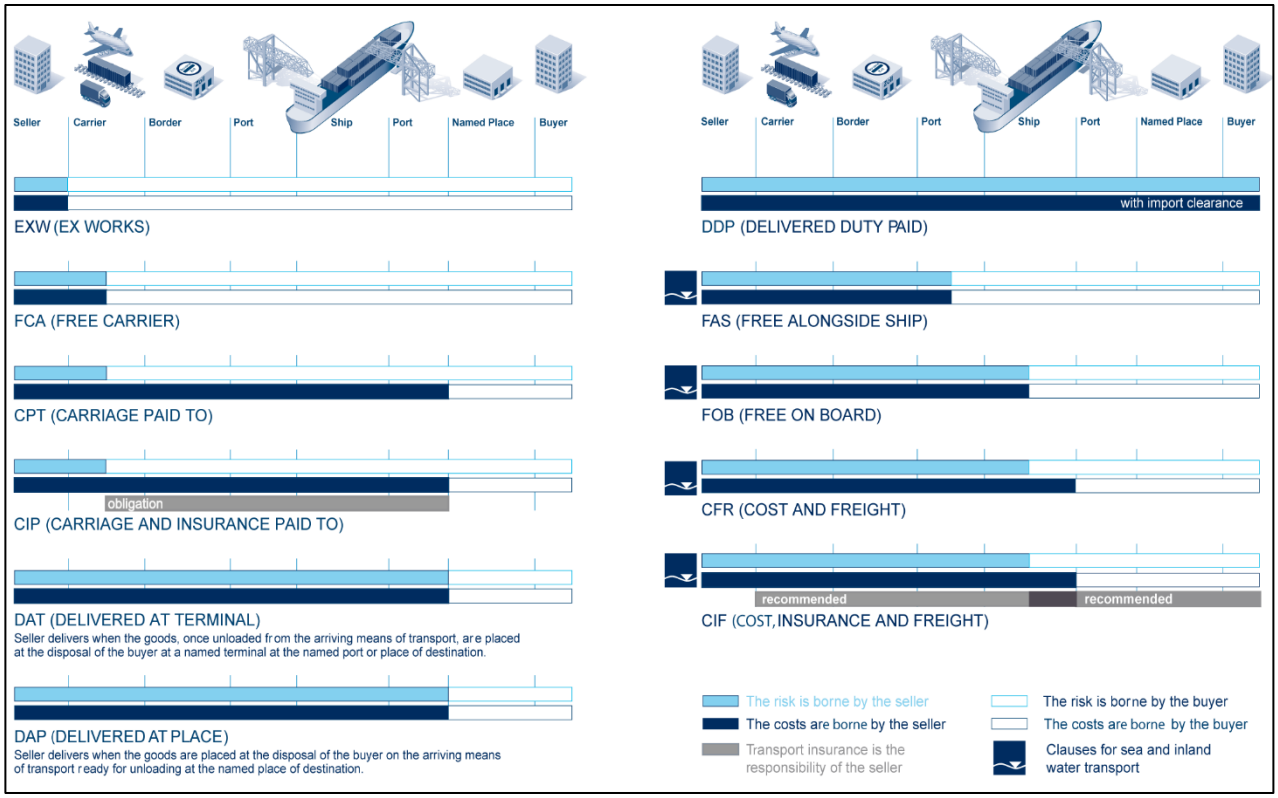


Figure 23 Summary of incoterms and transfer of risks (Commerce, 2010; SeaRates LP, 2017)

3.3.4 Risk Assessment and Actor Perceptions

The critical step in any risk management methodology is determining likelihood of occurrences of risks and their impacts. Different techniques and theories developed in this direction aim to obtain this information as pragmatically as possible. Further, they propose a consequential process of making an inventory of alternatives and choosing among them while making decisions on treating the risks (Asnar & Zannone, 2008; Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, Finucane, Peters, & MacGregor, 2004). However, this process of quantification of risks is intrinsically intertwined with the perceptions of the actors and stakeholders involved.

Slovic et al. (2004) identified three fundamental ways in which risk is often confronted in the modern world. They categorised based on the manner in which the risk is dealt with. They are dealing risk as analysis, dealing risk as feelings and dealing risk as politics. The process of dealing *risk as analysis* involves logic, reason, and scientific deliberation. This process is often prescribed through conventional risk management frameworks. The process of *risk as feelings* deals with abstracting them based on intuition and instincts. Finally, the concept of dealing *risk as politics* emerges when the scientific methods of abstraction confront the ancient intuitive deductions. This section explores the aspect of perceiving risks based on feeling before moving onto discussing its intervention in risk decision making process.

Slovic et al. (2004) refer to theories of cognitive psychology and neuroscience in highlighting that humans comprehend risks under two systems namely "analytic" system and "experiential" system. The concept of dealing risk as feelings refers to the latter one. Under this system the decisions made are usually intuitive, quick and not easily accessible to conscious awareness. The authors point out that this ability is "an important vestige of our evolutionary journey". The basic differences of the two systems mentioned in their paper are reproduced in Figure 24.

Experiential System	Analytic System
1. Holistic	1. Analytic
2. Affective: pleasure-pain oriented	2. Logical: reason oriented (what is sensible)
3. Associationistic connections	3. Logical connections
4. Behavior mediated by "vibes" from past experiences	4. Behavior mediated by conscious appraisal of events
5. Encodes reality in concrete images, metaphors, and narratives	5. Encodes reality in abstract symbols, words, and numbers
6. More rapid processing: oriented toward immediate action	6. Slower processing: oriented toward delayed action
7. Self-evidently valid: "experiencing is believing"	7. Requires justification via logic and evidence

Figure 24 Comparison of Analytical and Experiential Systems (Slovic et al., 2004)

One of the important characteristics under experiential system which drive the judgement or decision making process, especially regarding risks, is the "affect heuristic". It refers to perceiving a situation as being good or bad and identifying the stimulus which can result in that state based on earlier experiences. This process of decision making might not be grounded in conscious awareness. The main findings of Slovic et al. (2004) on risk perceptions extracted from the works of other authors (Finucane, Alhakami, Slovic, & Johnson, 2000; Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Loewenstein et al., 2001; Slovic & Lichtenstein, 1968) are discussed below.

People's perception of an event as a risk is influenced by their *feeling* towards the probable outcome. Their perception while judging an event as high risk is influenced by two factors. One is their *feeling of dread* towards *the possible outcomes* and the other is the *fear of unknown outcome*. The difference between the two is that in the first case the outcome is imagined and constructed in the minds of the people. In the second case the outcome is just not clear or never been observed. In both these cases, usually people either tend to invest lot of resources in treating these risks or avoid doing those activities altogether.

The judgements on determining probability and frequency of risks are influenced by *availability heuristics*. Availability heuristic generally refers to the shaping of one's cognizance based on the examples or situations which are immediately available. In this particular context, it means that people consider occurring of an event highly likely if either it occurred recently or being talked about often in the recent past. This judgement bias is influenced by the extent to which the memory of the event is intact. Under the influence of availability heuristic people generally encode the reality through images, metaphors and narratives that they come across.

The perception of frequency of occurrence is influenced by its *representation*. People perceive an activity or an event represented in terms of proportion (like occurrence of an event 20 times out of 100 instances) or percentage as being more frequent than when it is represented as probability (like the occurrence of an event having a probability value of 0.2). This distortion was identified as *proportion dominance*.

People tend become *insensitive* to the probability of *occurrence* of an event if the consequences are *emotionally extreme*. Suppose if of an event could be disastrous or highly fruitful, like a chance of getting cancer or a chance of winning a lottery. In either cases people would be very less receptive to change in probability of occurrence of such an event. The other example in this case would be the raging societal concerns towards the handling of hazardous goods such as nuclear material even though often the probability of getting exposed to radioactivity is low.

Decisions people take related to events and activities depend on the *values* they assign to them. Culture and norms also play an important role. An example could be that performing certain

ritual could be part of the tradition and people would be willing to spend more to uphold the tradition. Another example could be that the decisions to spend on insurances depends on the values people assign to the particular goods irrespective of the actual monetary value in the market.

Perspective \ Input	Objective	Subjective
Actual	PRA [7], FTA [37], DDP [14], CORAS [12]	Bayesian [29], Belief-based [23], Goal-Risk [4]
Perceive	N/A	our research direction

Figure 25 Risk Assessment Methods Classification (Asnar & Zannone, 2008)

Further, Asnar & Zannone (2008) point out that risk assessment methods like Bayesian and Belief based do use inputs from expert judgements. However, they fall short when there is objective data missing. Taking into account the variability of risk assessment based on subjectivity and objectivity of the inputs, an interesting classification of risk assessment methods was done by to differentiate actual risk and perceived risk Figure 25. While differentiating between actual risk and perceived risk, they noted interesting observations. They are briefed below.

In a competitive system, with lot of interplay of actors, trust becomes a fundamental aspect upon which perceptions related to risks are built. If a party believes that a particular actor is trustworthy, often the risks associated with the activities of that actor become less serious. Conversely, if the party feels that an actor cannot be entrusted with the responsibility of carrying out a task, they perceive having a contract with that actor as a risk. However, establishing trust usually takes significant amount of understanding of each other's business. The kind of relations that exist among the players, determines the levels of both likely hood of risk occurring and the impacts of that risk

The perceptions of risk are also formed based on the expectations and preferences of the actors. This observation is closely related to the ones Slovic et al. (2004) made related to risk as feelings and availability heuristics. The expectations part refers to the feelings the people have regarding the outcome. The preference aspect is related to the aspect of having a predisposition for or against some activity. The deviations of expectations from the corresponding preferences determine the severity of the risks. Both expectations and preferences are subjective to different actors and parties.

Cultures, norms and informal rules that exist influence the perceptions of people on risks. This observation is similar to the one made by Slovic et al. (2004) related to values systems. Value systems are seen to be existing at an individual level, whereas cultures and norms are seen to be existing at more community or collectivistic level. Either case, both these systems determine the way the risks are perceived in a similar manner.

While it is a common practice to reduce the actual risk within acceptable limits, this approach does not behave in a similar fashion when dealing with perceived risk. The authors believe that the actors can behave carelessly when they know that they are anyhow exposed to risk. The approach here should be to rectify the actor perception and reduce the deviation from the actual risk.

Slovic et al. (2004) mention that experiential system of perceiving risks could distort the decision making process in two ways. First, through deliberate interventions, one's affective reaction can be manipulated (like in the case of marketing and advertising). Second, the limitations of experiential system will force the decision maker to resort to a bias, especially when the experience has not come to pass. However, according to Slovic et al. (2004), for the risk analysis to benefit from the experiential thinking, the analyst must be sensitive to values which drive people's perceptions

towards risks. These include "qualities of dread, equity, and controllability". At the same time the degree of bounded rationality and level of uncertainty have to be acknowledged.

3.3.5 Reflection on Multi-Actor Study and its Relevance to the Research

Several aspects of multi-actor study have been touched upon in the previous sections. The underlying objective was to have a general understanding of interplay of different actors in international shipping industry. The approach taken towards meeting this was, first, to gather the techniques required to identify and understand the roles of the actors involved in the shipping domain. Secondly, it was necessary to have an overview of the kind of interrelations and interdependencies that exist in the industry among the parties and individuals. This is important because while conducting a risk analysis across organisations, the cause and effects of risks can be projected as being actor-centric. The third step was to obtain an awareness on how people perceive risks and base their judgements on those perceptions.

The study conducted on the literature that was reviewing different actor analysis techniques revealed that these techniques are spread over four conceptual dimensions of networks, perceptions, values and resources. Each of these dimensions gives an insight on specific aspects of actors in the system. Of course, the depth of insight depends on the level of detail at which the analysis was done. As far as risk based decision making in shipping industry is concerned, learning from all these dimensions have a role to play. Through the dimension of network, the existing interactions among the actors can be studied. By analysing the field through the dimensions of both perceptions and values, the actor specific interests, objectives and their organisational KPIs can be realised. The study dimension of resources would reveal information about potential actions and strategies that can be developed by organisations around other actors to improve their operations. Therefore, it can be established that the actor analysis cannot be restricted to one dimension

To incorporate all the required levels of analysis from all the four dimensions a more general approach of actor analysis is required. On these lines, it was found that actor analysis methodologies generally operate through six basic steps. Each of these steps have been studied within the context of international shipping trade lane. By operating through these steps, it can be observed that all the minimum required information for a risk based decision making in a multi-actor context can be obtained. A preliminary actor analysis was conducted through a desk research to identify the main actors, their roles, and their functions in a typical trade lane. The industry is actor intensive mainly because of there is need for expertise in different areas and no few actors can perform all the roles. These roles include packaging goods, road transportation, water transportation, security checks, granting export clearances, and so on.

Further, it can be learnt that actor in a trade lane or a shipping lane operate through formal contracts while dealing with other parties. These contract determine the extent to which the costs and risks are distributed among the parties in a trade lane. The internationally recognised and accepted terms in this context are the Incoterms. According to these terms there are 11 ways in which the costs and risks can be distributed among the actors. The incoterms are usually agreed between the shipper and the buyer. Based on the chosen terms, the shipper and buyer act further in making new sub contract with the intermediary parties like freight forwarders, shippers and customs agents. Therefore, to understand the extent of responsibilities to construct an interdependency map it is necessary to know under which incoterms the parties are operating.

The third aspect that was studied was related to actor perceptions around risks and their consequences. Several interesting findings were obtained. There is clear distinction on the way the analytical system and an experiential system operates among people. There are various ways through which the cognitive ability of the people could be distorted. People, by and large, label an event as a risk based on their feelings towards the consequences, the available heuristics, their expectations and preferences. Their ability to determine the probability of occurrence is influenced

by factors like representation and severity of the impact. Further, the values, cultures, social norms and informal rules determine their judgements while making decisions related to risks. Therefore, care should be taken while gathering the information from the actors operating in the field. To gather right kind of information, the actors and the analysts have to be aware of these distortions.

3.4 Direction for Developing a RBDM Approach

RBO method is a systematic process adopted by the distribution companies to ease their decision making process related to managing assets. This process essentially converges towards constructing a simple tool of risk matrix. The framework in which RBO process usually operates is the risk management framework advocated by ISO. This framework is a logical step wise approach and is not limited to any specific industry. The generality of this framework at a meta-level makes it convenient to consider it as a basis for developing RBDM Approach. Therefore, these steps which can also be looked as different phases of risk management process are adopted to form the core of the proposed RBDM Approach in this research.

Risk management practices employed in shipping industry have been primarily associated with safety cultures of the organisations and operators. Largely, they were developed as a reaction to a major accident or serious safety transgressions. They have been playing a less significant role as far as the organisational decision making related to managing costs and developing business strategies is concerned. Having said that, it is important to realise that they are effective in their own way. Each of the frameworks and methods adopted focus on specific values and interests of the practitioners. The main commonality however in each of these methods is that they all recommend a sequential approach similar to ISO framework of risk management.

In Table 10 all the risk assessment frameworks studied are correlated with the risk management process of ISO 31000 standard. The steps in each of these frameworks are aligned with the corresponding process blocks of ISO namely the blocks of “establishing context”, “risk assessment” and “risk treatment”. Risk assessment block as was seen is further divided into three steps which being “risk identification”, “risk analysis” and “risk evaluation”. Most of the steps align with these three steps. It can be noticed that the other two blocks which are “communication and consultation” and “monitoring and reviewing” are not mentioned in the table. The reason is that in the literature study conducted, it was noted that none of the risk assessment frameworks explicitly emphasized the requirement of these activities. This observation reinstates the uniqueness of ISO framework which is highlighted in section 3.1.1.

To improve the businesses and operations in shipping industry, it is not enough to formalise a risk management process without considering the aspects of multi-actor settings. Both the risk assessment frameworks in shipping industry and the RBO methodology fall short in this aspect. As was indicated in the previous section, a general actor analysis methodology has to be incorporated to gather essentials by analysing through all the four dimensions of networks, values, perceptions and resources. Further, it was discussed that there are several ways the perceptions of people can get distorted. Therefore care should be taken by being aware of these elements while gathering information.

Based on the discussion and findings, three main takeaways can be identified for the development of RBDM Approach. **First**, to facilitate an informed decision making construction of a risk matrix is essential. However, to construct a risk matrix, a thorough understanding of cause and effect of risk events have to be understood. Incorporating bow-tie framework will aid the process of developing a risk matrix. However, a mere adoption of RBO process is not enough. It has to be adapted for a multi-actor setting. **Second**, since the industry already has several forms of risk managements processes, it is also important for RBDM Approach to be compatible with different risk assessment techniques offered by the frameworks. **Third**, a general actor analysis methodology has to be incorporated in the risk assessment methodology. The objective should be to identify the roles and functions of the

actors, their interdependencies, their interests and values and their perceptions. Further, one should be aware of the distortions the perceptions can introduce while gathering the data

Table 10 Correlating steps of risk assessment frameworks with ISO31000 standard

Risk Assessment Frameworks in Shipping Industry	Risk Management Blocks as per ISO				
	Context	Risk Assessment			Treatment
		Identification	Analysis	Evaluation	
COMPACT Model	1. Understanding the business 2. Clarifying objectives of the Customs	3. Identifying risks	4. Assessing the risks	-	5. Respond to the risks
FSA	-	1. Hazard identification	2. Risk analysis 3. Risk control options	4. Cost-benefits assessment	5. Recommendations for decision-making
QRA	-	1. Listing the end states 2. Identifying the initiating events	3. Mapping the sequence of events 4. Estimating the probability of scenarios	5. Ranking accident scenarios	-
Safety Case	1. Scope 2. System Description	3. System Hazards 4. Safety Requirements	5. Risk Assessment 6. Safety Analysis / Test	7. Hazard Control / Risk Reduction Measures	8. Safety Management System 9. Development Process Justification
MARCS		1. Conducting historical statistics	2. Fault Tree analysis 3. Event Tree analysis	4. Seeking Expert Judgement	-

4. THE PROCESS OF RBDM APPROACH

The stage is now set to develop a RBDM Approach by adapting the RBO methodology and incorporating the multi-actor dynamics prevalent in the international shipping industry. The following sections describe the development of RBDM Approach by taking the leads from the three core essentials identified in section 3.4.

4.1 ISO Framework as the basis for RBDM Approach

It was directed that RBO methodology has to be adapted for shipping industry. The narrative of RBO approach of energy industry established that for an informed decision regarding business development to evolve, there should be a well-structured bow-tie diagram and a well-crafted risk matrix. To accomplish this, the industry follows the risk assessment process of ISO 31000:2009. ISO standard has been specifically developed to improve the business of the practitioners. Further, from the study of different risk assessment frameworks it was observed that all their process steps could be correlated to the broader process of ISO. Thus the RBDM Approach developed in this research has its phase-wise process inspired from the ISO framework.

The next step taken in the development of RBDM Approach was to incorporate the general six step multi-actor analysis approach. In this regards, the five phases of the RBDM Approach are *System Establishing phase , Identification phase, Analysis phase, Evaluation phase, and Decision Making phase*. In these phases the six steps of actor identification are merged as shown in Table 11. It can be noted that to have a logical flow in the process step 4 and step 5 of actor analysis have been interchanged. Figure 27 illustrates the process flow of the developed RBDM Approach. Section 4.3 discusses each phase of the approach in detail.

Table 11 Determining the Phases of RBDM Approach

Phases of RBDM Approach	Risk Management Processes of ISO	Multi-actor Analysis Steps
System Establishing Phase	Establish Context	1. Formulation of a problem
Identification Phase	Risk Identification	2. Inventory of the actors 3. Exhibiting the formal chart
Analysis Phase	Risk Analysis	4. Mapping out the interdependencies
Evaluation Phase	Risk Evaluation	5. Determining the actor perceptions
Decision Making Phase	Risk Treatment	6. Determining the consequences of the findings

4.2 Notions and terms in RBDM Approach

It was observed in the literature study that the usage of some specific terms associated with risk management has been recurring. In some cases the meaning of the term was not consistent. For, instance the notion of risk as identified in RBO methodology is not the same as identified by risk assessment framework like AEO Compact Model, Safety Case and FSA. Therefore for establishment of a structured RBDM Approach, it is necessary to have a clear understanding of different terms that will be used along the process and to clear the ambiguity if any.

Trigger: A stimulus that initiates an action or a function is referred to as trigger. In this context, trigger can be an initiator for any cause, an event or an impact. If the trigger lead to the occurrence of a risk event, then it is essentially a *cause* of that risk event.

Risk Event (or Risk): Any event which when triggered would have an impact on different aspects is called a risk event. This impact can be usually wither positive or negative. But in this research only negative impacts have been considered. An important consideration that has to be noted here is that if a risk event has occurred, the impact *shall* follow and not *may* follow. If the event does not have any impact or can lead to an impact it means that it is either not a risk event or a cause to certain risk event.

Risk Criteria: The risks are measured based on the level of impacts they have on the parameters which are important for the actors. These parameters are called as risk criteria and they can be either qualitative or quantitative. Often the KPIs which are established based on the values, interests and organisational goals are chosen to be the risk criteria. In the research that follows, cost impacts on different actors are considered.

Risk Cause: Any trigger that leads to a risk event becomes the cause for that risk**.** A risk event can have multiple causes either dependent or independent. In the context of RBDM, a cause is associated to the actor who is responsible for that activity or function. This responsibility can be identified by studying the actor interdependencies in the field.

Consequence: Consequence of a risk refer to the impacts of a risk event measured through the risk criteria. Just like a risk cause, in the context of RBDM, the consequences are associated with the different actors impacted. Further, there can be multiple consequences but unlike causes they are cannot be interrelated. If a consequence A of a risk event R is having another impact B, then the risk event R is either having two impacts A and B or there is another risk event R^1 triggered by a consequence A having an impact B.

Impact Level: It is the degree of impact, each consequence has on the risk criteria. The impacts are scaled from Very Low level (VL) to Very High level (VH). Each of these levels either have to be described (if the criteria is qualitative) or have to be associated with a range (if the criteria is quantitative).

Likelihood of Occurrence: The probability of either a cause occurring or a risk occurring is referred to as Likelihood of Occurrence (LoC) of that cause or that risk event. LoC values of different causes of a risk could be obtained through historical data, expert interviews and event logs. Based on the interrelations between different causes, the LoC of the risk event is evaluated. For the ease of representation, the evaluated LoC of a risk event can be categorised according the scale measuring from Very Low (VL) to Very High (VH).

Preventive Action: Any action that can reduce the LoC value of a cause or even eliminate it is referred to as being a preventive action. If LoC values of all the causes are eliminated then the LoC of risk event is zero. In other words the risk does not exist anymore. A preventive action does not reduce or stop the consequences from occurring once the risk event has been triggered.

Corrective action: Any action that can either reduce the level of impact or eliminate the impacts altogether is called a corrective action. If all the impacts on different risk criteria are eliminated, then it can be said that that particular risk event is eliminated.

4.3 Phases of RBDM Approach

Through the phases identified, the RBDM Approach aims to achieve two things - **first is the generation of bow-tie diagram and second is construction of a risk matrix, both in a multi-actor context**. A bow-tie diagram is a risk centric representation of a risk event in a multi-actor context. This means that it gives details about causes and consequences of each risk event in association with the actors. Risk matrix on the other hand is an actor centric representation of the multi-actor field with its risk events. This means that it gives details different risks associated with each actor. Both these representations would give clarity to the businesses, operators and organisations by making the field explicit to large extent. The process of RBDM Approach developed is illustrated in Figure 27. This section goes a step deeper to understand the requirements, operations and outcomes of each these phases.

4.3.1 System Establishing Phase

Before any analysis is taken up, the system has to be established with all its boundaries identified. In this research a studied was done on a typical trade lane in international shipping domain. Based on the findings RBDM Approach was developed. Now based RBDM Approach, if one were to establish the kind of system in which it can be generally applicable then few distinct characteristics of the system can be identified. They are mentioned below in no particular order.

Firstly, the system is dynamic with lot of events occurring along the time line. Secondly, it must have multiple actors associated with these events. Thirdly, the system should operate with specific rules which can be either formal or informal. Fourthly, interrelations in the form of cause and consequence can be distinctly identified. Fifthly, there must certain level of uncertainties operating through external and internal factors that influence the system.

4.3.2 Identification Phase

The identification phase of RBDM Approach consists of two actions: actor identification and risk identification. In both the cases the corresponding traditional identification methods can be deployed to make inventories of risk events and actors.

The goal of this phase should be to generate as information as possible. The effectiveness of overall analysis depends on how exhaustively this phase has been executed. Primarily, to carry out further analysis following outcomes are desirable.

- List of categorized risk events with their causes (or triggers)
- The frequency of occurrences of these causes
- List of actors and their roles in the supply chain
- Formal positions of actors and their responsibilities based on terms and contracts
- Preliminary list of impacts of these risk events
- List of risk mitigation actions, undertaken by actors, for specific risks

Further, to reduce the overall analysis time of RBDM few suggestions in the form of guidelines are laid down below.

***Guideline 1*:** It should be realised that if an event is labelled as a risk event, it means that has for certainty an impact. It cannot be that a risk event "may" have an impact. If it seems that an event may have an impact then that event is actually a "cause" to another risk event.

***Guideline 2*:** Avoid gathering information of risks events which do not have impacts spilling beyond the organisations boundaries of a particular actor. For example, a risk of having overhead electric wires hanging low near the entrance of an office building. This risk is very specific to the organisation and should be contained through their internal auditing.

***Guideline 4*:** Categorize risks as per the risk categories identified in Table 3**Error! Reference source not found.**. This will help in identifying both the actors and the kind of impacts they would have in the process.

***Guideline 5*:** Prefer employing identification techniques which are common to both risk identification and actor identification. These can be gathering data from the field experts through interviews, organising brain storming sessions, and resorting to historical data.

4.3.3 Analysis Phase

This phase deals with analysing the data gathered. This analysis is at two levels: one at risk event level and the other at actor level. At risk event level, risks are positioned between their different triggers and impacts. At actor level, the formal and informal relations existing among actors are identified, to map the interdependencies. The objective of this phase is to construct bow-tie diagrams for the risk events in a multi-actor scenario.

As was mentioned earlier, a bow-tie diagram is a representation of a risk event with it causes and consequences both of which are associated with the actors involved. A bow-tie diagram is a risk centric representation of the multi-actor dynamics around that risk. Figure 26 illustrates the concept of a bow-tie diagram in a multi-actor scenario. A risk can be triggered by different causes. Often there is an actor or group of actors responsible for each cause. If there is no actor responsible, then the cause can be labelled as external cause. Further, once the risk event is triggered there can be several impact on the risk criteria which are established based on the values and interests of the actors. For instance in the figure KPIs are the risk criteria. The blue and yellow dots are the barriers in the form of corrective and preventive action.

To develop a good bow-tie, the following information has to be extracted meticulously for each risk event through the analysis.

- List of all causes of a risk event along with their likelihood of occurrences.
- Formal and informal relations between the actors
- List of corrective and preventive actions, if any for corresponding risk events

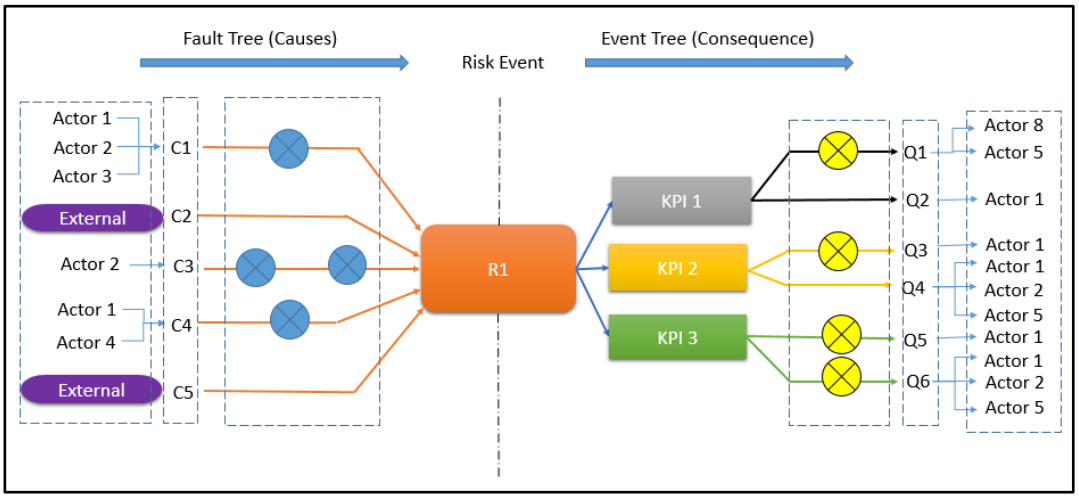


Figure 26 Bow-tie framework in multi-actor scenario

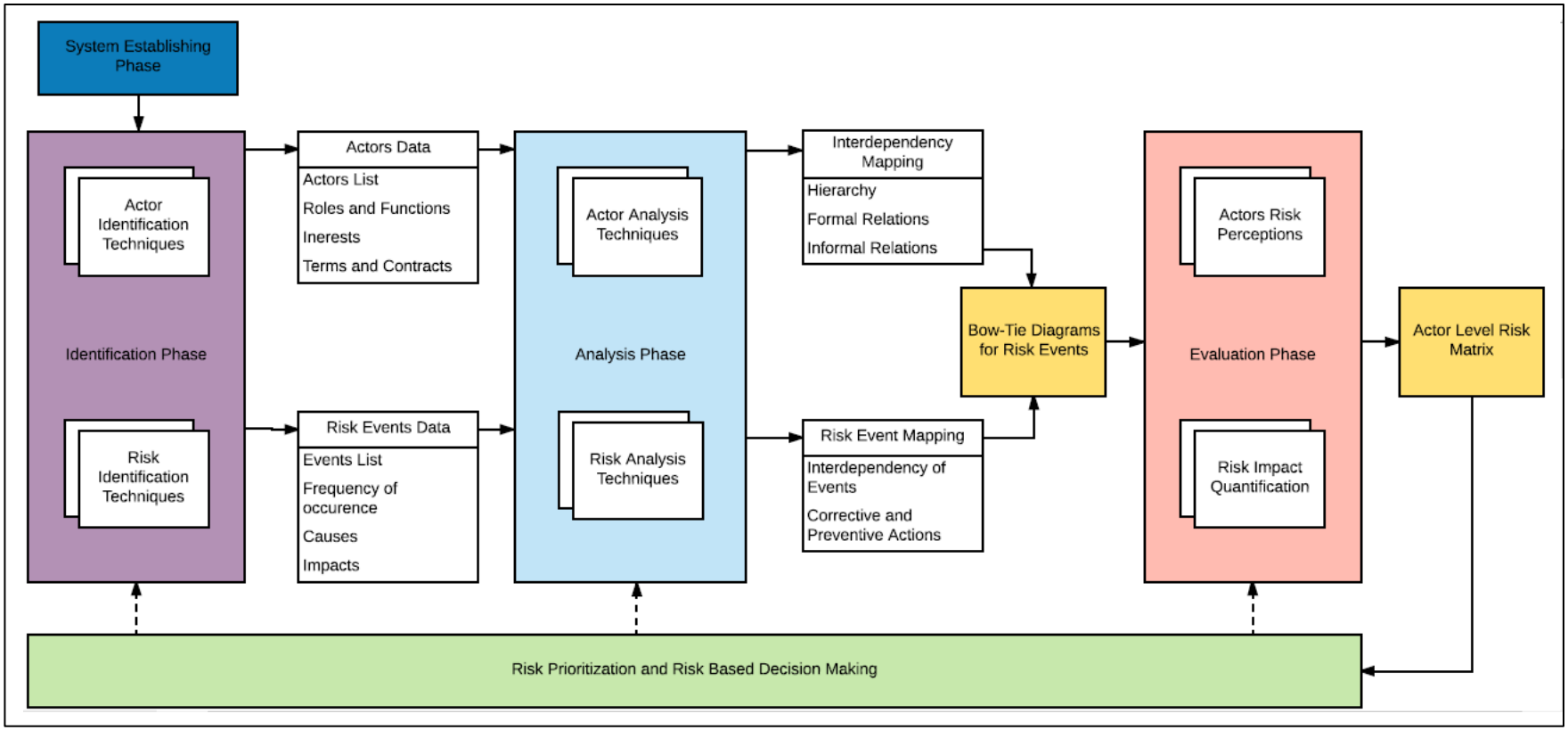


Figure 27 Process of RBDM Approach in a Multi-actor Domain

The following guidelines are to be considered while constructing the bow-tie diagram in a multi-actor scenario.

Guideline 1: Each cause has to be associated with an agent which can be either an actor, or external factor or another risk event and each of that cause has a value of likelihood of occurrence. It has to be understood that the causes are "likely" to trigger a risk event. This value can be established through different techniques like root-cause analysis, frequency distributions from historical data, expert opinions, and fault tree analysis and so on.

Guideline 2: The value of likelihood of occurrence of a risk event depends on the corresponding values of the causes. Calculation of this value could follow from the concepts of fault tree analysis. It is briefly discussed below.

Let P (RE) to be the overall likelihood of occurrence of a risk event.

Let there be n number of causes involved in triggering of risk event.

Let P (C_n) be the likelihood of occurrence of cause number n.

Usually, a risk event could be triggered in two[4] ways.

1. Any of the causes could independently trigger the risk event. In this case the overall likelihood of occurrence of a risk event would be same as that of the independent cause which has the highest likelihood of occurrence value when compared to other causes. This can be represented by following equation

$$P\ (RE) = Max\ \{P\ (C_1), P\ (C_2), \ldots..P\ (C_n)\}$$

2. The risk event could be triggered only when two or more causes occur together. In this case the overall likelihood of occurrence of a risk event would be the product of values of likelihood of occurrences of all these causes. This can be represented by following equation

$$P\ (RE) = P\ (C_1)\ X\ P\ (C_2)\ X\ \ldots..P\ (C_n)$$

Guideline 3: Categorize the likelihood of occurrence of risk events across a grade scale which could be from very low to very high as shown in Table 12. The number of levels used for scaling the values determines the dimension of risk probability /likelihood axis of risk matrix.

Table 12 Grading of Likelihood of Occurrence values

Range of Likelihood of Occurrence values		Grade of Likelihood of Occurrence	Scale
Lower (>)	Upper (<=)		
0.8	1	VH	Very High
0.60	0.80	H	High
0.40	0.60	M	Medium
0.30	0.40	L	Low
0.00	0.20	VL	Very Low

Guideline 4: Preventive Actions, if identified, are to be placed before the occurrence of a risk event across the respective causal line triggering the event. Preventive action against a particular can be any action which can lower the value of likelihood of occurrence of that cause.

Guideline 5: Consequences of a risk *must* follow after the risk event is triggered. In other words, risk events must for sure lead to an impact. If it was identified that a risk event *may* lead to an impact,

[4] According to fault tree analysis (FTA), an output can be triggered in four different ways - OR gate, AND gate, Exclusive OR gate, Priority AND gate, and Inhibit gate. In this thesis only the most basic OR gate and AND gate concepts are discussed. The analysis could be extended to other two ways also. Refer Appendix D for more information on Boolean operations, logic gates and FTA.

it means that this is not actually a risk event, but it is a cause to another risk event which could be either already identified or yet to be known.

Guideline 6*:* Corrective Action always follow risk events, and are to be placed before the corresponding impacts. The level of impact could be reduced based on the effectiveness of the corrective actions in place.

Guideline 7: Formal chart or a responsibility chart has to be mapped based on the analysing the contracts that exist among the actors. Actor interdependency map is closely related to responsibility map, except that the relations are in opposite direction. This notion is discussed below.

Consider actor A has contracted actor B to deliver goods and actor C to compile the required documentation for customs clearance. Further actor B has sub-contracted actor D to drive the vehicle. This means that B and C are accountable to A while D is accountable to B. In other words, A is dependent on B and C, while B is dependent on D. This notion is illustrated in Figure 28. The dotted arrows denote dependency and solid arrows denote accountability.

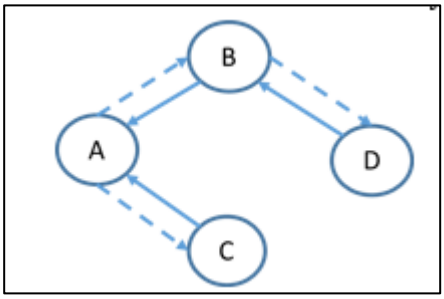


Figure 28 Notions of responsibility (accountability) and dependency among actors

Guideline 8: An action identified as a cause must be linked to an associated actor who is responsible for that particular action in the first place. For example in Figure 28, consider that if actor D defaults and a risk event is triggered causing a delay to A. Here, though B is not causing the risk event directly, he/she is responsible for the delay caused to A. In this regards details to construct bow-tie diagram would be as below.

Risk event: Goods were not delivered as per the scheduled time
Actor triggering the risk event: Actor B
Cause of the triggering event: Actor B hired actor D who defaulted.
Impact: Delay in delivery of goods to actor A

4.3.4 Evaluation Phase

While the analysis phase is rooted in the mathematical representations, evaluation phase of RBDM Approach depends how pragmatically the impacts are quantified. In this phase, actor perceptions towards risk play a major role. The objective of this phase is to construct a risk matrix for each actor and thereby through prioritizing risks, assist the actors to make decisions regarding their business development.

The inputs required for this phase are:

1. List of all the risk events which have impacted each actor
2. Impacts of each risk on the risk criteria of each actor
3. Levels of impacts categorized from very low to very high for each actor.

Guideline 1: Determine for each actor the impact levels based on their interests and perception. Each actor is not impacted by a risk event in similar way. For a small organisation, a delay of couple of days could be unacceptable, whereas for another organisation this delay could be minimal or manageable. This process of determining level of impact for each actors requires the researcher or the analyst to actively approach each concerned actor in the chain.

***Guideline 2**:* The number of levels of impact has to be consistent across all actors. This number determines the dimension of impact axis in the risk matrix. Usually the impact values are scaled across five levels. An example of scaling is shown in Table 13.

Table 13 Example of grading of cost impacts

Impact Range		Grade	Scale
Lower (>)	Upper (<=)		
€ 8,000.00	-	VH	Very High
€ 6,000.00	€ 8,000.00	H	High
€ 4,000.00	€ 6,000.00	M	Medium
€ 2,000.00	€ 4,000.00	L	Low
€ -	€ 2,000.00	VL	Very Low

***Guideline 3**:* The number of coloured regions depends on the level of detail the respective actor seeks while prioritizing the risks. Minimum number of regions a risk matrix could have to enable risk prioritization is two (one could argue that the whole matrix could be coloured with one colour. In that case there is no need for a risk matrix at all). The maximum number of regions possible could be equal to the number of cells in the risk matrix. The number of regions established determines the manner in which the decisions regarding risks would be taken. If the detail is too low then lot of risks by falling in the same regions would be of same priority to the actor. If the level of detail is too high then matrix becomes highly deterministic. Highly deterministic matrices prevail only when there is high certainty about the events and the factors and this is not the case in a multi-actor scenario. Since the purpose of a risk matrix is to be indicative, an ideal risk matrix would be to have 4-5 colours.

A typical 5x5 risk matrix is depicted in Figure 29. Sharp colour changes can be noticed from one cell to another in the middle region. To prioritize between the risks falling in adjacent cells, it is necessary to revisit the details gathered regarding those particular risk events and take decision accordingly.

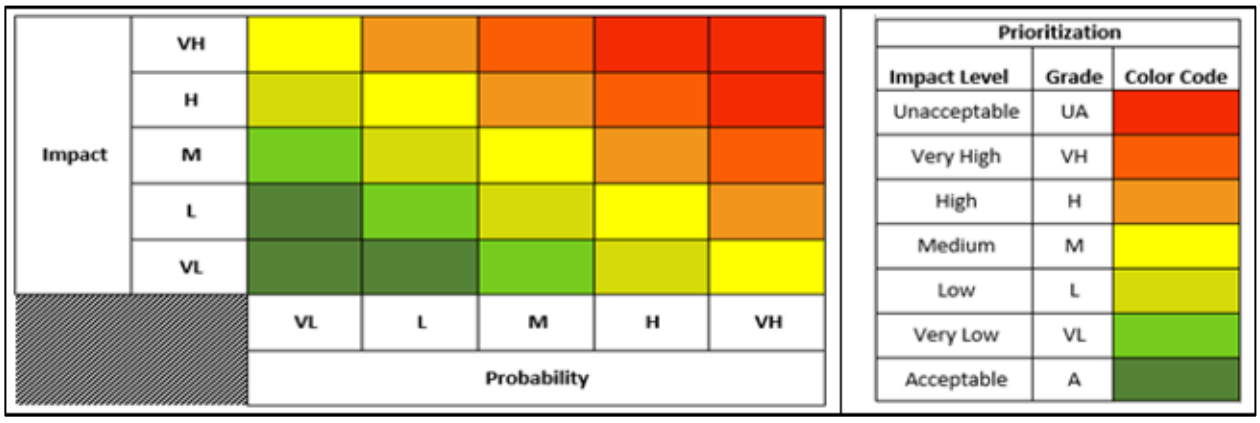


Figure 29 Example of a typical 5 x 5 risk matrix

4.3.5 Decision Making Phase

Through the development of risk matrix, the organisation or the individual are in position to take decision related to treatment of those risks that affect their values and interest the most. The risks that affect the risk criteria of an actor are spread across different regions of the risk matrix. Now the objective of actors would be to shift the risks which lie in unacceptable and high regions to low and acceptable regions. The strategies available for the actors to do so depends on the industry they are operating in and the resources they have in the form of financial capabilities and business relations.

In his work, Wijnia (2016) made a simple illustration of the categories in which the strategies chosen would fall. They are shown in Figure 30. If impact is along the vertical axis and likelihood of risk occurrence is on horizontal, then the four ways in which the strategies operate are shown. By reducing the impact through corrective actions, the risks are shifted down. By reducing the likelihood through preventive action the risks are shifted to the left. Further, it is advisable to transfer the risks which have high impact and low likelihood.

This broad categorization of risks is applicable in the context of shipping industry also even while dealing with risks which are beyond the control of a particular actor. However, the exact strategy to be implemented remains subjective. To be merely indicative, some of the strategies which could be possible are listed below.

- Renegotiating the contract terms and transferring the roles and responsibilities of the process
- Developing contracts with different parties if trust is an important value of the organisation
- Having a backup inventory for the goods being shipped or to be shipped if loss of business is a criteria
- Investing in increasing the shelf life of the goods if delay is a risk criteria.
- Forming alliances to mitigate the uncertainty and improve trust among the parties
- Having insurance packages in place to tackle the loss of cargo.

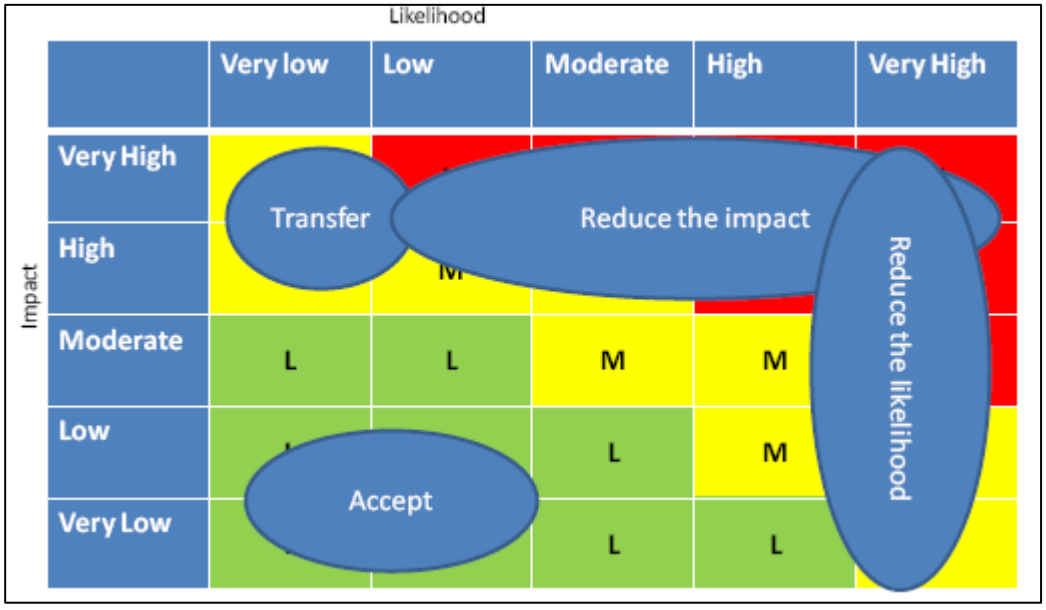


Figure 30 Risk intervention options in the matrix (Wijnia, 2016)

5. PROTOTYPE OF RBDM TOOL

RBDM Approach developed is both quantitative and qualitative. The quantitative aspect of risk assessment involves gathering the data, analysing it and evaluating the risks and impacts. Each of these activities are computation intensive, when large number of risks, their causes, and their impacts are being analysed. For the process to be faster, efficient and also to be well grounded in the theories developed, a sequence of logical steps have to be developed on some form programming language platform.

Further, like any other computation software, the code developed as the part of application is hidden from the user. In other words it is a black box. Therefore, the well-known statement of "garbage in, garbage out", used often used in the world of programming is applicable here. Therefore, to facilitate gathering of required sensible data, RBDM incorporates data gathering templates. The following sections discuss the development and working of the tool in detail.

5.1 Process of developing the tool

To develop a tool based on the conceptual process developed in the previous section, both top-down and bottom up approaches were employed. Top-down approach was used to reveal the minimum information and components required at each stage. Bottom-up approach was used to link the information gathered at the bottom levels stage wise to arrive at the objective. In other words, for top-bottom approach, the questions of "what" were asked to understand the minimum requirements, and for the bottom-up process the question of "how" was asked to connect and analyse the data. The process is illustrated in Figure 31.

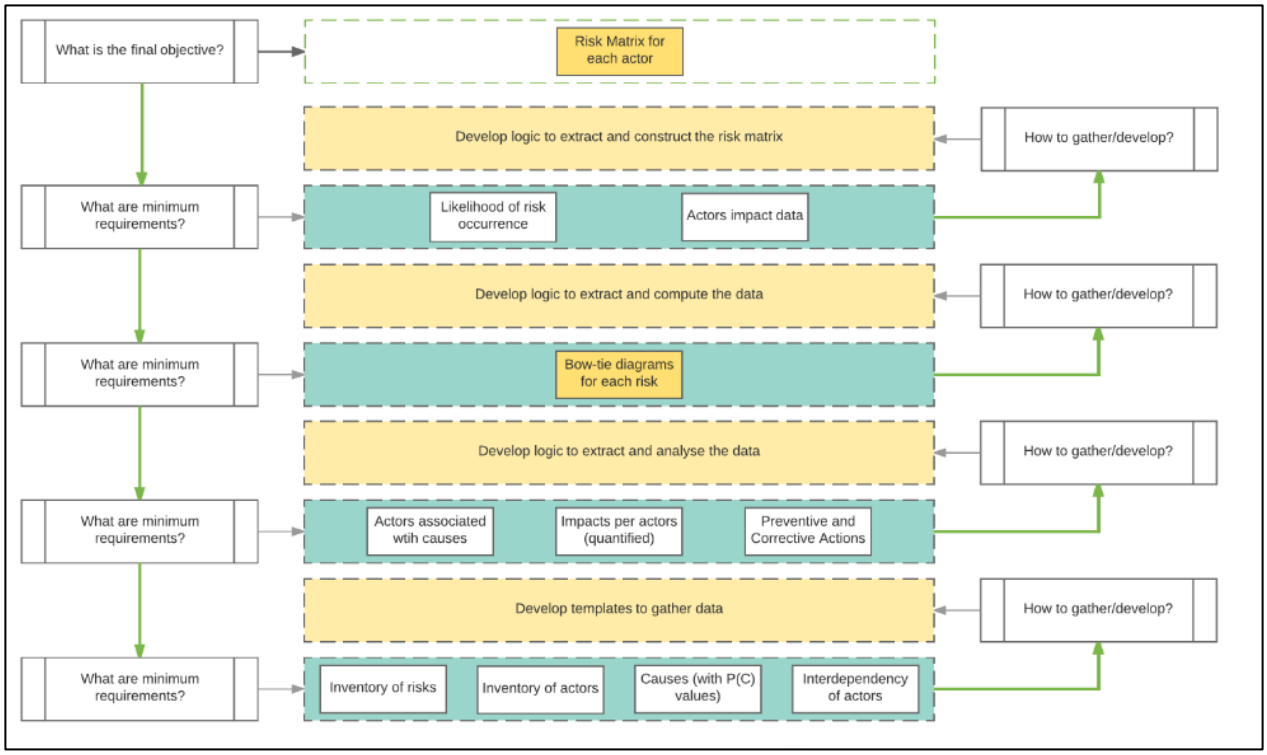


Figure 31 Top-down and bottom-up approaches for tool development

The motivation for the development of the tool was to demonstrate the possibility of applying RBDM Approach on a large scale along a trade lane. At the same time, this tool has to be simple, and easy to use for the operators. For this reason, Visual basic platform was used to develop front end codes for MS Excel application of Microsoft.

5.2 Main Components of the Tool

The tool has to serve three main purposes. First is that it has to facilitate easy and simple interface to provide the required inputs. Second is that it has to process the information and carryout analysis in the background effectively. Third is it has to generate the output based on the input. To accomplish these tasks the following components were developed in the tool.

5.2.1 Dash Board

To help navigating across different features of the tools a dashboard was developed. The current look of the dashboard is shown in Figure 32. Through this component five core aspects of the RBDM tool can be accessed. They are "Information Sheet", "Risk Register", "Actor Register", "Risk Matrix" and "Bow-tie Diagram". Information sheet describes the background of RBDM Approach and acts as a simple user manual for operating the tool. Each of the other components are discussed briefly in the following sections.

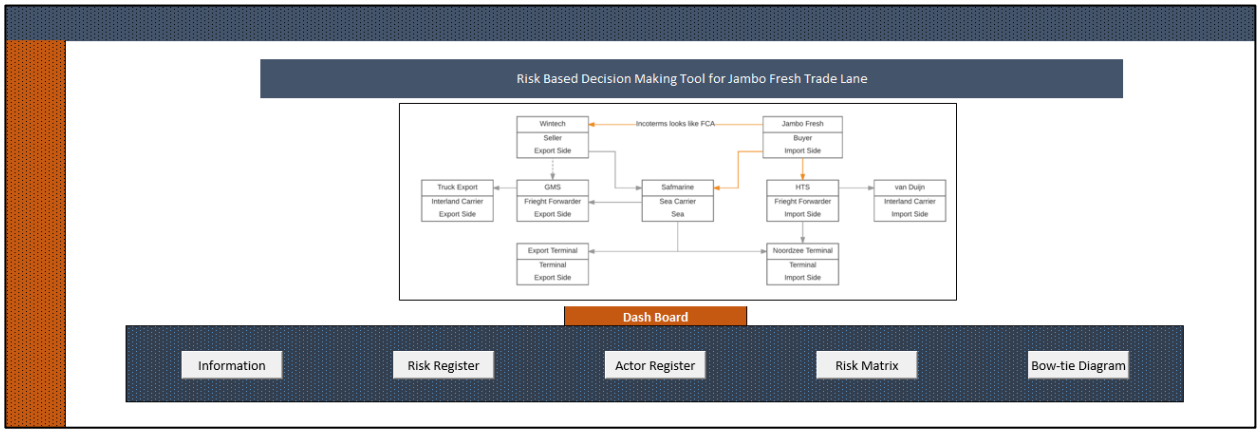


Figure 32 Dashboard of the developed RBDM Tool

5.2.2 Risk Register

It is basically a list of all the risks identified and recorded. Each risk event is assigned a number in the format of "R#" for the ease of identification and further analysis. The populated risk register used for analysis in this research is shown in Figure 33. It can be noticed that it also gives information about the likelihood of occurrence of the risk event along with the grade scale. Further, through this sheet one can "View" any risk, "Edit" them or even add details of a "New risk". These function can be done by the buttons located to the right.

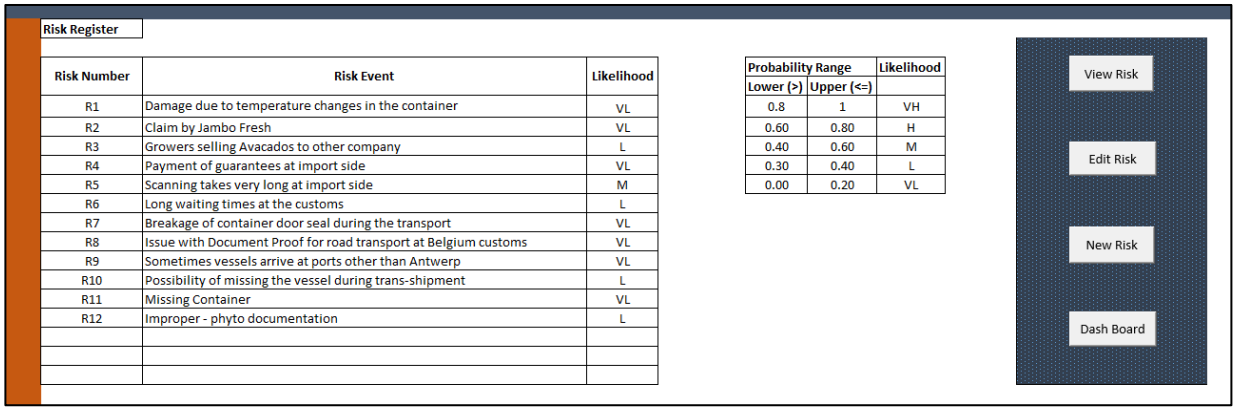


Figure 33 Risk register of RBDM Tool

By clicking on the "View Risk" button a pull down menu box pops up with list of risk number. Once the corresponding risk event to be viewed is chosen the "risk analysis form" of that particular risk opens up. Details about the risk form are briefed in the next section. "Edit Risk" button once clicked also will call for a similar pull down menu. However, after the risk number is selected this time, a "user form" is displayed on the screen. A user form is an interface assisting the user to input the right kind of information required for the analysis. Screenshots of the user forms are presented in 0. "New Risk" button will insert directly open up the blank risk analysis form which is shown in Figure 35. A new row with a new risk number is automatically filled in the risk register. Once the details about the new risk are populated in the risk analysis form, the risk event title will be updated in the risk register. Finally the "Dash Board" button will navigate back to original dash board after closing all the opened sheets.

5.2.2.1 Risk Analysis Form

This sheet captures all the information regarding the risk and the actors associated with it. A typical risk analysis form is shown in Figure 37. It has six distinct sections each pertaining different aspects of risks and the tool. The top block gives general information about the risk like the risk number, a short description of the event, the event title and also LoC of the risk event. LoC of risk event as was discussed earlier is calculated from the LoC of different causes.

The following second block gives details about the causes which include the cause number, the associated agent that is responsible for the corresponding cause, cause description and the LoC of that cause. The agents triggering this cause can be an actor, an external factor like weather, or another risk event. The third block captures the details of the preventive actions for each cause. Each preventive action will reduce the LoC of that particular cause.

The fourth block gives the details about the consequences. As mentioned earlier, a risk event must have an impact. In this prototype, consequences relate to the impacts on costs and finances of three different actors. The fifth block is related to the corrective actions which when executed would lower the impact levels of different consequences. The final impacts are captured in the last three columns of the consequence block. Finally on the right the sixth block has two buttons. One is to navigate back to the dashboard and the other is to generate one of the main outputs of the risk analysis that is the bow-tie.

5.2.2.2 Generation of a Bow-Tie Diagram

Once the risk analysis form of a particular risk event is populated, and the bow-tie button is clicked, the tool generated a risk event centric bow-tie. It is a quick representation of all the actors associated with this risk event. The representation fetches the basic data like the identification

numbers of risk event, causes, preventive actions, consequences and corrective actions. A typical unpopulated bow-tie diagram is shown in the Figure 34.

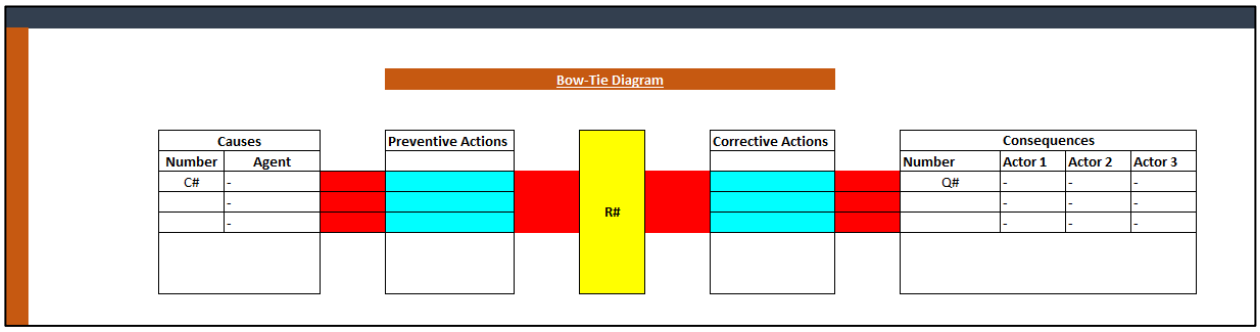
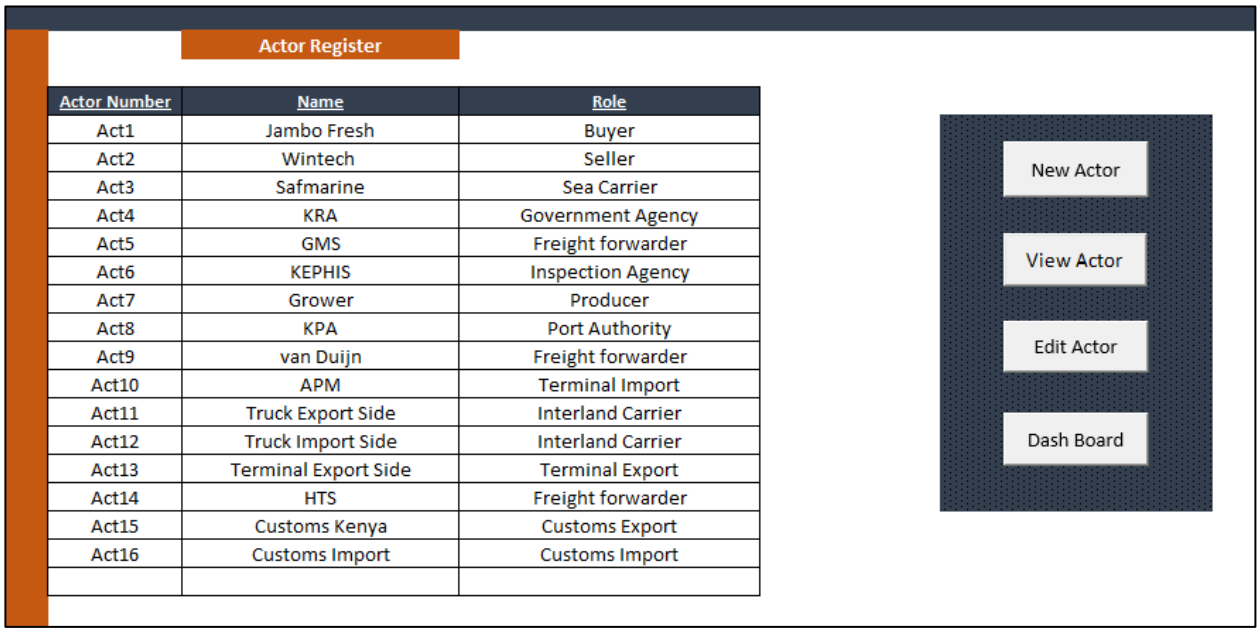


Figure 34 A typical Bow-Tie generated by RBDM Tool

5.2.3 Actor Register

This is a simple form indicating different actors and their roles in the system established. Just like the risk register it has buttons on the right side which can help the user to add a new actor, view the details about the existing actors, edit the details and navigate back to the dashboard. Figure 35 shows the actor register sheet of RBDM Tool.



Actor Number	Name	Role
Act1	Jambo Fresh	Buyer
Act2	Wintech	Seller
Act3	Safmarine	Sea Carrier
Act4	KRA	Government Agency
Act5	GMS	Freight forwarder
Act6	KEPHIS	Inspection Agency
Act7	Grower	Producer
Act8	KPA	Port Authority
Act9	van Duijn	Freight forwarder
Act10	APM	Terminal Import
Act11	Truck Export Side	Interland Carrier
Act12	Truck Import Side	Interland Carrier
Act13	Terminal Export Side	Terminal Export
Act14	HTS	Freight forwarder
Act15	Customs Kenya	Customs Export
Act16	Customs Import	Customs Import

Figure 35 Actor Register of RBDM Tool

5.2.3.1 Actor Analysis Form

Similar to each risk having a sheet of its own, all actors also have a sheet of their own. As seen in Figure 38, in its current form it has a modular look with four distinct blocks. The first block gives basic details about the actor like the actor identification number, actor description relate to roles and responsibilities, and actor name. In the second block deals with the information related to how the actor perceives risk and its impacts. This information is used to establish the impact scales of that particular actor. The third block is an output block where the information required to generate a risk

matrix in displayed. This block is populated automatically once the "Risk Matrix" button is activated in the block four. Finally block four also has a button to navigate back to the dashboard.

5.2.3.2 Generation of Risk Matrix

Once the risk matrix button is activated in a particular actor analysis form, the tool scans through all the risk forms and populated the LoC values of each risk event. Later it picks all those risk events which when triggered would impact this particular actor. It extract the impact values and measures it across the impact scale established in the actor analysis form. Once the levels of each risk have been identified, the tool maps the risks on the risk matrix template. Thus the actor-centric risk matrix is generated. A typical risk matrix is shown in Figure 36.

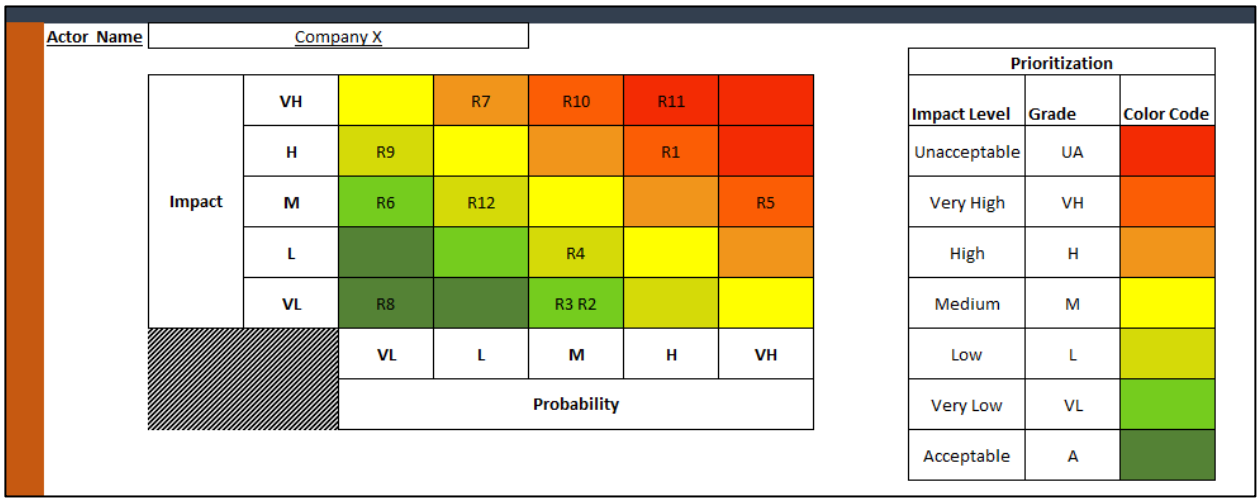


Figure 36 Typical Risk Matrix generated by RBDM Tool

5.3 Testing the Tool

Before proceeding further for field testing, a short exercise was conducted to test the functionality of the tool. This exercise dealt with constructing a dummy case imitating a simple scenario which is close to reality. Face validation, as it is known, is the process of testing the model or the tool that is built for its fit-for-purpose. This is done often by seeking the opinions of the domain experts who are usually academicians and researchers in that particular field or the experienced practitioners operating in the field. Domain experts in this case were the thesis supervisors. By inputting different kinds of information required for the analysis, the functionality of the tool in generating a risk centric bow-tie and an actor centric risk matrix was tested and improved.

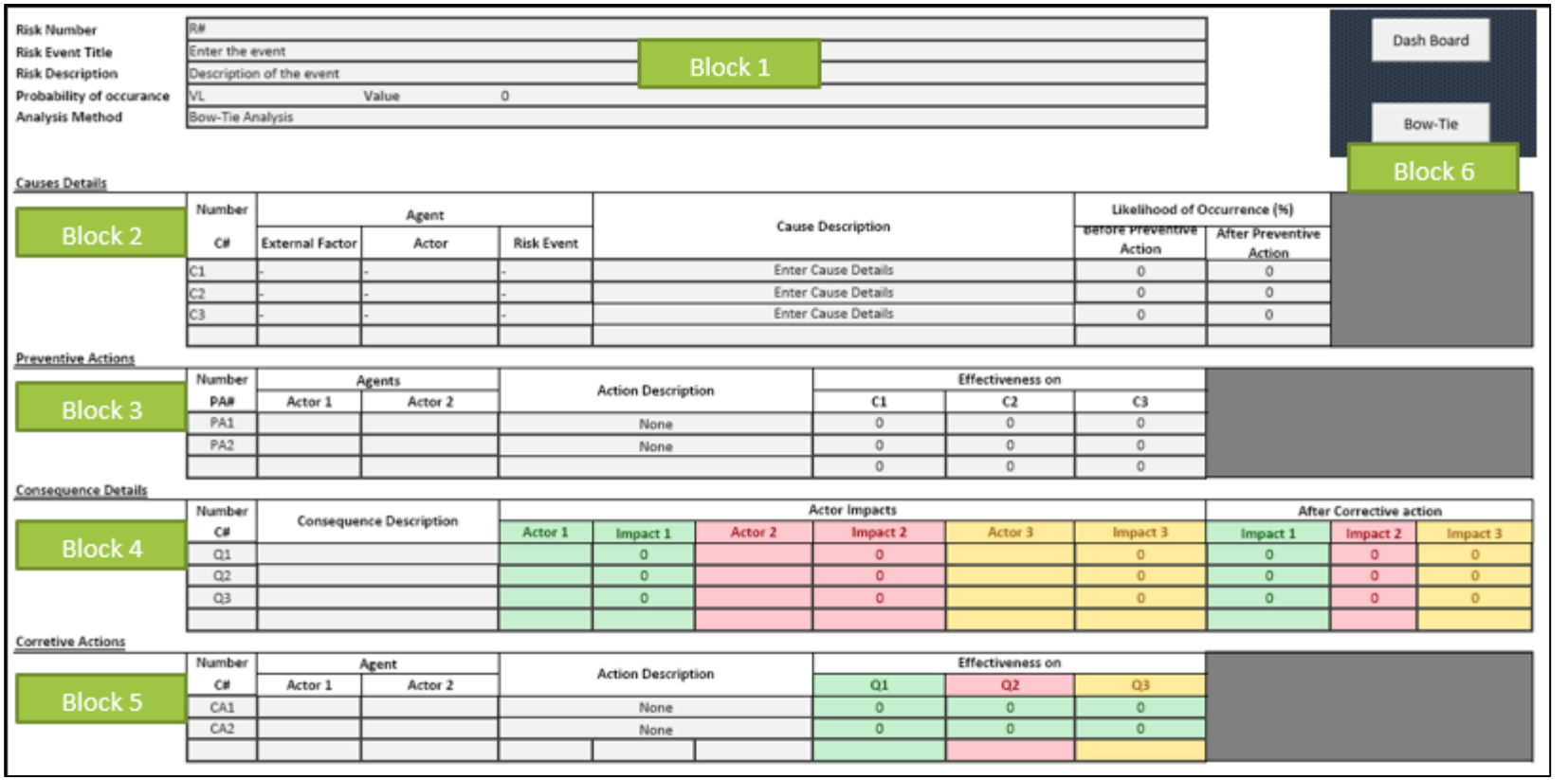


Figure 37 Risk Analysis Template

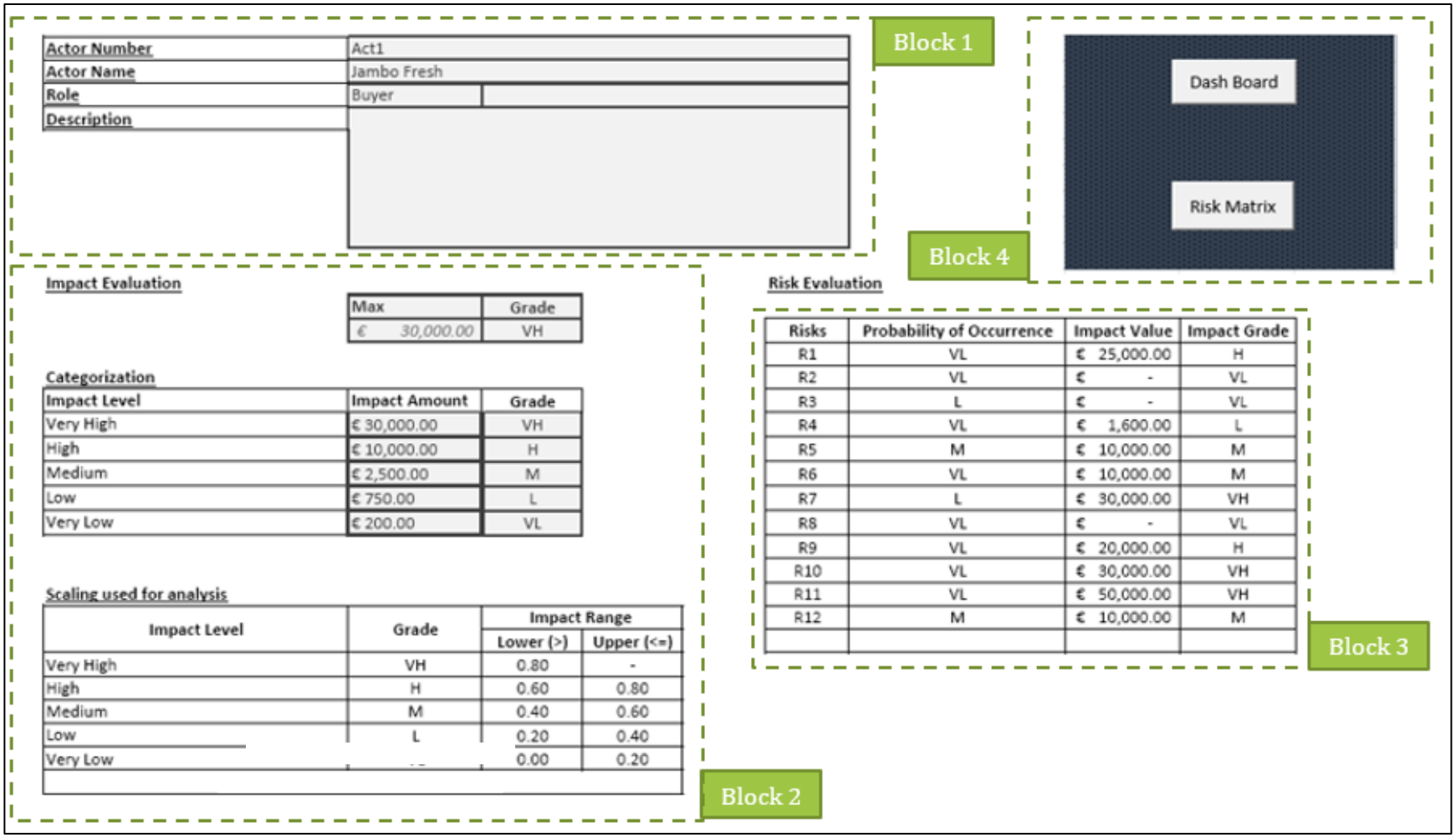


Figure 38 Actor Impact Analysis Template

6. DEMONSTRATION OF RBDM APPROACH

Looking back at the design science methodology, one of the central aspects of the research process is that the developed artefact has to be assessed using either a case study or field demonstration. The developed RBDM Approach is intended to help the practitioners in international shipping industry to prioritize the risks, triggered by parties outside their organisational boundaries, and thereby facilitate to them a focussed approach in taking decisions to improve their business. However, unless a practitioner or a real time operator in the international shipping industry uses it and relates to the results obtained, it cannot be satisfactorily justified. Further, by applying the developed RBDM tool to the real case and by achieving sensible results, it can be said that the tool has been structurally and functionally validated. This method of validation is usually referred to in the field of systems thinking as direct structure test (Pruyt, 2013).

In this regards, the trade lane of an avocado importing company called JamboFresh was explored and the developed RBDM Approach, along with the prototype of the tool, was used to identify and prioritize the risks in this trade lane. This trade lane was particularly chosen because firstly, it deals with the trade of fruits which are inherently perishable in nature. This means that time is an important factor in their daily business and any delay could lead to some form of undesirable consequences. Secondly, the company being located in Rotterdam made it convenient to commute to their place of operation. Thirdly and most importantly, the employees were highly interested in cooperating with the research and were kind to spare their time for conducting interviews. The interview details are presented in Appendix B.

6.1 Trade Lane of JamboFresh

As mentioned, JamboFresh is a fruit trading company based in the Netherlands. They import avocadoes from Kenya on large scale and sell them in bulk to the local customers, who are usually super markets and wholesale buyers. To scope this research, JamboFresh is assumed to be the end buyer of the fruits. The information gathered here regarding JamboFresh trade lane is done through interviewing the expert belonging to a company providing international shipping services and also the owners of JamboFresh company themselves.

The business model of the company is that they pre-order the shipment by paying in advance to the wholesale seller called Avosell[5] in Kenya. The decision for JamboFresh to pre-order the goods depends on the existing market dynamic factors like demand and market price in the Netherlands. Once the order is placed, Avosell begins the process of procuring avocadoes from the local small scale farmers in and around Nairobi in Kenya. Avosell has its warehouse in Nairobi. Batches of fruits are collected at the warehouse with Avosell themselves gathering them from the farmers, or the middlemen carrying them over to the warehouse or the farmers themselves delivering them at the warehouse.

Meanwhile, Avosell is also responsible to make a booking for the container with Avomarine[6], which provides international shipping services. Once Avosell receives a booking confirmation and a release authorization to pick up the empty container from the shipping line at port of Mombasa, Avosell notifies the freight forwarder. Freight forwarder then picks up the container and transports it to the warehouse. At the warehouse, once the customs inspector and KEPHIS inspector has inspected the goods, the container is loaded with boxes of avocadoes and is sealed. The temperature

[5] The name is altered due to confidential reasons.
[6] The name is altered due to confidential reasons.

of the container has to be maintained below 5^{0}C throughout for the fruits not to start ripening. Avosell is responsible in procuring export clearance documents which being Euro 1 (international movement certificate), and export licence document (issued by the Horticultural Crop Directorate after inspection, HCD).

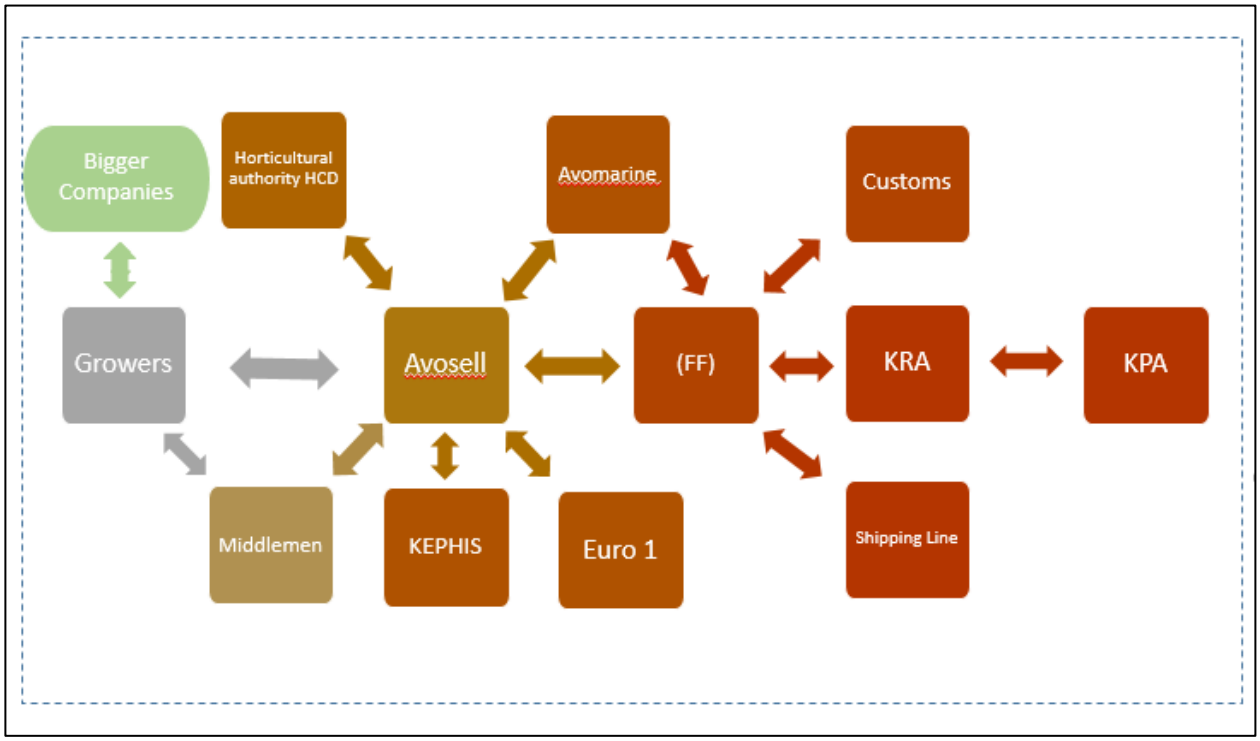


Figure 39 Interactions at the export side of the trade lane

Freight forwarder transports the loaded container form Nairobi to Mombasa Terminal and from there to Salalah Terminal. FF is responsible to get the customs clearance procedures done. Kenya Revenue Authority (KRA) is involved in providing customs clearances and conducting scanning. Once KRA approves of clearance, Kenya Port Authority (KPA) is notified. The authorities then direct the container to a designated place in the port where it is plugged to power to maintain the temperature. The container is in this "sleep" position till the vessel arrives. Once the vessel is loaded with other containers, Avosell receives Bill of Landing (BoL) which it ships to JamboFresh.

At the import side, unless JamboFresh receives this and produces to the customs at the import side in Antwerp (usually), the shipment is not released. The vessel usually arrives at the Nordzee Terminal in Antwerp. HTS, which is the freight forwarding company at import side, receives the container, does the scanning and clears the customs formalities. To transport the container from the terminal to the warehouse of JamboFresh in Rijswijk in the Netherlands, HTS contracts a transporting company called van Dijn. Once the container is unloaded, the empty container is transported back to allotted place in Antwerp.

6.2 Application of RBDM Approach

As can be seen, that the trade lane of JamboFresh is actor intensive. Owing to several interdependencies, it would be interesting to see to what extent RBDM Approach would facilitate in identifying and prioritizing the system level operational risks. In this section the three phases of RBDM Approach, namely identification, analysis and evaluation are applied on the JamboFresh trade lane.

6.2.1 Identification Phase

Identification phase is basically data collection phase. This phase has two pronged approach in gathering information. One seeks to identify actor related information and the other gathers data related to risks. In the earlier sections, several identification techniques were discussed. In this case of JamboFresh, the data was collected by carrying out semi structured interviews in the form of discussion, with the employees of JamboFresh and an employee of the shipping company. Particularly with JamboFresh, three sessions of interviews lasting more than hour and half were conducted.

6.2.1.1 Actor identification

The trade lane of JamboFresh was explored with the help of personnel operating in the field. This gave an insight on the nature of transactions and processes involved during the import and export of avocadoes. From the narrative of the trade lane, several actors participating in the shipping process could be identified. Their identified roles and functions are listed in Table 14.

Table 14 Actors along the trade lane of JamboFresh

Name	Role	Function
Jumbo Fresh	Buyer	Import avocadoes from Kenya. They place purchase order with Avosell in Kenya
Avosell	Seller	Have contracts with growers, buy avocados from growers; Avosell does not own farms; Avosell is a smaller exporter
Avomarine	Sea Carrier	Avosell makes a booking of a container with them. They are responsible to ship the container
KRA	Government Agency	Kenya Revenue Authority does scanning and authorizes the clearances at customs
GMS	Freight forwarder	They are the local freight forwarders at the export side. They transport cargo from warehouse to port.
KEPHIS	Inspection Agency	Kenya Plant Health Inspectorate Service. They are responsible in granting one of the export clearances for the fruit.
Grower	Producer	They are the local farmers in Kenya who grow avocadoes. They sell based on prices offered by the companies.
KPA	Port Authority	Regulate the vessel movement at Kenyan ports. Once the container has cleared the customs at the export side, it is under the authority of KPA.
Van Duijn	Freight forwarder	They provide inland transportation service at the export side. They carry the shipment from Antwerp port to JamboFresh warehouse.
APM	Terminal Import	They are the terminal at the import side responsible to allocate the space for the container parking

Truck Export Side	Interland Carrier	These are specific actors at the export side belonging to either GMS or other party. Once hired, they are responsible to maintain the temperatures of the shipment and container during the road transportation process
Truck Import Side	Interland Carrier	These are specific actors at the export side belonging to mainly van Duijn. They are responsible to maintain the temperatures of the shipment and container during the road transportation process
Terminal Export Side	Terminal Export	They are the terminal at the export side responsible to allocate the space for the container parking
HTS	Freight forwarder	They are freight forwarders at the import side. They are responsible to clear customs at the import side. This process includes taking the container through the scanning process and carrying out import clearance documentation
Customs Kenya	Customs Export	Customs at the export side They are responsible to provide export clearances.
Customs Import	Customs Import	Customs at the import side, mainly Belgium authorities. They are responsible to give clearance for the container to be picked up after the inspection and scanning process.
Middlemen Export	Inland Transport Export	They are the local transporters that bring the avocadoes from the farmers to the warehouse of Avosell.

6.2.1.2 Risk Identification

Understanding the process and actors involved was the first stage of the discussion with JamboFresh. The second stage of discussion dealt with gathering the details for different risk events. Since JamboFresh did not have any risk assessment practices in place, all the data gathering was conducted through interviews and going through their transaction documents like invoices.

It is important to highlight that some of risk events were identified initially by one of the supervisors, Dr. Boriana through a discussion conducted with the personnel of a shipping company. Overall 12 risk events were identified and explored in detail. The probable causes and their impacts to JamboFresh in particular are discussed below.

Risk Event 1 (R1): Damage due to temperature changes in the container

Temperature readings is a very sensitive information for avocadoes shipping. In the present situation, if a damage occurs due to temperature deviations it is difficult to find out who is responsible. JamboFresh has very little visibility on that. In some ports the carrier is responsible for ensuring the agreed temperature requirements are met. In other ports that is outsources to another company or to handlers, so the carrier needs to rely that they follow the agreements and procedures correctly. And sometimes if the damage occurs it can occur also before the goods reach a port. However, they also mentioned that they can obtain the temperature readings only at the specific points along the trade lane.

According to JamboFresh, there are three main reasons for the temperature setting to be tampered. First is that the drivers at the export side are supposed to maintain the temperature setting by connecting the container to the diesel fuelled electric generator. Usually to save fuel, they do not connect the cooling system. Second reason is that the fruits are not precooled before they are loaded into the container. The farther the tampering of temperature occurs form the port of import, the severe is the damage for JamboFresh. The third reason could be that Avomarine could be using faulty

measuring device to read the temperature. In the worst case it could be a full cargo loss of minimum €50000. However, the occurrence of this event is very low.

Risk Event 2 (R2): Claim put by JamboFresh

Once the cargo is damaged, JamboFresh puts a claim on either Avosell or Avomarine depending on the severity of the damage and location where the temperature was tampered. This is a risk for Avosell or Avomarine. However, there is no written contract with Avomarine in place. If the damage occurred during shipping, Avomarine is responsible to bear the claim. Currently, Avosell is covering for the damage loss. But, once Avomarine pays up, JamboFresh will return the amount back to Avosell. In other words, JamboFresh has transferred the whole risk to Avosell.

Risk Event 3 (R3): Growers selling Avocados to other companies

When the avocados are harvested even if there have been prior agreements growers it may happen that the glower sells the avocados to a bigger company offering better prices. The bigger companies may also offer additional bonuses to growers at the end of the harvesting period to make it more attractive for growers to work with them. Especially in situations with high demands, it may happen that the growers prefer to work with the bigger exporters who offer better prices. This is not a concern for JamboFresh however, because Avosell is responsible to gather fruits from the growers.

Risk Event 4 (R4): Payment of guarantees at import side

For the import to the Europe, there is a trade facilitation named EUR1 (or movement certificate) that enables the importers to import goods with reduced (or even free) import duty based on the trade agreement between the EU and the beneficiary countries. Particular to the Netherlands, there is a new regulation that for the selected container for the EUR1 document inspection, importer is required to pay the guarantee of around 1,500-1,600 euros per container. This guarantee money will be released back to the importer only after Customs establish that the EUR1 document is not fake. The occurrence of this is very low though as per JamboFresh.

Risk Event 5 (R5): Scanning takes very long at import side

If goods arrive via Rotterdam container scanning is a big issue. It can take up to one week before the container is scanned. For sensitive goods that can affect the quality. For some fruits coming from Columbia the damage of the delay can be so big that the whole cargo is lost.

JamboFresh had a period that 75% of the cargo was selected for a scan at import side. They were very surprised by this high rate. In other periods they have much less scans but in this specific period the scanning rate was very high. Overall they specify that the occurrence of this medium, but the impact could be of €10000

Risk Event 6 (R6): Long waiting times at the customs

There were some cases of customs declaration system down during the working day (from 9.00 am morning to 15.00 – 16.00 pm). With such process that works out of business expectation, JamboFresh needs to manage the order delivery to the customers. The occurrence of this very low mainly because the customs will fix the issue promptly. However, if occurred the impact could be of €10000

Risk Event 7 (R7): Breakage of container door seal during the transport

Avocados are transported under very specific conditions. The right combination of temperature, as well as oxygen and other gas needs to be maintained during the journey. There is a special plastic curtain that is paced inside the container to ensure the right conditions are kept. Any door opening can be damaging, as it will disturb the conditions and the fruit ripening begins and Ethylene gas is released. This gas can transiently increase the ripening rate of the fruits. If unattended, the whole cargo can be lost. This is a high risk especially if the temperature is destabilized at the export side and not so much at the import side. The loss can be that the whole cargo is damaged amounting to €30000 directly.

Risk Event 8 (R8): Issue with Document Proof for road transport at Belgium customs

The goods normally arrive in Antwerp, as it is faster. Belgian customs issues a document *"bewijs van wegvervoer".* There are often issues with that document. This is a risk for HTS but not for JamboFresh.

Risk Event 9 (R9): Sometimes vessels arrive at ports other than Antwerp

The vessel normally arrives in Antwerp, but sometimes they go via Felixstowe. When the ship arrives in the weekend some ports do not do handling in the weekend, the port of Rotterdam does. So it can happen that the goods arrive at port of Rotterdam as well. The occurrence of this however, very low, but the damage for JamboFresh could amount to €20000.

Risk Event 10 (R10): Possibility of missing the vessel during trans-shipment

Transhipment is when the goods are transferred from a smaller vessel to a bigger ship. For goods coming from Mombasa there is always a transhipment, as the big boats do not travel to Mombasa. The transhipment takes place in Salalah and there are big boats coming from China. If you miss the boat then it take a week. So at times it takes 21 days to receive the container but sometimes more than 30 days. The problem with missing the boat is not so much on the Kenyan port but on the transhipment port. For JamboFresh, the occurrence is very low but can have huge impact of €30000.

Risk Event 11 (R11): Missing Container

In practice it has happened that a container is lost. From earlier experiences they know of two cases when a container lots and reappears 7-8 months later. So the container is at the end there but the cargo is completely damaged. The value was in the range of 80 000 euros. If JamboFresh loses a cargo at the worst case, it firstly puts a claim on the shipper and secondly, buys the fruits from the local suppliers and sells it to customers. Though the direct loss is minimized to large extent, they feel that overall damage to business could be around €50000.

Risk Event 12 (R12): Improper documentation

It happened once that they had to get 3 times the phyto document and to pay for couriers. It was an administrative thing, the goods were not delayed but it accumulated extra costs. The first time the phyto was there but was not signed, so they had to ask for a renewed phyto. This was issued again and was sent by courier but when filling it in they forgot to put the date so the authorities did not accept it. So it had to be sent a third time. Further, it can also happen that Avosell fails to send the courier containing original bill of landing in time. To save some money, the employees at Avosell wait of different bills of landing to accumulate and send them in one courier. JF has recommended Avosell to use trusted courier service. The risk is of medium occurrence level and could have an impact of €1000 on JamboFresh.

6.2.2 Analysis Phase

Based on the basic information gathered in the identification, the stage is set is carry out the analysis of risks along the trade lane of JamboFresh. Table 16 lists out all the risk events identified through the discussions with JamboFresh. The values of likelihood of occurrences of risk events (P (RE)) was calculated[7] based on the Boolean logic discussed in the section 4.3.3. In this case the causes are all independent and each has a likelihood of triggering the risk event. The equation is reproduced here.

$$P(RE) = \text{Max}\{P(C_1), P(C_2), \ldots..P(C_n)\}$$

The grade scale used in this case is shown in the Table 15.

[7] The computation for each risk event was done on the developed RBDM tool.

Table 15 Grad scale used for likelihood of occurrence

Probability Range		Likelihood of Occurrence P (RE)
Lower (>)	Upper (<=)	
0.8	1	VH
0.60	0.80	H
0.40	0.60	M
0.30	0.40	L
0.00	0.20	VL

Table 16 List of Risk events used for analysis

Risk Number	Risk Event	Likelihood of Occurrence
R1	Damage due to temperature changes in the container	VL
R2	Claim by JamboFresh	VL
R3	Growers selling avocados to other company	L
R4	Payment of guarantees at import side	VL
R5	Scanning takes very long at import side	M
R6	Long waiting times at the customs	VL
R7	Breakage of container door seal during the transport	L
R8	Issue with Document Proof for road at Belgium customs	VL
R9	Sometimes vessels arrive at ports other than Antwerp	VL
R10	Possibility of missing the vessel during trans-shipment	VL
R11	Missing Container	VL
R12	Improper documentation	M

Further, the based on the information the interdependency map can also be plotted by following the notion discussed in section 4.3.3. JamboFresh is primarily dependent on three players for their business operations. This fact was also confirmed by observing the invoices that JamboFresh obtains from them. Firstly, it is dependent on Avosell for the product and its packaging. Secondly, it is dependent on Avomarine for the whole transportation process from export side to the import side. Thirdly, for the inland transportation from Antwerp to the warehouse in Netherlands it is dependent on HTS.

Further, according to employee of the shipping carries company, Avosell is dependent on the freight forwarder GMS for inland transportation. But JamboFresh is not sure about this, but they believe Avomarine could be dealing with GMS and Avosell gets some kind of commission from GMS. This is a hidden cost for JamboFresh. At the import side, HTS hires a transport company called Van Duijn for their inland transportation. In this regards, the interdependency map at a high level can be mapped as shown in Figure 40.

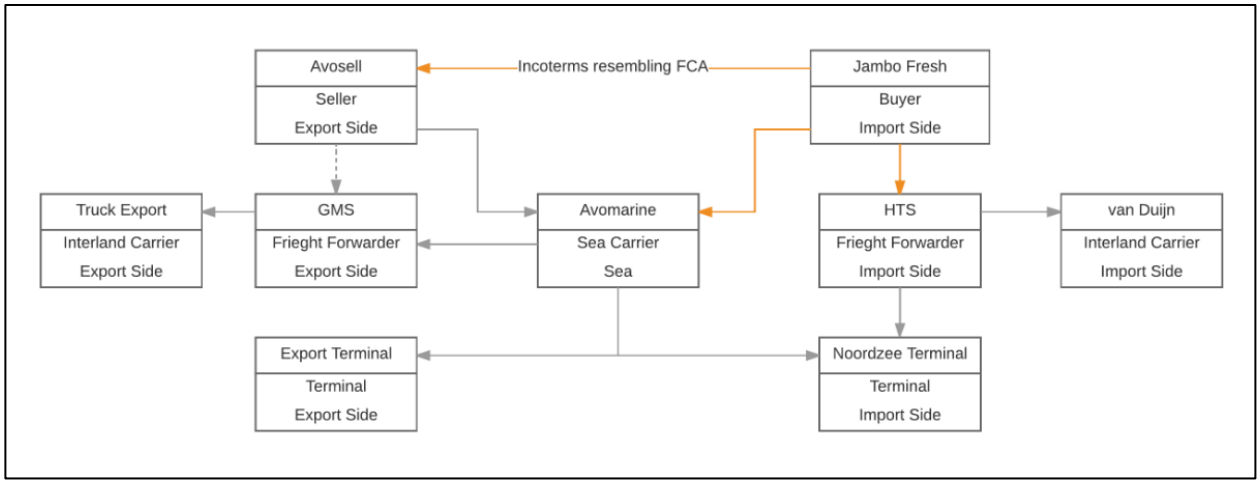


Figure 40 Interdependency map along JamboFresh trade lane

The next step of analysis phase is to construct a bow-tie diagram in a multi-actor setting. The risk events analysed particularly as a part of this demonstration are risk event 1 (R1) and risk event 2 (R2). Both are related to damage occurred to the cargo due to the tampered temperature settings. JamboFresh employees mentioned that monitoring temperature continuously is an issue and they are not sure exactly where the damage occurred. According to JamboFresh, R1 has three main causes. They are reiterated in Table 17.

Table 17 Reasons for tampered temperature settings

Cause	Description	Actor Responsible
C1	Fruits were not precooled before loading onto the container at Nairobi	Avosell
C2	The drivers shuts off the engine to save fuel at the export side especially during transportation from Nairobi to Mombassa and from Mombassa to Salalah	Avomarine
C3	The temperature measuring device is not working well. If the damage occurs, JF would put a claim on Avomarine.	Avomarine

Based on the location of the damage, JamboFresh could put a complete claim of either of the actors. This is the corrective action (CA1) for JamboFresh for this risk event. In this regards, the bow-tie diagram generated for risk event 1 using RBDM tool looks of the risk event will look as shown in Figure 41.

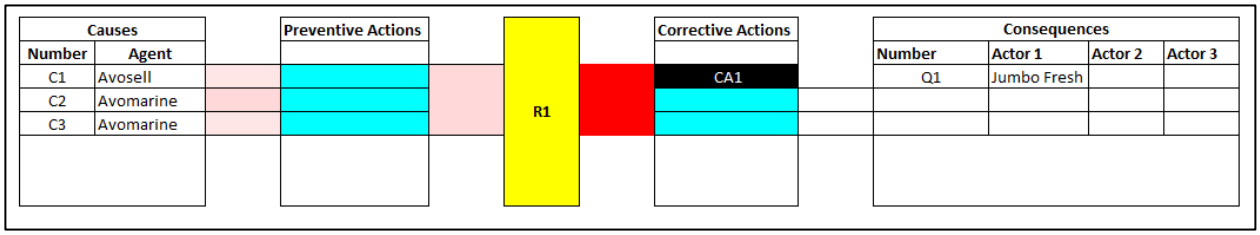


Figure 41 Bow-tie diagram for Risk Event 1

If JamboFresh puts a claim, it is a risk event for either for Avosell or Avomarine. That means CA1 of JamboFresh is a risk event (R2) for Avosell or Avomarine and risk event 1 will become the cause of R2. This interdependency of risk events is illustrated in Figure 42.

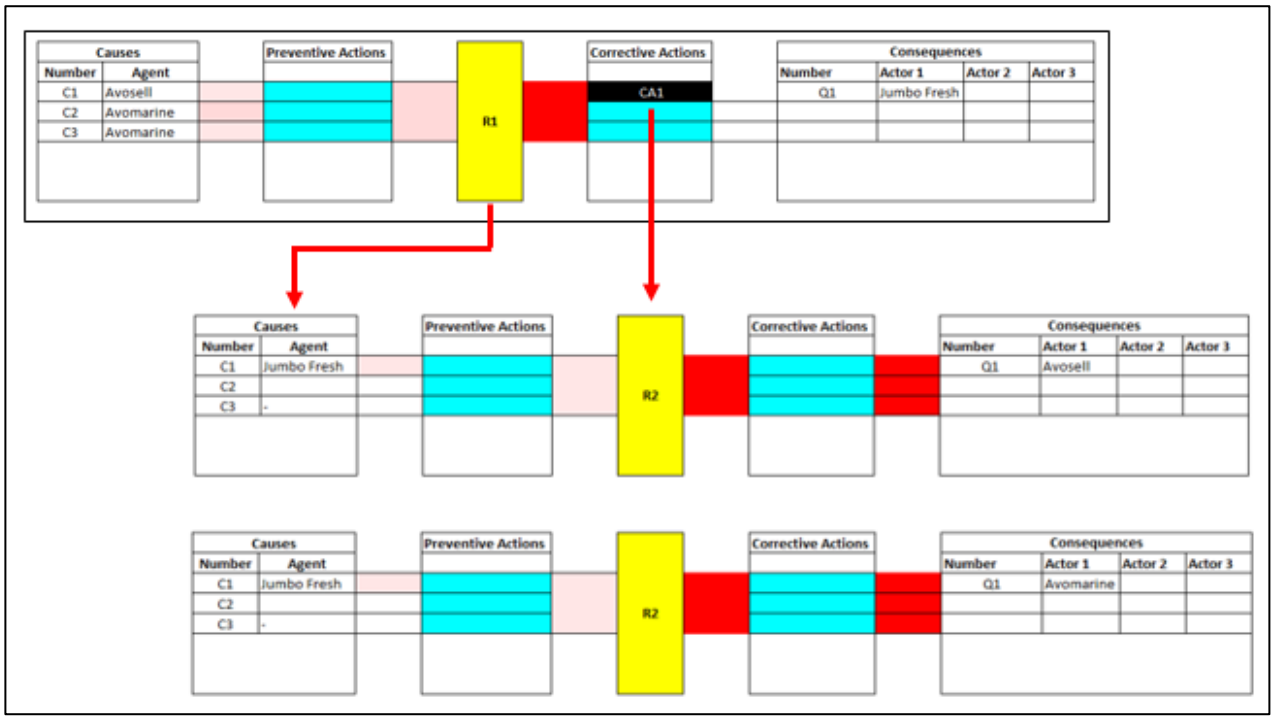


Figure 42 Interdependency of risk events R1 and R2

6.2.3 Evaluation Phase

This phase deals with gathering the actor perceptions about risk impacts and thereby generating a risk matrix. Initially, it was assumed that there is a linear relation between the grade and the impact on costs for Jumbo Fresh. There considering €40000 to be highest limit and €0 being the lowest, the grade was segmented into five scales as shown in Table 18. However, when realised that the upper range value of "very low" region was € 10,000, JamboFresh got uncomfortable and immediately calibrated the values of the table. The corrected values are shown in Table 19.

Based on these two sets of values, risk matrix for JamboFresh was generated (Figure 43 and Figure 44 respectively). Clearly the distribution of the risks events in the two matrices is different. The risk events are more spread out in the case of the non-linear scale.

Table 18 Linear Impact Scale

Impact Range		Grade	Scale
Lower (>)	Upper (<=)		
€ 40,000.00	-	VH	Very High
€ 30,000.00	€ 40,000.00	H	High
€ 20,000.00	€ 30,000.00	M	Medium
€ 10,000.00	€ 20,000.00	L	Low
€ 0.00	€ 10,000.00	VL	Very Low

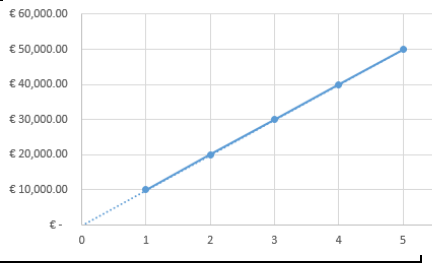
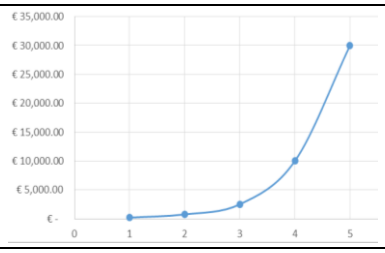


Table 19 Non-linear impact scale

Impact Range		Grade	Scale	
Lower (>)	Upper (<=)			
€ 30,000.00	-	VH	Very High	
€ 10,000.00	€ 30,000.00	H	High	
€ 2,500.00	€ 10,000.00	M	Medium	
€ 750.00	€ 2,500.00	L	Low	
€ 200.00	€ 750.00	VL	Very Low	



Impact	VH	R11				
	H					
	M	R10	R7			
	L	R9				
	VL	R8 R6 R4 R2 R1	R3	R12 R5		
		VL	L	M	H	VH
		Probability				

Figure 43 Risk matrix generated with linear impact scale

Impact	VH	R11 R10	R7			
	H	R9				
	M	R6		R12 R5		
	L	R4				
	VL	R8 R2 R1	R3			
		VL	L	M	H	VH
		Probability				

Figure 44 Risk matrix generated with non- linear impact scale

7. DISCUSSION

The conceptual process of RBDM Approach developed was used as the foundation to build the prototype of the RBDM tool. The tool was later applied to an international trade lane to study and demonstrate its working. This section looks at the practical feasibility of the tool and the extent to which the real case either correlated or contradicted with the theoretical findings. Based on the discussion, recommendations would be followed and a ground work would be laid for future work in the direction of improving the organisational decision making based on risks.

7.1 RBDM Approach and Application of the Tool

RBDM Approach incorporated the core process steps of ISO framework except the step of Communication and consultation and the step of monitoring and reviewing. However, the core philosophies of both these steps have been have been diffused into the Approach by incorporating the broader concepts of multi-actor analysis. Commutations and consultation, as understood in section 3.1.1, stresses that the risk management process should incorporate the interests and objectives of the stakeholders. However, RBDM Approach is doing more than that by being significantly actor-centric. The step of monitoring and reviewing essentially points out that a comprehensive risk management is an iterative process. This philosophy is captured in RBDM Approach, however only to an extent. Once the identification phase has been carried out, all the subsequent processes in RBDM are dependent on that. Any change in the date, is reflected in the bow-tie or the risk matrix. For this to happen however, the details of actions taken by an actor to mitigate an identified risk have to be updated in the system. Thus the aspect of monitoring and reviewing depends on the extent to which RBDM Approach is updated and used. Overall it can be established that RBDM Approach is built on the general framework of ISO risk management 31000.

To have more structured discussion on the RBDM Approach and its tool, each of the phases are discussed separately below.

System Establishing Phase:

This phase at a high level established the system to which RBDM Approach could be applied to. The first criteria was that system should be dynamic. JamboFresh trade lane which was chosen for evaluating the RBDM Approach was dynamic in nature and is actor intensive. Even though it is importing only avocadoes, one can observe the wide range of activities that go around a single shipment of avocadoes. Even a simple event like sending the documents over post could have implications and if not executed well, could cause a delay of days leading to loss of business to the JamboFresh traders.

Further, it can be seen that there are both formal and informal contracts existing among parties operating. JamboFresh deals with the main supplier through an informal contract of trust. However, the process of the shipping and the execution happens according to the rules and regulations of the specific countries. By observing the nature of interactions, an interdependency map was established. This map as mentioned earlier helps in identifying the relations between causes, risk events and consequences. Several external and internal risk triggering factors could also be identified. For instance, it was mentioned that market price, which is an external factor, affects the purchase order of JamboFresh. Overall it can be established that JamboFresh trade lane fits well to quality for being called as a system.

Identification Phase:

Undeniably, this is the most critical phase of the whole RBDM Approach. The main reason is that through the steps involved in this phase, not only the problem field is explored, but also a formal contact with the actors involved in the system would be established. For a RBDM Approach

developed the way it is to be effective, stakeholder cooperation is highly important. If the actors develop a trust on the ongoing analysis they would be more actively willing to share the information and talk openly about the issues at hand.

Several actor and risk identification techniques were listed in the conceptual process. It was also recommended that for efficient and faster analysis, such techniques have to be chosen so that both risk and actor identification could be carried out at one go. In the case of JamboFresh gathering information on risk events and actors involved was done through semi-structured interviews and discussions with the company associates. They main observations are discussed below.

Though by interviewing one or two experts in the field, one can draw an overview of the processes involved quickly, extracting all the information required for RBDM process is time consuming. This is so because for the actor to disclose right kind of information, he has to be aware of exactly what we are seeking. To illustrate this, if asked to share some information of a risk event, people usually tend to give information of the causes and consequences of a risk event. To help the interviewee distinguish between different notions takes some effort and skill from the interviewer. To do so with several actors would be an elaborate process. One way to approach this issue would be to think about organising workshop sessions and brain storming sessions involving different actors. Here the interviewer would have to play the role of mediator too.

The issue of confidentiality and non-disclosure impedes the data gathering process. Due to competitive environment and due to commercial reasons the actors are not ready to part with any kind of information which they feel is sensitive. However, when JamboFresh got to know that another big company is also part of this research process, they were less shaky to participate actively.

Gathering accurate information is impractical, if not impossible. The actors tend to deal with ranges of values than to work with exact figures. The reasons are that the extracting accurate information is difficult and also due to lot of uncertainty, the values themselves are not consistent. This difficulty is particularly felt when gathering data regarding the direct impacts to the business

The other obvious but an important difficulty is to schedule an appointment with the people operating in the field. Trading is a very dynamic activity involving several uncertainties. One should be not be surprised if the scheduled appointment would be cancelled in the last moment. This affects the process of data gathering.

The data gathering process relies heavily on the skill of the interviewer. He or she must be capable of filtering out unwanted information. Bringing an element of risk analysis phase already while gathering the information could help speed up the process. Having said that, care should also be taken that there could be some data hidden in the information shared.

Analysis Phase:

This phase deals with making sense of the gathered data and trying to find the causal relations among them. Two main focus areas are the actor interdependencies and cause and effect relations of risk events. This information is used by the tool to construct a bow-tie diagram of risk events which are actor dependent with triggers outside the organisational boundaries.

It could be that the type of incoterms in use along a particular trade lane might not be obvious to identify. As was the case of JamboFresh, they were not certain of the kind of incoterms under which they are operating. However, after studying the processes closely, one can associate the kind of incoterms in play. In such situations construction of an interdependency map relies solely on the information revealed about the kind of contracts the actors operate with.

One way to gather interdependencies and liabilities information is to study the invoices of the organisations. During the course of discussion with associates of Jumbo fresh, while studying the transactions related costs, it was established that at the high level, JamboFresh deals with three main actors. By studying their invoices and focussing on different line items, potential risk events that

could affect those line items could be identified. However, this exercise was not done with JamboFresh mainly due to time constraints.

Often there are several Informal contracts at play. In the case of JamboFresh they have an ongoing relation based on trust with Avosell. Also, they have an unwritten contract with Avomarine regarding the claim for the damaged goods. As was mentioned before, Avosell currently paid for the damage that occurred to the goods even though it was Avomarine which has to pay for the claim. Avosell did that based on the trust that if in future Avomarine abides to the claim, JamboFresh would pay back. By paying for the loss, Avosell strengthened the contract based on trust. By not paying Avomarine weakened the unwritten contract. Thus, one can learn that trust based contracts can be as binding as or may be even more binding as a formal contract.

Not only risk perceptions but also actions could depend on cultural, social, economic and political factors. This was observed in the case of truck drivers in Kenyan side trying to save fuel and thereby save some money by turning of the cooling systems. This is a case of principal agent problem where the incentive the agent (driver in this case) is looking at is not aligning with the goal the principal (the freight forwarding company) is trying to achieve.

Often the interviewee would provide information with strings of uncertainty attached to it. For example, when asked about the level of impact a delay of a week would lead to, the associate replied that he was uncertain as it depends on the market price of the fruit. He was more comfortable in providing roughly the maximum and minimum values of the damage that could occur. But if one were to construct the actual scenario, the interdependency of the risk causing triggers have to be considered. That is, in this case the maximum damage will occur if there is a delay of week and the market price of the fruit is at its maximum. In other words, the formula to be used is P (RE) = P (C1). P (C1)

Evaluation Phase:

The objective of this phase was to construct a risk matrix for each actor based on the bow-tie relations mapped in the analysis phase. For this to happen, it is important to learn about how the actors associate themselves with the risk and how they *feel* about them. While discussing the risk events with JamboFresh, several interesting observations were made.

The events which have not been part of their experience were usually categorized as very low occurring risks. For instance risk of Avosell losing the market to other companies could impact the trade deal between Avosell and JamboFresh severely.

Perceiving the risk based on the impact as being high or very high is a common error. This was evident when JamboFresh identified risk 1 (R1), which is related to tampering of temperature setting in the container as their most important risk. However, if looked at the risk matrix of JamboFresh (Figure 44), R1 is the least priority risk event. In fact the risk of scanning taking a longer time is a greater risk for JamboFresh. The discrepancy here is mainly because JamboFresh has corrective action in place and they have already mitigated the risk.

Perceptions of risk impacts are not linear. The recording in Table 18 and Table 19 show the differences of how JamboFresh perceived the impact when graded according to a scale. The risk matrices generated for both the instances differ considerably (Figure 43 and Figure 44 respectively). If noticed, the risks were more concentrated in the safe region in risk matrix with linear impact scale. Whereas in the risk matrix with non-linear scale the risks are more spread out.

Perceptions on levels of likelihood of risk occurrence can also vary. For instance, an event occurring twice in a month can be of low frequency to a large player, but it can be high for a sensitive player. In the analysis it was considered that the occurrence of risk is common for all the actors. However, to have a consistent value likelihood of risk occurrence of a risk event and to conduct a reasonable analysis thereby, it is essential to establish the inter-relations between the causes and their factors.

Currently it is possible to go from Medium impact to High impact by increasing the value just by 0.001 or even lower. In other words, the transition from one grade scale to next one is very sharp. Risks falling in these regions can distort the results. Such risks have to be re-examined carefully before taking the decision regarding risk prioritization. Usually risks that fall at the border of acceptable and unacceptable regions, and high and medium regions would need the re-evaluation.

Risk matrix template is currently generic to all the actors. However, the colour coding is also actor dependent. Acceptable and unacceptable regions have to be identified by the specific actor before a risk matrix is generated. This means that in risk evaluation, or rather in risk identification stage, another component is added as a part of risk perception. Thus, the actor has to actively participate in three aspects. First is in identifying the inter-relations between the factors causing the triggers to a risk event likelihood of occurrences of a risk event. Second is to calibrate the impact levels along the grade scale. Third aspect is to identify the regions in the risk matrix by providing colour coding based on the available capacity to deal with the risks.

7.2 Validation of RBDM Tool Prototype

As a part of the thesis, a prototype of RBDM Tool was developed on Visual Basic platform in Microsoft excel application. The working of this artefact of the research is grounded in the conceptual process developed for RBDM Approach. It distinctly operates in through phases of RBDM Approach. The objective of the tool is to analyse the risks in a multi-actor setting and thereby to provide visibility of events that are occurring beyond the organisational boundaries of a particular actor. This functionality of the tool was tested at two levels. First is done by consulting and seeking the opinions of the domain experts and the thesis supervisors. Second is done by gathering the real time data from the operators in the field, generating the results using the tool and discussing with them the overall usefulness of the tool. In the language of systems thinking, both these methods can be categorized as direct structure and more specifically face validation tests (Pruyt, 2013).

The first stage of face validation dealt with developing a dummy case of an international shipping process. Different values were fed to the tool and based on the results generated the tool was verified and improved. This set the stage for the tool to be deployed in the field by applying it on the trade lane of JamboFresh. Through the user forms the required subjective risk data was captured in a structured way. After conducting analysis, the tool generated consistent and sensible results. The tool was to large extent successful in demonstrating that the RBDM Approach can be adapted to shipping industry. However, it should be noted that the effectiveness of tool in improving decision making process of the organisation is not realised was not demonstrated.

7.3 RBDM Approach and Data Pipeline

In section 1.3, the emerging large scale digital trade infrastructure of Data Pipeline was introduced. The main aim of the pipeline is to improve the transparency across the trade lane. Prior to the development of RBDM Approach, it was established that both the concepts of data pipeline and RBDM have similar objectives of improving visibility. In this context, it became interesting to realise the extent to which both these could work towards achieving the common objective and thereby, improve the overall decision making of the operators. Having establish the concept of RBDM Approach so far, it is time to look at both these from the same light.

One of the issues that data pipeline seeks to confront is the **issue of information fragmentation** in global supply chain. This means that critical information is often locked with some specific actors and having access to it is either difficult (or costly) or may be even impossible. Several reasons were identified earlier like transferring the tasks to third parties, consolidating different kinds of goods in same cargo and at times even clouding the information due to have a competitive advantage in the market. Now, knowing that information is critical for RBDM Approach to facilitate decision making effectively, this issue of information fragmentation is a limitation to the approach. Though RBDM attempts to make the system explicit by gathering the information as much as possible, if the data is withheld on purpose by the actors, then effectiveness of RBDM goes down. However, if data pipeline is in place to arrest the issue of information fragmentation then by linking up with the pipeline, RBDM Approach can accelerate the improvement process of the supply chain.

One of the advantages of data pipeline was that it facilitates **piggybacking** of data. This means that the information collected could be reused to assess the security risks by the Customs and government agencies. If this assessment is not restricted to security risks but also extended to operational risks, then piggybacking would be highly beneficial for RBDM Approach. In other words, an inventory of risks obtained by studying a particular trade lane could be used identifying risks in different trade lanes and thereby saving considerable amount of time in identification phase. Creating an inventory basically means creating a database of potential threats. With this list available RBDM Approach can already conduct a preliminary analysis to study the system.

The benefits of **synchro-modality** were mentioned in the descriptive of data pipeline. If there is timely information, the stakeholders can react and arrange for the transportation based on the need of the situation. This aspect is related to the decision making phase of RBDM Approach. Now, with the presence of real time data, it might be that the operator will have to react to multiple events which is either not practical or leads to additional costs. In these situation, the best one can do is to optimise the decision making by prioritizing the risk each event offers. Considering that often there is less time to do a cost-benefit analysis, an established RBDM model linked with the real time data of data pipeline could be highly effective.

Data pipeline aims to promote the authorities and authorized practitioners to **pull the required data**. Having a RBDM tool connected data pipeline would enable the actors to gather the required information, without relying on other party to provide it. This means that risks would be assessed quickly and easily.

Data pipeline through a continuous exchange of event information can also trigger a notification or an alerting mechanism thereby allowing the affected actors to take a timely action. Since the data pipeline could be a repository of the real time information, if coupled with RBDM process, can have large scope in improving the efficiency throughput along the shipping lane. For example by assessing the information available at a particular time, the actors who are to be affected by a triggered risk event can develop strategies (yellow dots in Figure 45) to quickly mitigate the impacts, thereby shifting the risk even from a high risk category in the risk matrix to a low risk category. Similarly, actor responsible for causing an action leading to a risk event strategically act in order to place a

barrier (blue dots in Figure 45) in the form of corrective action and thereby prevent or lessen the likelihood of risk firing.

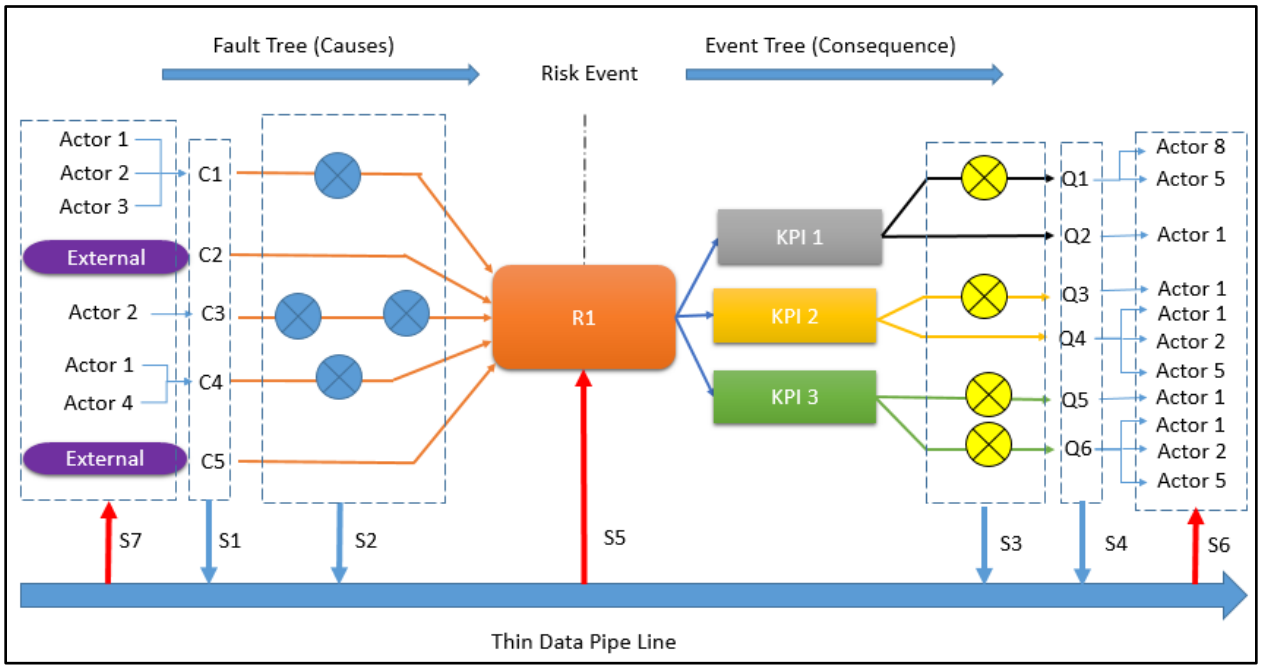


Figure 45 Possible areas of integrating data pipeline and RBDM

Tilson et al.(2010) pointed out that the research direction for development of any digital infrastructure should be focussing on incorporating values and interests of the actors involved. RBDM Approach once adopted, could facilitate in **articulating different system values** and thereby orient the businesses of the associated actors towards them. This capability is enhanced enormously by integrating RBDM, the data pipeline is further reinforced and vice versa.

It can be concluded that by the integration of these two concepts several, if not all the, actors will be benefitted in multiple ways. Customs can benefit from improved the security. Buyer will have clear visibility of the process flows and can restructure the contracts and agreements to best suit his organisational needs. Seller can foresee the bottle risks and critical paths in the shipping process and plan ahead. Adoption of data pipeline by the operators in the shipping industry and linking the RBDM tool to data pipeline would be a giant leap for the process of digitalizing the global trade

8. CONCLUSIONS

Structured by the design science research methodology this research progressed considerably in developing a process of RBDM Approach and a prototype of it tool which became the artefact of the research. In the process the underlying objectives of the research that were established in Section 2.1 were met one by one. This chapter revisits the two main research questions formulated and attempts to answer them based on the findings and discussions presented in the previous chapters. The five sub questions which were formulated to answer the main research questions are reconstructed as answers and discussed correspondingly.

1. ***How can risk based optimisation approach, which is used in asset management in energy infrastructures, be adapted to improve the quality of international shipping?***

Since the conception of an idea to adopt RBO from energy industry to international shipping domain this research has come a long way. By following a three pronged approach RBDM Approach was developed and eventually a working prototype of RBDM Tool was produced. First approach adopted was to study the core concepts of RBO methodology, and there by establish conceptual basis for developing the process of RBDM Approach. The second approach was to explore the different risk assessment frameworks practiced in the shipping industry and to establish the existing gaps. The third approach was to identify relevant multi-actor techniques and considerations that need to be incorporated in the RBDM Approach. Finally, based on the developed process flow, the prototype of the RBDM Tool was developed.

In this regards, four sub-questions were formulated. They were formulated in such a way to derive upon a structured and a holistic answer to the first research question. Thus, to improve the quality of international shipping the RBO approach, which is used in asset management in energy infrastructures, has to be adapted by:

a. Coping with the challenges posed by RBO approach of energy industry when it is introduced to shipping industry as-is

Often, to manage assets through RBO method, the energy companies use a well-designed risk matrix. To construct this matrix however, the companies follow the ISO 31000 framework of risk management. One of the critical step in the analysis stage of the process is to develop a bow-tie diagram of each risk event. Since asset management is limited to the boundaries of the organisation none of the aspects of RBO which being the ISO framework, or bow-tie diagram or risk matrix do not incorporate the concepts of multi-actor dynamics. Thus, the three main challenges that RBDM Approach need to cope with are **firstly** to equip the ISO framework at every stage with relevant multi-actor techniques. **Secondly**, to represent the multi-actor dynamics through the bow-tie diagram and **thirdly** to develop a risk matrix which is actor centric. The manner in which these challenges are coped with in RBDM Approach are discussed below.

The first challenge is related to ISO framework, which formed the basis for the developing RBDM Approach. The logical of phase-wise flow of RBDM was derived from the sequential steps prescribed by the ISO frameworks. However, at each stage relevant steps of actor analysis were incorporated. The system establishing phase accommodates the problem formulation step of the actor analysis. In this phase along with establishing the system boundary, specific inputs like the information related to risk criteria related to main actors are established. The identification phase calls for possible actor identification techniques. In this phase the information about both the actors and the risk events are listed. The analysis phase deals with studying the interrelations between the actors and mapping the formal interdependency maps. This facilitates the construction of bow-tie diagram in a multi-actor context. The evaluation phase deals with

gathering the data required for evaluating the risks by taking into consideration the distortions caused due to actor perceptions. By evaluating the impacts for each actor subjectively this stage generates a risk matric for each actor. The decision making phase is inherently calling for subjective actions. Based the risks prioritized the organisations and actors take relevant informed decisions by taking into the considerations the resources available.

The second challenge is related to construction of bow-tie diagram. As was mentioned bow-tie diagram is the main output of the analysis phase of the RBDM Approach. In a multi-actor context this diagram represents the risk events by associating the causes and consequences to the responsible and impacted actors respectively. This information is derived by studying the nature of contractual terms that exist among the actors. Further, it was also identified that often the actors operate through informal contracts. Therefore, based on the interdependencies that exists among the actors the cause and effect relations are mapped around the risk events.

The third challenge is related to generation of an actor centric risk matrix. Once all the risks are analysed, those risks are picked form the risk register which have impacted the risk criteria of a particular actor. Based on the impact scale established for that particular actor, the risk is categorized from very low impact scale to very high impact scale. This scale was developed based on the perceptions, interests and values of that particular actor. After having categorised all the risk according to their impacts along the scale, risk matrix is mapped. In this way, RBDM Approach develops risk matrix for each actor.

b. Narrowing down the limitations offered by current risk management practices that are employed by the actors in the international shipping industry

The second area of the literature study focussed on reviewing the different risk management practices that are currently employed in the shipping industry. Though there were number of risk assessment frameworks scattered across the globe, it was found that five main risk assessment frameworks were being use predominately. They are AEO Compact Model, FSA, QRA, Safety Case and MARCS. While they all focussed on some particular aspects of the industry, they had some limitations as far as organisational decisions making based on risks are considered. These limitations and the extent to which they are addressed in RBDM are discussed below.

Firstly, it was found that except the Compact Model framework, all of the risk assessment framework focussed on the specific aspects of ship safety and health. The Compact Model focusses on risks that affect the objectives of the Customs. No framework specifically focussed on those risks which impact the factors that determine the normal operations of the businesses like time, costs, reputation and so on. RBDM Approach developed in this research demonstrated its functionality by working with impacts on operational costs. However, it is not restricted to this risk criteria alone and can be used for different focus areas.

Secondly, all the risk assessment frameworks recommended a quantitative approach in assessing the risks. Further, they were mostly devoid of human element and none of the risk assessment methods addressed the need for multi-actor considerations in the risk assessment process. As understood from notion of risk criteria established in section 4.2, RBDM Approach facilitates both qualitative and quantitative approaches. Further, the central idea of RBDM is to adapt to a multi-actor setting.

Thirdly, it was noticed that almost all of the risk assessment practices recommend the risk treatment measures. However, these measures cater the specific areas of focus like safety and health to which most of the frameworks cater to. Though, through the risk treatment measures they might be able to mitigate the risks. However, unless they facilitate the identification of the KPIs related to organisational interests and thereby assess the risks affecting those KPIs, they will fall short in enabling the organisations to take decision related to businesses development. RBDM Approach encourages the organisations to identify the KPIs as risk criteria and thereby facilitating the identification of risks that affect these KPIs.

Fourthly, it was found that all the risk assessment frameworks recommend similar step wise approach for identifying and managing risks. However, by determining kind of risk assessment techniques to be used at each step and by focusing on specific areas, they render being inflexible in accommodating other approaches. On the other hand, RBDM Approach does not dictate any specific risk assessment techniques in its process steps. However, it does specify the kind of input it requires at each stage. In this way it is flexible in accommodating other frameworks and rigid in restricting the kind of information that is fed in.

c. Incorporating the relevant multi-actor theories in the process of RBDM Approach

The third area of literature study in this research dealt with understanding the basic multi-actor concepts which are relevant for the risk assessment. The important findings and their incorporation in RBDM Approach are discussed below.

Firstly, it was gathered that generally different actor analysis techniques available in the literature operate on four dimensions which are networks, perception, values, and resources. Each of these dimension reveal certain kind of specific information related to the actors in the system. Probing through the dimension of network would provide the details about the dynamics of actors operating through interactions and interdependencies. The perception dimension takes the study closer to the individual level and gives a clarity on subjective notions related to risks and the surrounding events. From the dimension of values the basic interests at both individual and organisational level could be gather. This would aid in establishing the risk criteria. Lastly, through the dimension of resources, the strategies identifies the capabilities of the actors to react to the severity of the risk events. For RBDM Approach, it was realised that exploring the field in all these directions is important at different stages. Therefore, a more general approach based on six core steps of any actor analysis have been incorporated in the framework of RBDM Approach

Secondly, in international shipping industry particularly there are actors appearing at different stages of the shipping process, playing different roles. Broadly, at the export side, after shipper has packaged the consignment, it is transported by the freight forwarder, inspection authorities provide clearances and later it is shipped by the shipping. Similarly at import side the freight forwarder receives the shipment and gets the clearance formalities done with the Customs and bring it to the buyer. However, the roles and responsibilities on who should bear the burden of costs and who should absorb the risks is determined by the nature of contracts among the actors. The well-known contract terms used internationally are the Incoterms. However, in the case of JamboFresh it was observed that there will also exist relations based on trust. Therefore, in the identification phase of RBDM Approach it is also important to get information both formal and informal relations.

Thirdly, it was learnt that there many way in which the actors can get influenced while making judgements about risks, their occurrences and their impacts. Some of the common ones found in the literature are that the perception on frequency of occurrence is influenced by its representation. Also if the consequences are emotionally extreme people tend become insensitive to the frequency of occurrence of an event. Further, the decisions people take related to events and activities depend on the values they assign to them. Often, the kind of trust between the parties builds determines the level of risks involved in their businesses. At an individual level, the perceptions of risk are constructed based on the expectations and preferences of the actors and usually cultures, norms and informal rules that exist influence those perceptions. While developing RBDM tool, efforts were made to gather structured data in a consistent manner through the user forms. However, RBDM Approach is not devoid of these vulnerabilities entirely. Therefore, the analyst or the practitioner has to be aware of these distortions

Fourthly, as was discussed, each of the phases of RBDM Approach have processes incorporated the multi-actor concepts at each stage. Identification phase of RBDM Approach is pillared on employing the actor identification techniques which deal with gathering information about actors

involved in the shipping process. This information involves the list of actors, their roles and functions, their interests and values, and their operational transactions and contracts. Analysis phase of RBDM Approach depends on the techniques of mapping causal relations and actor interdependencies. This is done by studying the formal and informal relations that exist among the actors operating in a trade lane. By mapping these inter relations, bow-tie diagrams in a multi-actor setting for each risk event could be constructed. Evaluation phase relies heavily on gathering actor perceptions on risks and their impacts. To construct a risk matrix the three main inputs required are 1. Actors' perceptions on likelihood of occurrences of risk triggering causes, 2. Actors' insights on the risk impacts, 3. Actors' capacity to treat the risks.

d. Developing a RBDM Tool that is feasible to be used by the practitioners in the shipping industry

It is evident that constructing a risk matrix for several actors demands certain level of computational capabilities. There is clearly a need for an application built on platform which is user friendly and which can analyse and produce the results consistently. The developed RBDM tool demonstrated that RDBM approach can be used to identify and prioritize risks for multiple organisations. However, to what extent it can affect the businesses is yet to be realised. If the framework is used by the experts in the field and the developed prototype of the tool could be advanced by building it on more sophisticated programming platform, RBDM Approach would have to potential to improve the visibility of the shipping chain.

It is not impossible to put to practice, but it is not easy either. The main challenges are having data connectivity, providing data security and importantly the cooperation of the parties which operate in the trade lane. Integrating with a digital infrastructure like data pipeline should be the next step for RBDM Approach to effectively improve the quality of the shipping line.

The second part of thesis deals with integrating the RBDM Approach with Data Pipeline, which is a proposed digital trade infrastructure aimed at improving the visibility across the supply chain. The research question formulated to study this feasibility was:

2. How can the quality of the global supply chain be further enhanced by integrating RBDM Approach with the data pipeline concept?

Data pipeline is a digital trade infrastructure concept, where several information systems within different organisations and business in the supply chain would be linked to have required visibility to all the actors in supply chain. Motivation for this concept emerged from the fact that the current supply chain industry is troubled significantly by the issue of information fragmentation. However, for the concept of data pipeline to be embraced and research in the direction of development to be progressed, there is a dire need for the participation of the stakeholder. The reason that it is not practical for a government or group of governments to build such a large scale infrastructure at a global level, mainly due to lack of expertise and finances. Therefore for the businesses and private stakeholder to invest in the adoption of data pipeline, they should be at least aware of the advantages that a data pipeline would offer.

RBDM Approach aims to lower the uncertainties by targeting the risks beyond organisational boundaries in an actor-intensive shipping chain. This objective of increasing the visibility aligns perfectly with the objective of data pipeline. Thus, if both these concepts are integrated together, the overall quality of the supply chain would be enhanced significantly. Further, the quality of the global supply chain be further enhanced by integrating RBDM Approach with the data pipeline concept by:

e. By exploiting the potential ways in which RBDM and data pipeline can reinforce each other

The effectiveness of RBDM Approach depends on the amount of right kind of information it has access to. The most important phase with respect to information gathering is the identification phase. Since data pipeline would register different events and transactions, the identification

phase of RBDM Approach could tap the pipeline and extract the information required for further analysis. Further, by having a link to the real time data continuously, the actors can be well informed beforehand and can take decisions catering to their values and interests based on the situation. On the other hand, the potential advantages RBDM Approach offers with regards to improvement of business of the stakeholders through articulating values along the shipping line, could motivate the stakeholders in investing in the development and adoption process of data pipeline.

9. LIMITATIONS

The core idea of this research is to develop a RBDM Approach that can improve the decision making process of the organisations and businesses operating in a multi-actor setting of international shipping. Based on the approach a prototype of the tool was developed and it working was demonstrated by applying on an international trade lane. In this chapter however, the limitations to the research are identified.

Limitation to this research were contributed by firstly the inherent limitations existing in the thesis and secondly the limitations of the developed RBDM Approach. It has to be acknowledged however that when probed into details one can find numerous limitations at different levels. However, only those ones which seemed highly important and could have repercussions are discussed in the following sections.

9.1 Limitations of Thesis

As a part of this thesis panned several topics in an attempt to converge them under an umbrella of RBDM Approach. These topics (or may be keywords) include RBO, asset management, Digital Trade Infrastructures, Data Pipeline, multi-actor analysis, actor perceptions, bow-tie framework, risk matrix, Incoterms, risk assessment frameworks, risk assessment techniques, design science methodology and process of international shipping. Though the research was successful in capturing the overall general idea and main concepts of these areas that are required to develop RBDM Approach, none of them were explored in depth. This could make the work seem falling short of the providing clarity at places.

Having said that, there are some inherent limitations that the process of thesis offers which have restricted the boundaries of exploration and level of detail. Firstly, time factor played an important role in scoping and narrowing down the amount of work. Secondly, RBDM Approach is a methodology which thrives in a multi-actor setting. However, gathering input from most, if not all, along a single trade lane is highly impractical considering the constraints of time and resources, both for the researcher and the actors.

9.2 Limitations of RBDM Approach and the Tool.

The above limitations identified contributed significantly to the limitations in the developed RBDM Approach and the prototype of the tool. Further, the approach and the tool developed have its own limitations. Some of the glaring limitations are discussed below.

First, the effectiveness of the approach developed relies on the information that is being analysed and processed. This approach requires the active participation of all the actors involved to provide information. However, considering their busy schedules and even lack of interest, it is not practical to assume that all the actors will provide realistic information. Having wrong information is a risk event in itself than not having any information at all.

Second, the notions related to risk as used in the Approach have deliberately been defined so. This was done mainly to counter the flow of irrelevant and inconsistent information particularly when there are several versions of definitions of these notions. However, in the narrative of RBDM Approach, it was emphasized repeatedly that this approach takes into consideration the subjective definitions regarding notions surrounding different aspects of risks. This may seem counter intuitive. But it must also be observed that narrative also emphasized the need to be aware of distortions caused by different perceptions. Therefore, while gathering the data, though different perceptions

exists, they have to be streamlined eventually to fit into the notions defined. Having said that, this is not a simple straightforward process. The actors themselves have to be educated and made aware of these distortions and differences in the notions. This is a daunting task considering large number of actor playing different roles in the system.

Third, in an environment like shipping domain, the dynamics of actor interactions are volatile and they keep changing based on several factors like seasonal cycles, weather, business strategies, regulations and other commercial and political reasons. These fluctuations call for the need to update the data used in the RBDM Approach regularly. Without having an access to the real time data and an automated system to pull and analyse that data, this process of updating the information needed for risk analysis through RBDM Approach is not possible.

Fourth, the information gathered for analysis is often sensitive. The operators would not prefer disclosing certain information like finances and contractual agreements unless they are sure that their data is secure and not visible to their competitors. The features of data security and access to only authorized personnel are not incorporated either in the process or the tool.

Fifth, the tool developed in its current form can only be used by an analyst or a consultant who has the complete control over the data. Unless the analyst shares the information, the visibility to the actors is obstructed. Having a single control over the data makes the system vulnerable to cyber-attacks and data tampering.

Sixth, the tool did not demonstrate the compatibility and flexibility of the RBDM Approach in accommodating different kinds of risk assessment techniques like Fault Tree and Event Tree analysis. Considering that several risk assessment practices in the shipping industry already employ these techniques, it is important for RBDM Approach to demonstrate its ability to align with them so as to avoid duplicity of the processes. Further by demonstrating so, a step ahead would be taken in persuading the practitioners to adopt RBDM Approach.

Seventh, the tool also did not demonstrate the ability to deal with multiple risk criteria. In the research only the impacts on costs have been considered though it was acknowledged that different actors have different priorities and interests while developing their business. This led to the demonstration of largely a quantitative risk assessment.

Eighth, the tool has its own legacy limitations of the Visual Basic programming platform. Currently, the computational strain of the application can be observed especially while constructing a risk matrix for one actor among fifteen actors. This calls for a high end front end programming.

Ninth, the effectiveness of RBDM Approach in improving the overall decision making process of the organisations has not yet been realised. Through face validation and demonstration only its functionality and the structure were tested and not its applicability to large scale.

10. RECOMMENDATIONS

Based on the literature study, the narratives of different aspects of RBDM Approach, the application of its tool and the overall limitations, few important recommendations could be identified. In this regards, the following sections lay down the recommendations both for the future work and for the upgradation of existing knowledge base.

10.1 Recommendations for Future Work

It is important to realise that RBDM Approach is an aid to generate a well informed decision and it is not a decision maker itself. It works by making the events in the system explicit. With this understanding, for generating effective results, few recommendations are listed here for both development and application of the approach.

First, it is yet to uncover the full potential of the tool. In this regards, it is recommended to use the tool to gather the risk data from more number of actors and then to analyse them subjectively. The results could be used to generate a system level risk matrix or a common risk matrix which can look like the one shown in Figure 46. The risks are subjective, meaning that for one actor R1 could be very high severity whereas it could be very low for others. Further, by identifying common risks the actors can form cartels or groups to collectively mitigate the risks. The organisations can take more well informed decision regarding their actions.

Severity of the risks → / Actors in the system ↓	Acceptable	Very Low	Low	Medium	High	Very High	Unacceptable
Jumbo Fresh	R1 R3	R2					
Avosell	R2		R1			R3	
Avomarine	R2				R1		
KRA	R2		R1	R3			
GMS		R3	R2	R1			
KEPHIS	R1			R2	R3		
Grower	R1	R3	R2				
KPA	R1				R2		R3
Opticool			R1 R2			R3	
APM	R3				R2	R1	
Truck Export Side			R2	R3			
Truck Import Side	R2		R3		R1		
Terminal Export Side		R1	R3				
HTS	R1				R3	R2	

Figure 46 Risks across the system

Second, in its current nascent form also, RBDM Approach has a societal impact, particularly on the actors who adopt it in the shipping industry. This is because it was observed that not many organisations have formal risk assessment practices in place. If considerable number of actors along the trade lane can adopt the tool as-is, they can use it to study both their internal processes and

external occurrences. By making the system explicit, they might identify areas where they feel more information is needed or the areas where they think that more resources have to be spent. For instance, in the case of JamboFresh, it was seen that they perceived a particular risk related to temperature settings as being very severe. However after employing RBDM Tool, they see that this was least severe. Thus RBDM Approach made the company to know more about themselves. Thus it is recommended for the actors to start using RBDM Approach and equip it with additional features as the development progresses.

Second, the feature that RBDM Approach could accommodate different risk assessment techniques, particularly fault tree and event tree analysis, was not explored in the research. The companies and the businesses usually embrace a new approach as a part of their organisational procedures only if there are minimal disturbances in either replacing the existing approach or upgrading it. Therefore for the transition to be smooth, it is essential to show affirmatively that RBDM Approach could accommodate different risk assessment techniques. There is a large scope in improving and demonstrating the capabilities of RBDM Approach in this aspect.

Third, while it was acknowledged that different actors have varied interests and objectives related to their business developments. Based on the values their KPIs differ and thus different kinds of risk criteria can be established. In this regards it would be interesting to develop an approach by integrating RBDM and other multi criteria analysis techniques available in the literature.

Fourth, it was pointed out that the currently the RBDM Approach is vulnerable to data security issues like lack of confidentiality, data tampering, cyber-attacks and no restricted access. Further, it was also mentioned that currently the tool developed is inherently subjected to the legacy issues of Visual Basic and is also shows signs of computation strain. Thus, there is a good scope for developing the code on a more secure and effective platform which is user friendly.

Fifth, having observed the call for the need for real time data and an automated system to extract it and process it becomes highly essential for RBDM Approach to be linked with the Data Pipeline concept. On these lines, an elaborate feasibility study on linking the RBDM equipped with data security features to the emerging Data Pipeline could be taken up. The opportunities the integration could also be explored extensively to gain the trust of the stakeholders to invest in Data Pipeline.

Sixth, it that can be observed that the RBDM has been developed to be as general as possible so that it is not restricted to a particular industry. However, its overall effectiveness in improving the decision making process has not been realised. Unless its capabilities are demonstrated it cannot be generalised. Therefore, the recommendation here would be to adapt and apply this approach to a shipping industry on a large scale, and based on the effectiveness of the results generalize it to make it an industry independent and a standalone decision making tool.

10.2 Recommendation to Current Knowledge Base

Risk based decision making has been used in several contexts in the literature. RBO is one of them that has been developed to be used effectively in the field of asset management which is restricted to a particular organisation. However, there are hardly any risk management frameworks that cater to facilitation of effective decision making based on risk assessment in a multi-actor context. RBDM Approach developed in this research can be considered as a step taken to fill this void. Since most of the work in this research is done to demonstrate the applicability of the Approach to the shipping industry, less focus was put in aiming to fill the existing knowledge base.

Therefore the recommendation here would be to adapt and structure according to the academic standards thereby to establish the RBDM Approach as a comprehensive framework to facilitate an effective decision making based on risk assessment in a multi-actor context.

11. REFLECTION AND SELF-CRITIQUE

This report presented the results of work that spanned for six months. To arrive at this point, however, it took several discussions, diverse thoughts and some intense sessions of exploration, probing and analysis. Time has come to critically analyse the process of this thesis work that was able to produce this report. In this regards, this section reflects on the scope of the thesis, the manner in which it was approached and what I, as the researcher, have gathered at a personal front.

The Premises of the Research

The central idea during the inception was to develop a tool that would facilitate decision making by developing a risk matrix for multiple parties in a multi-actor context of shipping industry. The decisions taken hence in the form strategies would improve the businesses of the organisations. This premise established that there are four sequential stages namely risk identification, risk prioritization, organisational decision making and business improvement. However, in the real world this sequential process is hardly followed or even at times necessary. Often, it can happen that once the possible events with severe consequences are identified, the operators or the managers would react promptly before waiting to identify and prioritize other risks. This does not mean that tool is not capable of improving the business at all. In a scenario where there are multiple risks that can fire during a particular period, then it is important to prioritize them based on their severity. The tool will then be highly effective. Thus, to put it in simpler and more general terms, the tool is effective only in particular situations.

The other critical aspect that is interesting to visit is related to the ownership and thereby the legitimacy of the tool. Currently, the manner in which the tool was developed is that it can be used by an analyst who can either be working in an organisation in the system or an independent party hired to improve the business of that organisation. In either case, having access to information related to other organisations is difficult and time consuming. Further, the analysis is vulnerable to biases and incorrect information leading to skewed and distorted results. This makes the legitimacy of results questionable especially while considering to take strategic decisions having a legal dimension. Thus the other pretext upon which the thesis finds itself is that all the organisations participate actively in providing clear and unbiased information to the analyst.

The initial plan was to develop a common risk matrix for all the actors in the shipping line. By common matrix, it means that there is one risk matrix which will prioritize risks for all the parties along the axes of likelihood of occurrence and the impacts. The point upon which this thought emerged was that since the severity of a risk is subjective by adding another axes of multiple actors along could help in representing the whole system in one single illustration. However, this kind of 3D representation would yield different planes of risk matrices each corresponding to a particular actor. In other words, a 3D representation in this fashion would be just of individual risk matrices aligned on the axes of likelihood of occurrence and the impacts provided all the impacts are measured across same criteria. Having said that, it cannot be that it is impossible to represent the whole system. For instance Figure 46 depicts one way of possible representation. There could be other ways. The point that is being made here is that in this research the possible methods of representing the whole systems was not probed specifically.

Thesis Approach

By looking back I realise that at the initial stages, I was highly ambitious and set forth to accomplish quite a few things. The initial idea was to split the thesis planning into two phases of conceptual development and application development as shown in Figure 47. This plan was a result of an initial finding of a preliminary research that pointed out that bow-tie framework is a central pillar for RBO approach. The conceptual phase focussed on developing a bow-tie in multi-actor context and based on it build a RBDM process which would result in a common risk matrix. The application phase dealt with development of a tool which would help in generating the risk matrix. As the study progressed, more concepts emerged particularly related to risk management and actor analysis and a structured RBDM Approach evolved as shown in the main sections. The planning according to the conceptual phase was significantly consistent.

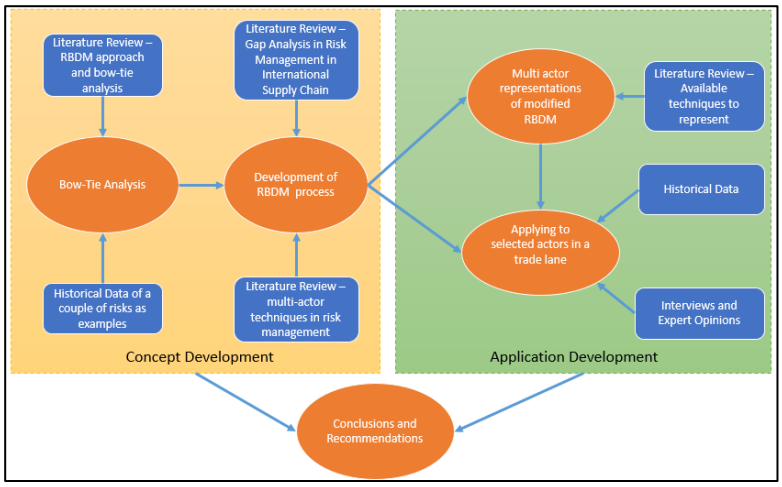


Figure 47 Initial thesis plan

In application development however, there was a deviation from the idea to generate a common risk matrix. Initially I set off to develop the programme using high end software platforms like Python and C++. But later it was established that generating individual risk matrices was a precursor to generating a common matrix. Taking into account that this is still a prototype and is meant to be used by most of the people, a familiar application of Excel was chosen. There is still a good scope of developing the tool using high end software and develop executable applications. Figure 48 shows the preliminary illustration of RBDM Approach.

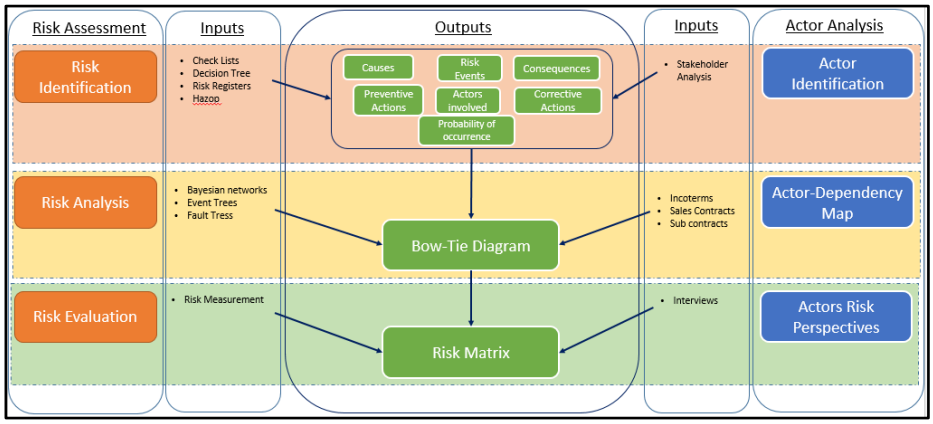


Figure 48 Preliminary RBDM Approach Process

Personal Journey

Any long task once completed generates two things. First is deliverables that it set forth to meet and second is the experience that it brought. Both these outcomes are different in nature. While the deliverables can be picked up by anyone, the experience stays with me unless I express it. Though it is not easy to ascribe words to everything that I learnt and gathered, I would attempt here to shed light on some aspects that would also act as reminders to me in future.

Undoubtedly this journey has been an enriching experience at several levels. I was able to get a good exposure to six different areas of which I had superficial or no knowledge before. The firstly I was not aware that risk management and asset management are so intricately intertwined though I knew that both disciplines occupied prime importance in an energy company. Secondly, shipping domain is a new arena into which I never ventured so much though I knew that logistics and supply chain are complex and evolving sectors. The third aspect is risk management practices particularly in shipping industry. I feel that there is still lot of scope for companies to actively embrace these practices not just for health and safety but for studying impacts on their daily operations as well. The fourth aspect that intrigued me was human elements and interactions present in a trade lane. This is a world in itself. Fifth area was the concepts of Data Pipeline and Digital Infrastructures. This has been entirely new to me and it really captured my interest. Last, but not the least, working with Microsoft Excel and developing codes using Visual Basic. I confess that I enjoyed writing code more than writing the report.

If I were to identify areas where I could have been better and would have approach differently, I can distinctly spot a few. Firstly, I feel that I got lost in details on several occasions while studying different topics and even while developing the tool. I felt often that lot of things were relevant and could be linked to my thesis work. This costed significant part of my thesis time. Secondly, I have not estimated precisely the effort ant time required to write the report. I would have rather spent more time in this regards. Thirdly, I would make more effort in obtaining access to conduct few more interviews with at least couple of more actors. This would bring contentment that the tool developed was tested satisfactorily.

All in all, was the thesis more than I can chew? I would say it was just enough. Though I could have done few things differently, I am content with the end product considering that I dealt with different topics and developed a tool without any prior coding knowledge.

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Appendix A. LITERATURE STUDY

Literature study formed the conceptual base of this thesis. In section 3.1, the concepts of RBO approach used as a part of asset management in energy industry. Section 3.2 gave the overview of different risk assessment practices employed in the shipping industry and in section 3.3 threw light on some important aspect of actor-analysis. Here the manner in which the literature study was conducted is discussed.

The main objective while studying RBO approach was to understand the underlying process of risk management. The study of this approach was guided by the work of Wijnia (2016) which was a decade long research on the examining the potential of RBO approach in managing assets. This study covers in depth the different aspects of asset management and discusses the results of different experiments conducted in an electricity distribution company called Enexis. Based on the leads provided further probe was don't to understand more about ISO framework, bow-tie analysis and risk matrix.

The next extensive study conducted was to gather an overview of risk assessment process in shipping industry as they are practiced today. The two search engines used in this context are Google Scholar and Scopus. The search results depend on the key words used. Further, there are operations like using quotations to obtain the articles with exact phrases or words in it or the Boolean operations as used in Scopus. Table 20 shows the number of results varied based on the search results.

Table 20 Keywords and search results

Search Engine	Keywords	Search results
Scopus	issues AND in "risk management" in "supply chain"	274
	"risk assessment" "supply chain" AND shipping	55
	risk management in supply chain	38
	"risk assessment models" "supply chain"	31
	"risk assessment" "decision making" international AND shipping	16
	"multi-actor" "risk assessment"	15
	"international shipping" AND "cost management"	1
	"Risk based decision making" "shipping" "risk assessment" international AND shipping	1
	"risk assessment framework" "supply chain" review	3
	("risk assessment models" "supply chain") AND (transport)	3
Google Scholar	risk assessment shipping "multi actor"	6800
	"risk assessment framework" "supply chain" review	663
	"risk assessment" "multi actors"	73
	"risk assessment" "multi actors" "shipping"	5
	"actor level bow-tie analysis"	0
	"system level bow-tie analysis"	0
	"Actor level risk analysis"	0

However, not all the results were useful. Most of the papers either dealt with a particular topic in detail or the access to a paper was not easy. Further, some other papers were describing about new ways of assessing risks, but those methodologies were not put to practice. As mentioned, the intention was to look for that literature which gave an overview of risk assessment methodology which is in practice. Table 21, however lists down some informative literature which was close to relevance for this research.

Table 21 Literature related to risk assessment in international shipping

Paper/Article	Authors, Year	Comments	Citations
Cold chain management - An essential component of the global pharmaceutical supply chain	(Bishara, 2006)	Requirements for Good Storage and Distribution Practice for pharmaceutical industry	59
Benchmarking supplier risks using Bayesian networks	(Lockamy III, 2011)	Particularly about Bayesian. With information, these models are very effective in decision making process	35
Impact of the container security initiative on Taiwan's shipping industry	(Y.-C. Yang, 2010)	Risk matrix and risk management alternatives	34
Fuzzy hierarchical model for risk assessment: Principles, concepts, and practical applications	(Chan & Wang, 2013)	Solving risk management problems considering both qualitative and quantitative criteria to tackle imprecise information.	26
Facilitating uncertainty treatment in the risk assessment of container supply chains	(Z. L. Yang, Bonsall, & Wang, 2010)	two novel risk modelling methods- fuzzy evidential reasoning approach and Bayesian network decision support tool	14
Replenishment policies considering trade credit and logistics risk	(Tsao, 2011)	optimal replenishment policy for a retailer	14
Interrelationships of risks faced by third party logistics service providers: A DEMATEL based approach	(Govindan & Chaudhuri, 2016)	third party logistics service providers (3PLs);generation of threshold value to prioritize risks	10
The rise and success of the barcode: Some lessons for financial services	(Milne, 2013)	Not related to risk management, however gives insights on how a technological intervention can cause disruption in the process.	6
A proposed decision-making model for evaluating a container's security score	(Riahi et al., 2014)	targeted approach based on risk analysis	6
Assessing security risk in global supply chains	(Meixell & Norbis, 2011)	The two-part assessment methodology reported here includes a scoring system for evaluating each of the participants in the supply chain in turn	5
Origin and impact of supply chain risks affecting supply security	(Vilko & Hallikas, 2012)	This paper considered the impacts of the risks on the daily operations and businesses from the perspectives of actors themselves.	4
Performance drivers of shipping loans: An empirical investigation	(Mitroussi, Abouarghoub, Haider, Pettit, & Tigka, 2016)	Number of factors connected with the performance of corporate bank loans	3
Who bears the lion's share of a black pie of oil pollution costs?	(Kim, 2010)	ensure efficient risk sharing among the U.S. public, the shipping sector, and the oil cargo sector	2

Supply chain network design under uncertainty with new insights from contracts	(Tabrizi & Karimi, 2014)	role of contracts in uncertain environments	2
Fatigue Risk Management: A Maritime Framework	(Grech, 2016)	Fatigue as one of the reasons for risks	2
Exploring company ability to meet supply chain security validation criteria	(Chang & Wu, 2015)	The study results show that self-risk assessment and the formulation of security policies are the most difficult items to accomplish for AEO validation	1
Ocean transport and the facilitation of trade	(Veenstra, 2015)	Reveals that the uncertainties far outweigh the additional costs.	1
Global supply chain security: Emerging topics in research, practice and policy	(Thomas & Vaduva, 2016)	covers a range of emerging topics from risk assessment to technology deployment to continuity planning	1
Assessment of dynamics and risks in supplier selection processes	(Ruhrmann, Hochdörffer, & Lanza, 2014)	Focused on supplier selection process	1
Influence of institutional and moral orientations on relational risk management in supply chains	(Cheng & Chen, 2016)	Relation are risks. Relational governance is required	1
An extended framework for supply chain risk management: Incorporating the complexities of emerging industries and large-scale systems	(Burns, 2017)	extended and more generalized framework of supply chain risk	0
Risk assessment and control of inland ships navigation safety - A case study of Shanghai inland waters	(Liu, Sun, Chen, Zhang, & Jin, 2016)	Specific to navigation safety focusing on the inland transportation.	0
A quality assessment framework for large datasets of container-trips information	(Makridis, Fidalgo-Merino, Cotelo-Lema, Tsois, & Checchi, 2016)	quality assessment framework that combines quantitative and qualitative domain	0
Defining aspects of hazardous material transport routing	(Rahman, Norton, & Portera, 2013)	Demonstrates a need for the safe practices of hazmat transportation by all parties including the supplier, manufacturer, distributor and the end consumers on a global scale.	0

This literature search established that there was no extensive literature available related to risk management frameworks that are being practiced in international shipping. The two articles which stood out however were the works of Mullai (2006) and Bichou (2008). The important risk assessment frameworks have been discussed in the main sections. Some other frameworks which are worth mentioning are listed in the table below.

Table 22 Other Risk Assessment Frameworks in Shipping Industry

Risk Assessment Framework	Steps in the process	Developed for/by	Focus Areas
USCG Risk-Based Decision-Making (RBDM) Guidelines	• Getting started with risk assessment • Selecting risk assessment tools • Performing risk	United States Coast Guard (USCG)	• Marine accident risks in general • Safety and health • Marine environment
Risk-Effect Model (REM)	• Identification of the causes of events • Assessment of the probability of accidents • Calculation of effects of accidents • Assessment of the probability of consequences of people and environment • Assessment of the individual, societal, environmental and economic risks	The Netherlands Government	• Marine accident risks in general • Risk of maritime transport of dangerous cargoes in inland waters • Safety and health • Marine environment
Novel Risk Assessment Framework for Maritime Safety Management System	• Define the problem • Identify factors and their interactions • Select appropriate orthogonal arrays (OA) • Conduct experiment • Conduct analysis of variance (ANOVA) and other Taguchi-related analyses • Identify significant factors and their interactions • Find the optimal combination of factor levels to minimize the system risk level • Recommend for implementation	Sing Sii, Wang, & Ruxton (2001)	• General - maritime systems
Swedish Maritime Administration (SMA) marine accident/risk analysis procedures	• Introduction: background, definitions, scope • Analysis of marine accidents and near accidents – all categories • Exposure data analysis for vessels and manning on merchant ships and commercial fishing vessels • Analysis of individual marine accidents and near accidents • Analysis of occupational accidents and injuries and work-related	Swedish Maritime Administration (SMA) (2002)	• Marine accident/risks in general • Risks of oil spills • Safety and health • Marine environment

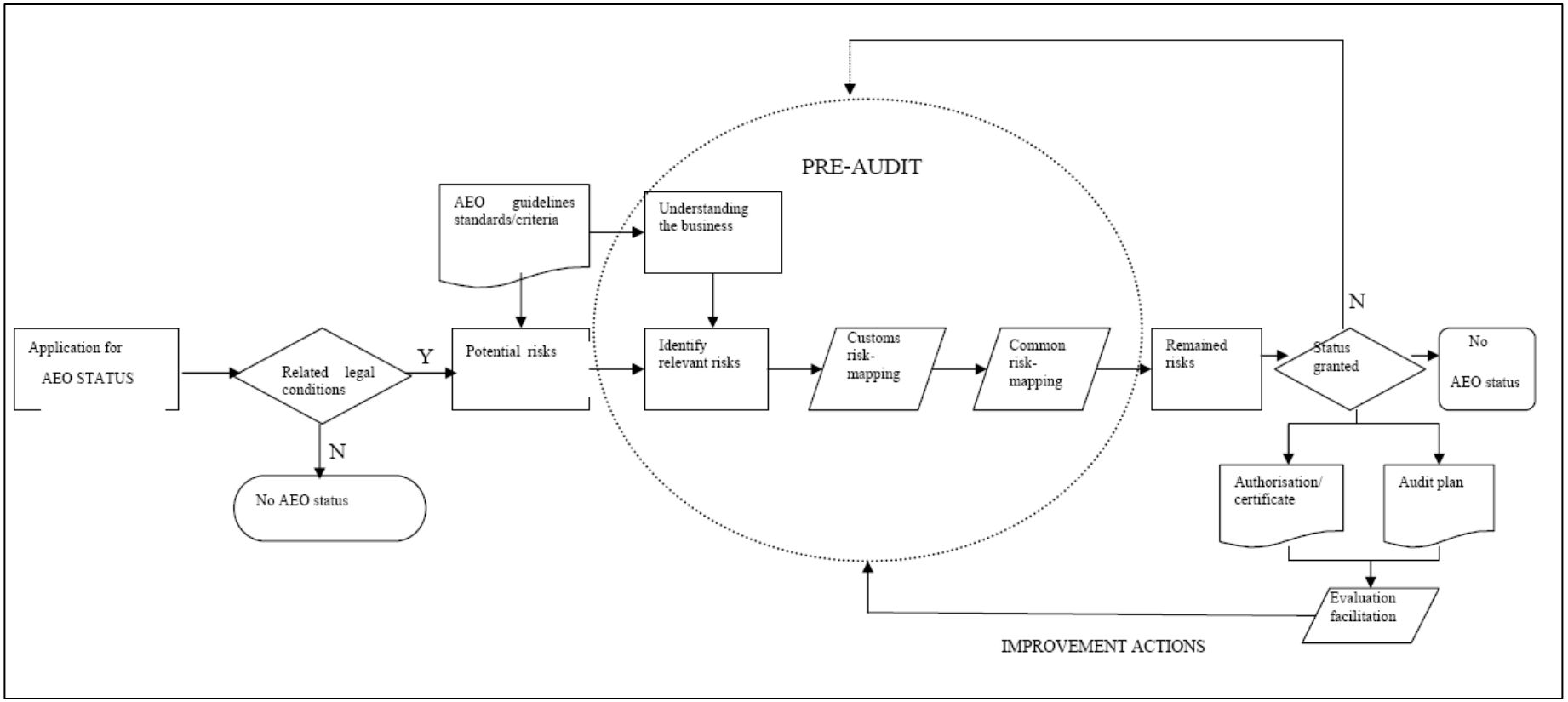


Figure 49 AEO Compact Model

Figure 49 shows the process the Customs authorities follow to assign the AEO status to the companies or the operators applying. It can be observed that risk assessment is an integral part of the process.

Appendix B. INTERVIEW WITH JAMBOFRESH

Interactions with JamboFresh occurred on three different occasions. The first interaction was a formal meeting and it was more getting to know the firm. The following two meetings were semi-structured interviews. This section summarizes the discussions that occurred among the people involved.

Meeting 1: Date 7th April 2017

Participants: Two associates of JamboFresh, Tuty Arsyida (TU Delft), Anil Ravulakollu (TU Delft), Boriana Rukanova (TU Delft) and Yao-Hua Tan (TU Delft)

Summary:

- JamboFresh import only avocadoes from Kenya. They consolidate the fruits gathered and sell to the local agents. Agent later sell them in the market or usually to the super markets.
- Often there are no formal written contracts. Verbal contracts can be usually found while trading with fruits and vegetables. It is a closed community and people rely on the word and the relationships
- The current status of JamboFresh is to remain the way they are and maintain their position. They outsource all the tasks. They have no intension of vertical integration or expansion.
- Their core interest is to invest more in the development of the farming methods of the by providing more education. They believe in social aspects of business development.
- The discussion then moved onto gathering information about the issues which affect their business.
- **Issues on the import side**
    - **Payment of guarantee for container with EUR 1 Certification**: new regulation where for selected containers for EUR1, a guarantee needs to be payed of around 1500-1600 euros and the guarantee is released only after Customs has established that the EUR1 document is not fake. It could take up to 6 months before the money is freed-up. In case of a number of containers arriving per week the effect on businesses is quite significant.
    - **Non availability of Customs systems**: The customs declaration system is often down, it can be down 9.00h till 15.00-16.00h. It is known under normal conditions when a container will arrive and will be released. JamboFresh does pre-selling and notifying customers that the goods would be available at a specific time. These are all verbal contracts. In case the system is down and the customs declaration cannot be launched. The consequences are that in an optimistic scenario, JamboFresh needs to pay for the waiting time of the truck. In a worst case, the customer cancels the order and buys from somebody else. This means that JamboFresh loose the customer and need to look for a new customer for the avocados. If there is high demand, the customer may agree to wait till the next day; in case of low demand the customer will go to the next seller.
    - **Long time for container scanning in Rotterdam:** If goods arrive via Rotterdam container scanning is a big issue. It can take up to one week before the container is scanned. For sensitive goods that can affect the quality. For some fruits coming from Columbia the damage of the delay can be so big that the whole cargo is lost. Before AEO companies were allowed to pick up their containers and do an external scan. Now this is no longer possible, taking away one of the important AEO benefits

- **Issues related to temperature setting**
  - **Opening the container door:** Avocados are transported under very specific conditions. The right combination of temperature, as well as oxygen and other gas needs to be maintained during the journey. There is a special plastic curtain that is paced inside the container to ensure the right conditions are kept. Any door opening can be damaging, as it will disturb the conditions and the avocado can wake up and start maturing.
  - **Lack of precooling:** At the moment the avocados are harvested and transported to the packing house. Ideally they need to be put immediately in cool conditions after harvesting but this is not possible at the moment. They are loaded in a pre-cooled container.
  - **Lack of visibility of temperature settings throughout the shipping process:** At the moment there is a procedure about pre-cooling but JamboFresh would like to get more visibility and control over the temperature throughout the whole journey. Ideally in the future they would like to get more control also earlier in the process (from harvesting onward). It does not happen often but if something goes wrong and the conditions are not set right the whole cargo can be damaged, which results in huge costs. Availability of more information about temperature readings and gas levels throughout the journey, as well as more control on the staffing of the container can help also in legal disputes
- It was discussed with the associates the research work going on in TU Delft. It was highlighted TU Delft was interested in identifying costs and inefficiencies throughout the whole chain and identify areas for improvement. Cost-benefit research focusses on developing a trade and compliance cost model and a risk-based model for cost analysis

Preparation for meeting 2

The first meeting gave an overview of the importing company. The associates agreed to provide required information for the ongoing research at TU Delft. Particularly for this thesis, there is still lot of information required to get a satisfactory case study to explore the tool. By consolidating the meeting notes of Boriana (including the earlier meetings she had), Tuty and Anil, a document was prepared by highlighting the unknown information.

- **Actor Mapping**

Actors along the export trade lane of Jumbo Fresh

7. Growers – Grow Avacados. They sell based on prices offered by the companies. However trust also plays an important role in establishing contracts.
8. Avosell (shipper, exporter) - Have contracts with growers, buy avocados from growers; Avosell does not own farms; Avosell is a smaller exporter
9. Bigger Companies –External actor - They offer better prices to the growers sometimes.
10. Middlemen – Supply the produce to Avosell
11. KEPHIS - Kenya Plant health inspectorate Service.
12. Avomarine – Avosell makes a booking of a container with them
13. Release authorization –After which Avosell can pick the empty container.
14. GMS – Freight Forwarder - GMS brings the goods to the port. Presents entry for customs.
15. Shipping Line – To book the vessel
16. KRA (Kenya Revenue Authority) - Does the scanning
17. KPA (Kenya Port Authority) – Regulate the vessel movement

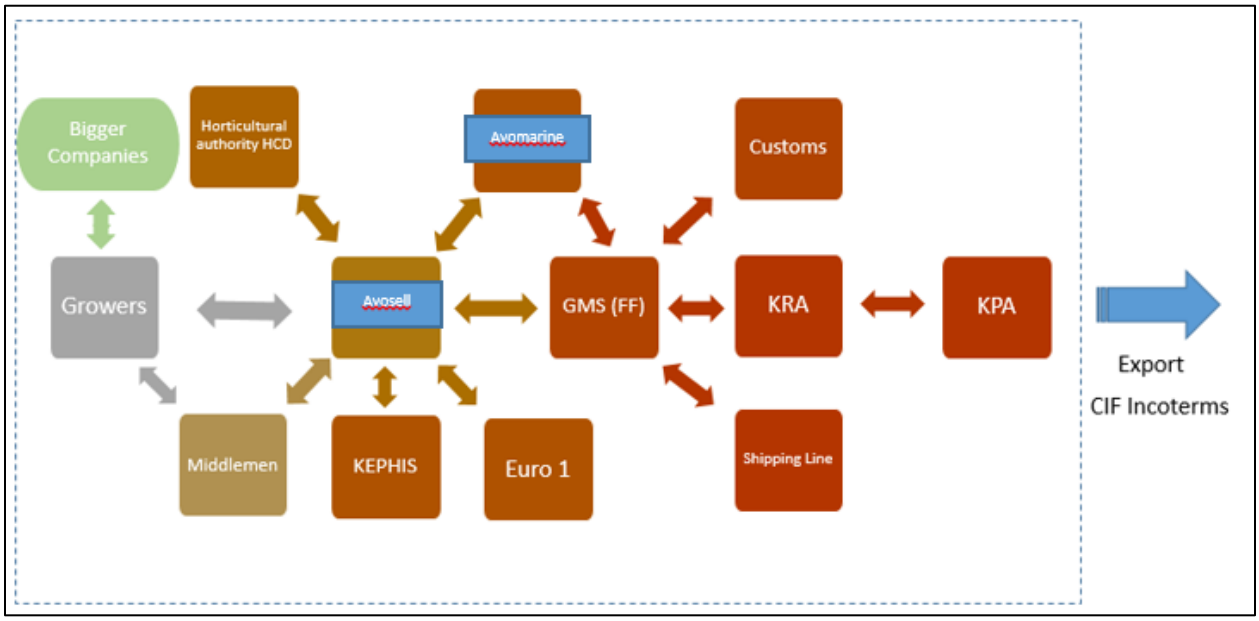


Figure 50 Export side Actor mapping

- **Actors along the import trade lane of Jumbo Fresh were yet to be identified.**
- **Process at import side:** Goods arrive in Antwerp, Belgium. There is a Customs Agent in Belgium handling the security clearance and arranging a transit declaration. The goods are picked up from Antwerp by a transport company called OptiCool. They bring the goods to the warehouse in Rotterdam. In Rotterdam there is a Customs Agent (called HTS), responsible for the Phyto-sanitary clearance (getting the P2 codes), as well as for the import declaration clearance.
- **Bottlenecks identified in earlier discussions:**
  - Issues related to the EUR 1 document
  - Scanning of containers takes long time
  - Availability of customs systems (sometimes the systems are unavailable)
- **Risk Identified from the notes**

  There were 12 risks that could be identified from the notes. For all the events, the frequency of occurrence was not yet determined. Further, there was no mention of actions that could be related to preventive or corrective actions.
  - **Risk 1:**

    Event: Growers selling Avocados to bigger company

    Causes: 1.Bigger Company offers better price, 2.Contracts are based on trust.

    Consequences: 1.Loss of business? How much? To whom?

    Preventive Actions: Unknown

    Corrective Actions: Unknown
  - **Risk 2:**

    Event: Payment of guarantees at import side

    Causes: 1. Regulatory announcement (by?)

    Consequences: 1. Setting aside large amount of money – 1500-1600 euros (High/low?), 2. It can take up to 6 months (Monetary loss?)

    Preventive Actions: Unknown

Corrective Actions: Unknown

- **Risk 3:**

  Event: Scanning takes very long at import side at Rotterdam/Antwerp

  Causes: 1. High scanning rate

  Consequences: 1. Loss of business? How much? (High/low?), 2. For sensitive goods that can affect the quality (Monetary loss?), 3. Benefits of AEO certification is lost (quantify?)

  Preventive Actions: Unknown

  Corrective Actions: Unknown

- **Risk 4:**

  Event: Long waiting times at the customs

  Causes: 1. Non- availability of customs systems (often down) for too long (how much?)

  Consequences: 1. Loss of business? How much? (High/low?), 2. Customer cancels the order (Monetary loss?), 3. JamboFresh needs to pay for the waiting time of the truck

  Preventive Actions: Unknown

  Corrective Actions: Unknown

- **Risk 5:**

  Event: Customer cancels the order

  Causes: 1. Non- availability of customs systems (often down) for too long (how much?), 2. Use of verbal contracts, 3. Loss of reputation

  Consequences: 1. Loss of business? How much? (High/low?),

  Preventive Actions: Unknown

  Corrective Actions: Unknown

- **Risk 6:**

  Event: Breakage of container door seal during the transport

  Causes: Not clear yet

  Consequences: 1. Loss of whole cargo? How much? (High/low?), 2. JamboFresh needs to pay for layers in case there are disputes

  Preventive Actions: Unknown

  Corrective Actions: Unknown

- **Risk 7:**

  Event: Issue with Document Proof for road transport ("bewijs van wegvervoer") at Belgium customs

  Causes: Not clear yet

  Consequences: 1. Loss of whole cargo? How much? (High/low?), 2. JamboFresh needs to pay for layers in case there are disputes

  Preventive Actions: Unknown

  Corrective Actions: Unknown

- **Risk 8:**

  Event: Sometimes vessels arrive at ports other than Antwerp

  Causes: 1. when the ship arrives in the weekend some ports do not do handling in the weekend

Consequences: 1. Delay. How much? (High/low?)
Preventive Actions: Unknown
Corrective Actions: Unknown

- **Risk 9:**
  Event: Possibility of missing the vessel during trans-shipment
  Causes: 1. for goods coming from Mombasa there is always a transhipment, as the big boats do not travel to Mombasa.
  Consequences: 1. 7 – 30 days delay. Cost?
  Preventive Actions: Unknown
  Corrective Actions: Unknown
- **Risk 10:**
  Event: Possibility of missing container
  Causes: Not clear
  Consequences: Cargo is completely damaged. How much?
  Preventive Actions: Unknown
  Corrective Actions: Unknown
- **Risk 11:**
  Event: Improper - phyto documentation
  Causes: Not clear
  Consequences: Accumulated administrative costs. How much?
  Preventive Actions: Unknown
  Corrective Actions: Unknown
- **Risk 12:**
  Event: Damage due to incorrect temperature settings
  Causes: 1.In some ports the carrier is responsible for ensuring the agreed temperature requirements are met. 2. It could be that the truck driver did not follow the procedures for keeping the container cool. 3. If the container is not pre-cooled, it takes time when the goods are already in the container to reach to the agreed temperature.
  Consequences: Damaged cargo. How much?
  Preventive Actions: Unknown
  Corrective Actions: Unknown

- The template to study the risks and which was later shown to the associates of JamboFresh is shown below.

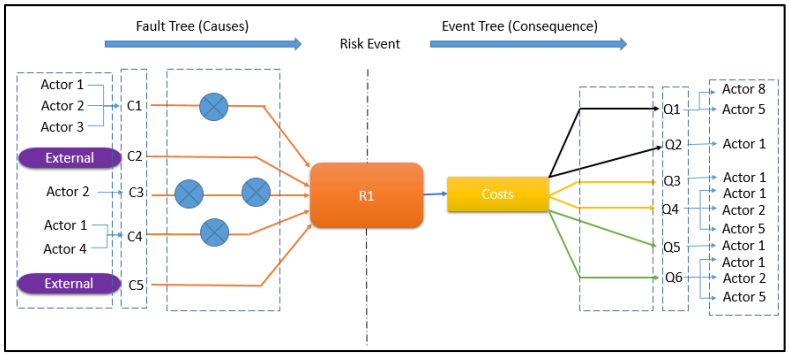


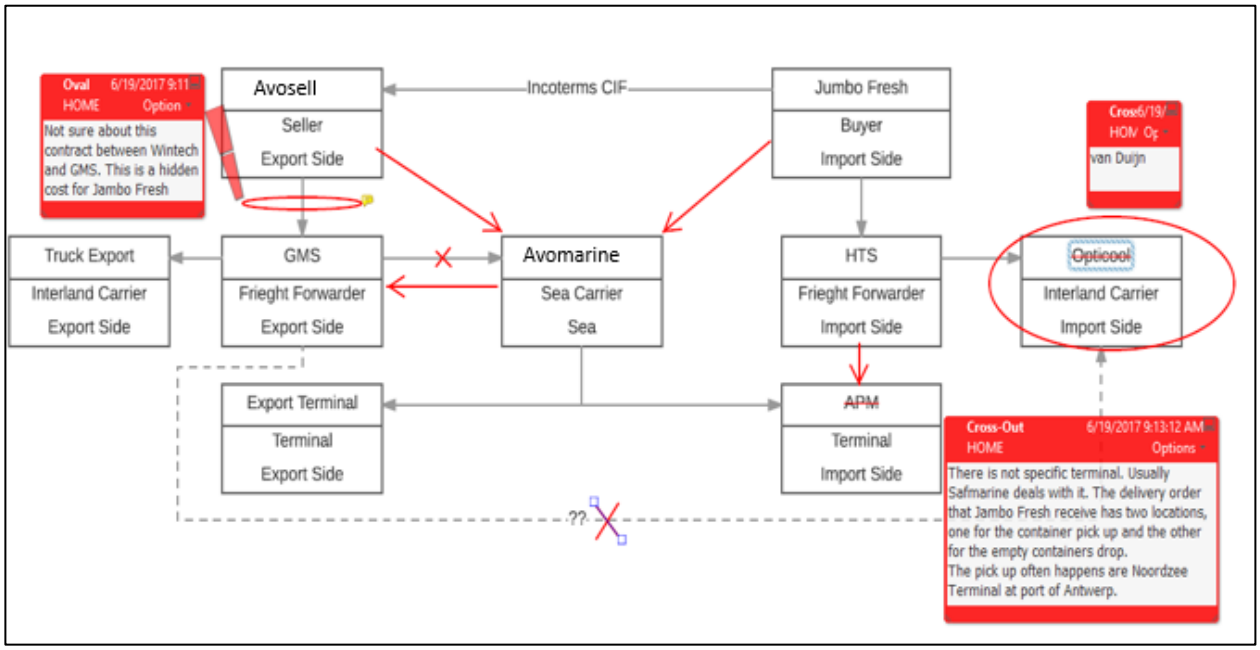
Figure 51 Template for Risk Analysis

Meeting 2: Date: 15th June 2017

Participants: Two associates of JamboFresh, Tuty Arsyida (TU Delft), Anil Ravulakollu (TU Delft)

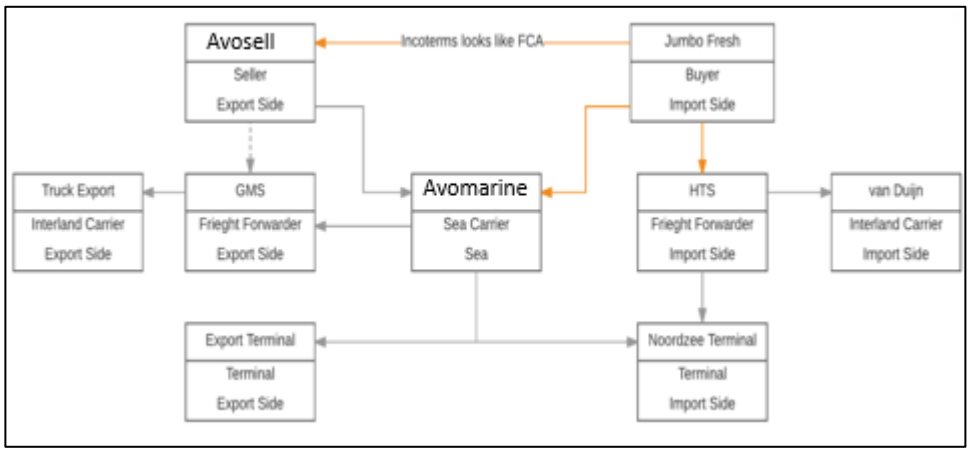
Summary:

- Risk based decision making application was showed to JamboFresh. They liked the application and agreed that it was useful in identifying the risks that are out of their control and can have an impact on them
- They mentioned that one of the concern is not just the direct cost impact, but also the cost of lost business opportunity. However, they agree that it is difficult for them to quantify. It depends highly on the then prevailing market price
- When asked if they have any process close to risk management, they mentioned there is no formal procedure in place. They stressed that they run their business on intuition and the "feel" of the market
- The **interdependency map** that Anil constructed based on previous meeting notes was showed and discussed with them. The following is the markup evolved from the discussion

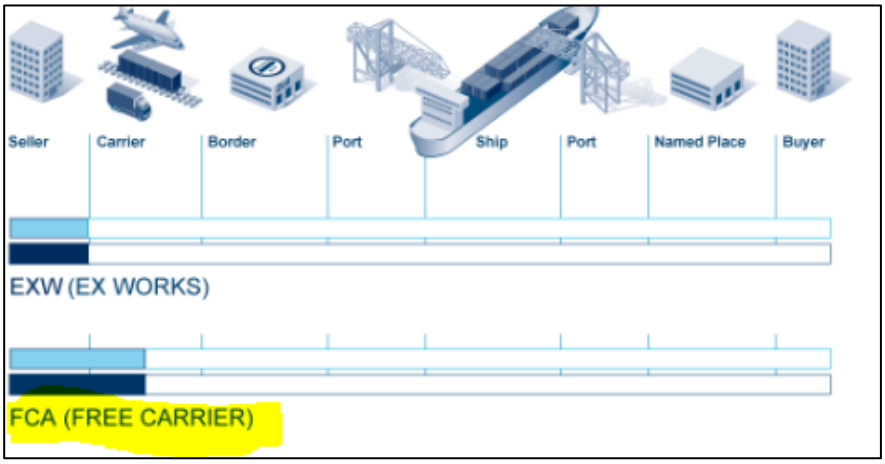


- The **basic business model** of JamboFresh is that it places order with Avosell only after they have sold their current batch of fruits. The selling price here is varying depending on the market and this determines the purchase of the next batch of the product. The money is paid to Avosell in advance. Avosell then is responsible to procure the fruits. Once they procured, they load the goods on the container at Nairobi. From then on Avomarine is responsible to carry the container form Nairobi to Mombasa Terminal and from there to Salalah Terminal and finally to Noordzee Terminal. Here HTS is responsible for scanning and transporting it to the warehouse, which is now located in Rijswik in the Netherlands. Further, they pointed that the inland transporter is now van Duijn.

- **JamboFresh receives three invoices** at a high level – frist one from Avosell for the sale of the product, second one from Avomarine for all the inland transportation at the export side and also for the sea transportation and the third one from HTS for the processes and inland transportation at the export side. The following is the **updated interdependency map.**



- For any mishaps JamboFresh puts claims on Avomarine. This is a "**corrective action"** for the risk event occurring during export inland transportation and sea transportation.
- When asked about the **incoterms**, they said that there are not exactly sure under which of the terms they operate. However, by looking at their process flow and studying their invoices, they seem to operate under FCA (Free Carrier) because JamboFresh bears the costs of inland transportation both at export and import side and also on the sea.



- The discussion moved on to **risks for JamboFresh.** They two main factors that affect their business is delay and cost. They prioritize delay over cost because having direct impact on cost is of lower scale than the indirect impact on cost due to delay. At times due to delay, JamboFresh resort to buying goods from other sellers locally to hold the market position and to maintain the relations with the customers. These are additional costs due to large delays and loss of goods.

- JF considers 30k-65k euros as being the **highest impact** for them while a couple of hundred euros as **low impact.** When asked about any insurance they have in place to avoid high impacts they said they do not have any insurance as they did not feel need of it because they put claims directly on Avosell or Avomarine. However, they are now thinking to have an insurance package anyway. Based on this we began discussing the risks that were identified during the call Boriana had with David on 5th April 2017.

- **Discussion on risks that were identified during the call with an expert from Avomarine.**

1. **Growers selling Avacados to-other company**

When the avocados are harvested even if there have been prior agreements growers it may happen that the glower sells the avocados to a ~~bigger~~ company offering better prices. The bigger companies may also offer additional bonuses to growers at the end of the harvesting period to make it more attractive for growers to work with them. Especially in situations with high demands, it may happen that the growers prefer to work with the bigger exporters who offer better prices.

JF Response - This is not a risk for JamboFresh, as they directly deal with Avosell and they are not involved in the procuring methods of Avosell.

2. **Payment of guarantees at import side**

For the import to the Europe, there is a trade facilitation named EUR1 (or movement certificate) that enables the importers to import goods with reduced (or even free) import duty based on the trade agreement between the EU and the beneficiary countries. Particular to the Netherlands, there is a new regulation that for the selected container for the EUR1 document inspection, importer is required to pay the guarantee of around 1,500-1,600 euros per case (or per container?). This guarantee money will be released back to the importer only after Customs establish that the EUR1 document is not fake.

JF Response – EU committee forced Dutch authorities to collect the guarantee amount. JamboFresh was affected by this once within two months. The amount is evaluated per kilo of the goods. **The occurrence of this is Low and the impact is very high** (in their relative terms).

3. **Scanning takes very long at import side**

If goods arrive via Rotterdam container scanning is a big issue. It can take up to one week before the container is scanned. For sensitive goods that can affect the quality. For some fruits coming from Columbia the damage of the delay can be so big that the whole cargo is lost.

JamboFresh had a period that 75% of the cargo was selected for a scan – where?. They were very surprised by this high rate. In other periods they have much less scans but in this specific period the scanning rate was very high

JF Response – Scanning depends on the capacity at the port terminal**.** Officially, customs has to direct the goods to the area of scanning. But often, the physical scanning is done by HTS and this causes some delays. There can be demurrage costs also which amount to around 300 euros.

The occurrence of this is Medium and the impact is Low (in their relative terms).

4. **Long waiting times at the customs**

There were some cases of customs declaration system down during the working day (from 9.00 am morning to 15.00 – 16.00 pm). With such process that works out of business expectation, JamboFresh needs to manage the order delivery to the customers

JF Response – Any delay is a risk. Either scanning at customs or waiting time at customs. While usually the cause for the delay is with the customs process, another main cause could be that the original copies of the bills and declarations from Avosell have not reached JamboFresh yet. JF believes that in Kenya, Avosell employees prefer to send the documents in a stack after waiting for another shipment to be loaded rather than sending them immediately after one shipment is sent. This is more to do with the mind sets of the people.

The occurrence of this is Medium and the impact is Medium (in their relative terms).

5. **Breakage of container door seal during the transport**

Avocados are transported under very specific conditions. The right combination of temperature, as well as oxygen and other gas needs to be maintained during the journey. There is a special plastic curtain that is paced inside the container to ensure the right conditions are kept. Any door opening can be damaging, as it will disturb the conditions and the avocado can wake up and start maturing.

JF Response – This is a serious concern for JF. If the temperature is destabilized, fruit ripening begins and Ethylene gas is released. This gas can transiently increase the ripening rate of the fruits. If unattended, the whole cargo can be lost. This is a high risk especially if the temperature is destabilized at the export side and not so much at the import side. The loss can be that the whole cargo is damaged amounting to 30k euros directly.

The occurrence of this is Low and the impact is Very High (in their relative terms).

6. Issue with Document Proof for road transport ("bewijs van wegvervoer") at Belgium customs

The goods normally arrive in Antwerp, as it is faster. Belgian customs issues a document *"bewijs van wegvervoer".* There are often issues with that document.

JF Response – This is no risk for JF as they are not impacted by this event.

7. **Sometimes vessels arrive at ports other than Antwerp**

The vessel normally arrives in Antwerp, but sometimes they go via Felixstowe. When the ship arrives in the weekend some ports do not do handling in the weekend, the port of Rotterdam does. So it can happen that the goods arrive at port of Rotterdam as well

JF Response – occurrence of this is low, however at times rerouting can cause delays measuring in days. However, not much impact was ever felt on cost.

The occurrence of this is Low and the impact is Low (in their relative terms).

8. **Possibility of missing the vessel during trans-shipment**

Big problem is when the goods are transferred from a smaller vessel to a bigger ship (there is a transshipment). For goods coming from Mombasa there is always a transshipment, as the big boats do not travel to Mombasa. The transshipment takes place in Salalah and there are big boats coming from China. If you miss the boat then it take a week. So at times it takes 21 days to receive the container but sometimes more than 30 days. The problem with missing the boat is not so much on the Kenyan port but on the transshipment port

JF Response – occurrence of this is very low, in fact never occurred with JF. However, usual time for the cargo before it gets spoilt considering that the temperature is maintained throughout is 28-30 days. Any delay beyond this could mean that a heavy damage has

occurred. Though such a delay did not happen to JF particularly, it has occurred previously for other company.

The occurrence of this is Very Low and the impact is Very High (in their relative terms).

9. Missing Container

In practice it has happened that a container is lost. From earlier experiences they know of two cases when a container lots and reappears 7-8 months later. So the container is at the end there but the cargo is completely damaged. The value was in the range of 80 000 euros

JF Response – They fear that this could happen and estimate that it can take around a week or so to trace back the container. If an event as mentioned above occur, then it is heavy loss for the business.

The occurrence of this is Very Low and the impact is High (in their relative terms).

10. Improper - phyto documentation

It happened once that they had to get 3 times the phyto document and to pay for couriers. It was an administrative thing, the goods were not delayed but it accumulated extra costs. The first time the phyto was there but was not signed, so they had to ask for a renewed phyto. This was issued again and was sent by courier but when filling it in they forgot to put the date so the authorities did not accept it. So it had to be sent a third time

JF Response – This can be tied back to the earlier risk event 4 where Avosell fails to send the courier containing original bill of landing in time. To save some money, the employees at Avosell wait of different bills of landing to accumulate and send them in one courier. JF has recommended Avosell to use DHL but they cannot enforce.

The occurrence of this is Medium and the impact is Medium (in their relative terms).

11. Damage due to temperature changes in the container

They requested the carrier earlier to provide this information but still have little view on that aspect. Temperature readings can be very sensitive information, as in case of damage claims can be placed. At the moment if a damage occurs due to temperature deviations it is difficult to find out who is responsible. JamboFresh has very little visibility on that. In some ports the carrier is responsible for ensuring the agreed temperature requirements are met. In other ports that is outsources to another company or to handlers, so the carrier needs to rely that they follow the agreements and procedures correctly. And sometimes if the damage occurs it can occur also before the goods reach a port. It could be that the truck driver did not follow the procedures for keeping the container cool. Next to that in the contract there is an agreed temperature but if the container is not pre-cooled, it takes time when the goods are already in the container to reach to the agreed temperature

JF Response – This is the most important risk of all. They identified three main causes for this.

1. Fruits were not precooled before loading onto the container at Nairobi
2. The drivers shuts off the engine to save fuel at the export side especially during transportation from Nairobi to Mombassa and from Mombassa to Salalah
3. The temperature measuring device is not working well. If the damage occurs, JF would put a claim on Avomarine.

The closer is the alteration of the temperature to the export side the more impact it has on the cargo. The occurrence of these events is low and there is regular monitoring of the temperature.

The occurrence of this is Low and the impact is High (in their relative terms).

- Later **Tuty discussed cost compliance model (CCM)** that she developed as a part of her research. They admitted that they were not aware of so many different kinds of costs that occur in a trade lane and that their business is not as complex as it is shown in the model.
- We inquired about how usually JF encounters the "**hidden costs**" in their daily business. They said it is rare as they feel that the systems in Netherlands are transparent. However, they pointed out in the invoice of Avomarine regarding the inland transportation at the export side and said that they were not clear of how those costs pile up. They feel that there could be some hidden costs there.
- Finally to provide clarity on their business, they were kind to allow us to take that **copies of three documents**: Delivery Order Amendment by Avomarine, *Import Factuur* (Import Invoice) by Avomarine, and *Factuur* (Invoice) from Huttges Transport Service (HTS)

Preparation for Meeting 3

The information obtained was fed into the RBDM tool developed. The following impact scaling and categorization was used and the risk matrix was thus generated.

Impact Evaluation

	Max	Grade
Enter Maximum Damage	€ 30,000.00	VH

Categorization

Impact Level	Impact Amount	Grade
Very High	€ 30,000.00	VH
High	€ 24,000.00	H
Medium	€ 18,000.00	M
Low	€ 12,000.00	L
Very Low	€ 6,000.00	VL

Scaling used for analysis

Impact Level	Grade	Impact Range	
		Lower (>)	Upper (<=)
Very High	VH	0.80	-
High	H	0.60	0.80
Medium	M	0.40	0.60
Low	L	0.20	0.40
Very Low	VL	0.00	0.20

Risk Evaluation

Risks	Probability of Occurrence	Impact Value	Impact Grade
R1	VL	€ 30,000.00	VH
R2	VL	€ -	VL
R3	L	€ -	VL
R4	VL	€ 1,600.00	VL
R5	M	€ 300.00	VL
R6	M	€ 300.00	VL
R7	L	€ 10,000.00	VL
R8	VL	€ -	VL
R9	VL	€ 500.00	VL
R10	M	€ 30,000.00	VH
R11	VL	€ 30,000.00	VH
R12	M	€ 300.00	VL

Figure 52 Initial values used to evaluate risks for JF

Actor Name: Jumbo Fresh

Impact	Probability				
	VL	L	M	H	VH
VH					
H					
M	R12 R6 R5				R10
L	R7 R3				
VL	R9 R8 R4 R2				R11 R1

Prioritization

Impact Level	Grade	Color Code
Unacceptable	UA	
Very High	VH	
High	H	
Medium	M	
Low	L	
Very Low	VL	
Acceptable	A	

Figure 53 Preliminary Risk Matrix for JF

Meeting 3: Date: 26th June 2017

Participants: Two associates of JamboFresh and Anil Ravulakollu (TU Delft)

Summary:

- The purpose of this meeting was to validate the results obtained with JamboFresh associates.
- The results obtained were shown to JamboFresh.
- They were not surprised to see that there were not alarming risks in the red regions. They pointed out that they outsource almost all of the shipping process. In this way they are able to have claims in place.
- However, they noticed that some of the values were not estimated well. All the risks were again analysed independently. New impact values close to being realistic were given. They changed the scaling of the impact levels. The generated risk matrix is shown below.
- Overall the associates were pleased with the results and the tool. They mentioned that if all the actors along the trade lane participate, this tool will be really helpful in identifying the unknown risks and would surely facilitate in improving business.

Impact Evaluation

	Max	Grade
Enter Maximum Damage	€ 30,000.00	VH

Categorization

Impact Level	Impact Amount	Grade
Very High	€ 30,000.00	VH
High	€ 10,000.00	H
Medium	€ 2,500.00	M
Low	€ 750.00	L
Very Low	€ 200.00	VL

Scaling used for analysis

Impact Level	Grade	Impact Range	
		Lower (>)	Upper (<=)
Very High	VH	0.80	-
High	H	0.60	0.80
Medium	M	0.40	0.60
Low	L	0.20	0.40
Very Low	VL	0.00	0.20

Risk Evaluation

Risks	Probability of Occurrence	Impact Value	Impact Grade
R1	VL	€ 25,000.00	H
R2	VL	€ -	VL
R3	L	€ -	VL
R4	VL	€ 1,600.00	L
R5	M	€ 10,000.00	M
R6	VL	€ 10,000.00	M
R7	L	€ 30,000.00	VH
R8	VL	€ -	VL
R9	VL	€ 20,000.00	H
R10	VL	€ 30,000.00	VH
R11	VL	€ 50,000.00	VH
R12	M	€ 10,000.00	M

Figure 54 New scaling of impact values

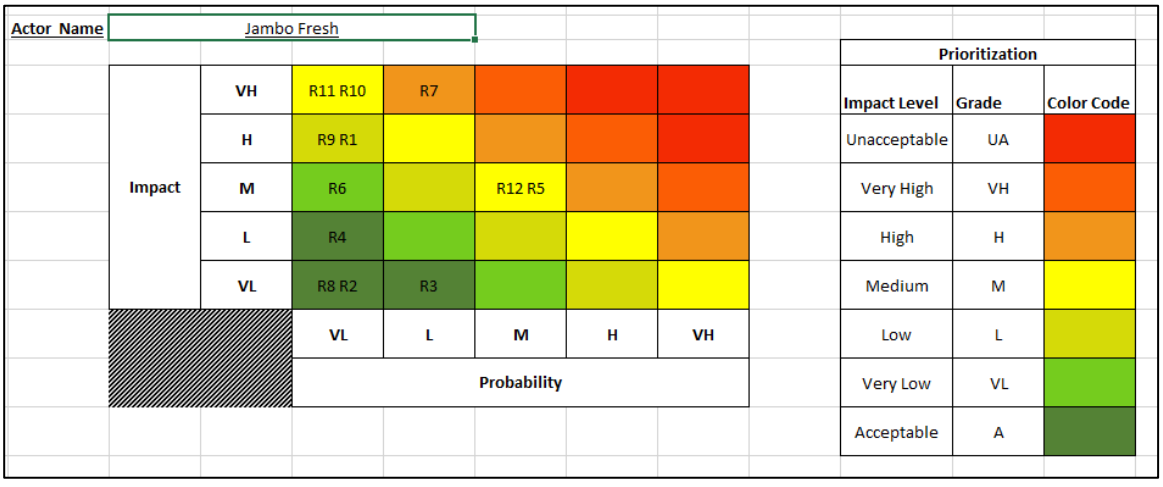


Figure 55 Final Risk Matrix for JamboFresh

Appendix C. DATA PIPELINE AND CORE EU

Improving Visibility through Data Pipeline

Data pipeline as being a large scale digital infrastructure was introduced in the main sections. It was stressed that main contribution of data pipeline for supply chain would be taking a giant leap towards digitization and thereby developing the system into smart supply chain. Data Pipeline aims to improve transparency across the trade lane. Figure 56 illustrates the typical information exchanges that occur along the trade lane between the consignor and the consignee. It can be noted that different actors seek different kind of information. For instance EU seeks data for purpose of carrying out statistical and fiscal analysis. A third country seeks the data to assess the risks and study the extent of compliances of the operators with regulations and norms.

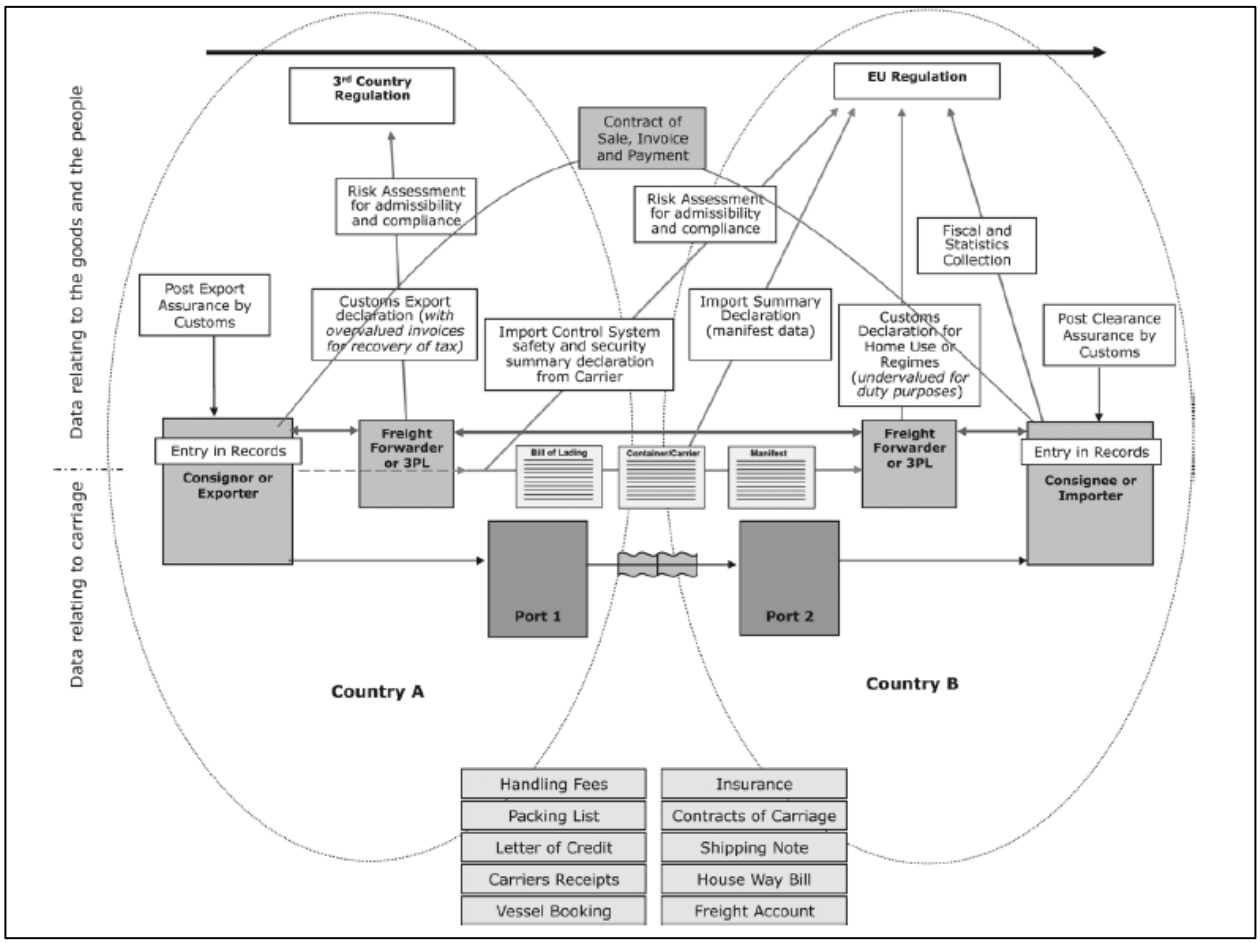


Figure 56 Information exchange in a typical trade lane (Klievink et al., 2012)

Currently, the manner in which is data is provided to the respective actor is discretized. Data Pipeline aims to connect different internal systems as shown in Figure 57.

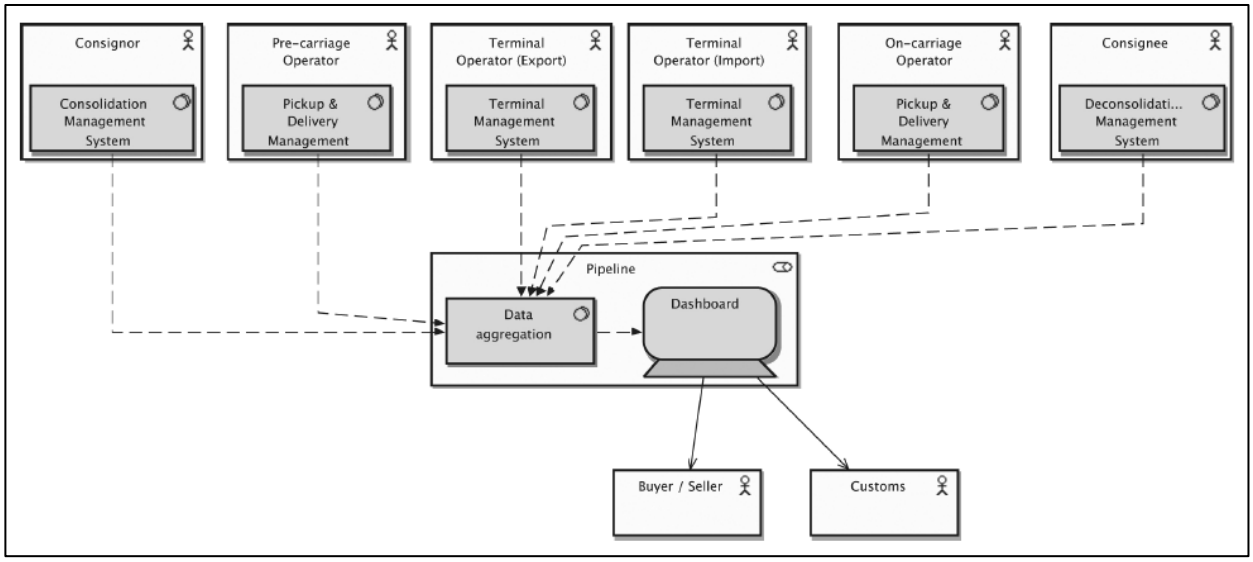


Figure 57 interconnecting different information systems Klievink et al., 2012)

CORE Project

Funded by European Commission, under the Seventh Framework Programme, CORE Project was initiated in 2014. CORE project for global supply chain implies that the project works towards establishing a Consistently Optimised Resilient global supply chain. The project aims to showcase that the existing global supply chain systems can be enhanced by focussing on the enhancement of "efficiency, speed and reliability of legitimate trade and logistics" and on the aspects related to supervision of global trade, security of the supply chain and other challenges posed to the societies due to global trade and logistics. In this regards, different demonstrators have been initiated each catering to different aspects of enhancements in the supply chain. (The information here is gathered from the official web site[8] of CORE).

Table 23 Demonstrators of CORE Project[9]

Demonstrator	Objective/Focus Area
GM Demonstrator	Demonstration of benefits of CORE in security, efficiency and resilience in an intercontinental trade lane of General Motors between US and Europe
Demonstrator FALACUS	Demonstration of the effectiveness of Next Generation of Scanning systems and CORE Dash board in increasing the rate of scanning in the trade lane of Italy –US.
Demonstrator Felixstowe	Establishment of a seamless data pipeline to gather reliable and accurate information involved in the trade lanes between UK-China

[8] http://www.coreproject.eu/media/16662/16-12-22-core-leaflet-2.pdf
[9] Reference - http://www.coreproject.eu/about.aspx

	and UK-Australia and thereby enabling security to business and border agencies.
Demonstrator Rotterdam	Employing improved security measures and data sharing systems to improve the business controls of the supply chain and thereafter demonstrate the use of these controls by government inspection agencies.
Demonstrator Schiphol	Applying the data pipeline concept to air trade lane between Kenya and Netherlands
Demonstrator Belgium	Demonstration of "Drugs free import" and best practices of "long range rail transportation"
BSH Demonstrator	Demonstrating the importance of having a better quality data in supply chain operations by developing an efficient port- hinterland connection
DHL Demonstrator	Demonstration of the benefits of the security control tower, with real time tracking the shipments data.
P&G Demonstrator	Demonstration of the importance of having temperature control and monitoring systems in sea containers in lowering the costs and carbon foot print.
Intermodal transport of dangerous goods demonstrator	Demonstration of the use of European satellite navigation for tracking and tracing the transport of dangerous goods.

To manage the project effectively, several work packages and deliverables are put in place with different members of the consortium as being responsible. It can be noticed that two demonstrators in this project deal with data pipeline.

The work packages of CORE Project are not restricted to demonstrators. They are also related to provision of support activities, coordination activities, management activities and research and development.

Appendix D. RISK ASSESSMENT TECHNIQUES

The notions of risk assessment techniques differs from risk assessment frameworks in this report. Risk assessment framework, as mentioned earlier, refers to broader outline in the form of guidelines to not only execute a risk assessment process but also facilitate in decision making process. A risk assessment technique on the other hand refers to a tool or a method which is used to analyse particular aspect of risk assessment process. Risk assessment told may be an integral part of frameworks. Having established this basic difference, this section presents a consolidated list of risk assessment techniques prevailing across industries.

In the literature there are few works which studied different risk assessment techniques and presented an overview. Mullai (2006), after studying different literature has reviewed various risk assessments listed in Table 24. He later compared them on the lines of their strengths, their weaknesses, the information they dealt with (particularly events description, risk estimation, factors causing accidents, and recommendations), the complexity and expertise required. His main conclusions are that most of the techniques are suited for certain applications and situations. For instance, as he points out FMEA is more suited to systems like electronic controls and mechanical systems than HAZOP technique. The latter one is more suited for analysing systems with continuous processes like fluid mechanics and thermal systems. Further, he identifies that there are qualitative, quantitative and hybrid methods in risk analysis. At a general level, they conclude that these techniques require certain level of expertise related to understanding and applying.

Table 24 Different Risk Assessment techniques(Mullai, 2006)

1. Hazard Checklists (HCl)	12. Failure Modes and Effects Analysis
2. Preliminary Hazard Analysis (PrHA)	13. Hazard and Operability (HAZOP)
3. Hazard Review (HR)	14. Fault Tree Analysis (FTA)
4. Hazard Review (HR)	15. "5 Whys" technique
5. Preliminary Risk Analysis (PrRA)	16. Event Tree Analysis (ETA)
6. Change Analysis (ChA)	17. Human Reliability Analysis (HRA)
7. What-if Analysis	18. Event and Causal Factor Charting
8. SWIFT Analysis	19. Cost analysis techniques
9. Relative Ranking/Risk Indexing (RI)	20. Pareto Analysis (PA)

Marhavilas, Koulouriotis, & Gemeni, (2011), on the other hand, presented a well cited paper by conducting a similar review of literature regarding different techniques. But they restricted their search to years spanning from 2000-2009. They began by classifying the techniques under three categories namely quantitative, qualitative and hybrid. Quantitative is largely dependent on historic data and operate through established mathematical relations. Qualitative analysis depends on both analytical estimations and the analyst's ability to conduct analysis. Hybrid techniques are usually complex mainly because they are used based on the situation or the needs. This ad hoc character brings in lot of unreliability and hence hybrid techniques are not that prevalent.

After discussing each technique in detail, they later compared them based on their advantages, disadvantages and the possible future developments in each of them. Further, they evaluate each techniques based on different criteria. The evaluation results are reproduced in Figure 59. Not only that, their paper also presents the statistical analysis conducted on amount of literature is produced under each category. According to their results around 65% of the literature caters to quantitative methods. To have a good overview of techniques, it is recommended to read their article.

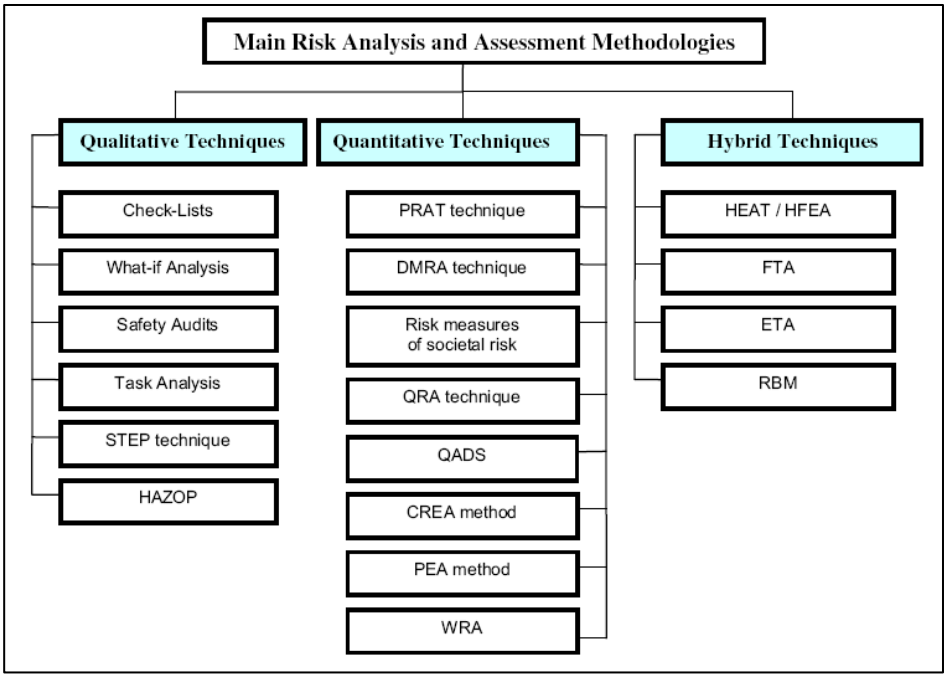


Figure 58 Different techniques[10] under the three categories (Marhavilas et al., 2011)

An overview illustration of the characteristics of the various risk analysis and assessment techniques, comparatively with settled evaluation criteria.

Evaluation criteria	Qualitative Techniques						Quantitative Techniques								Hybrid Techniques			
	Check-Lists	What-if -Analysis	Safety Audits	Task Analysis	STEP	HAZOP	PRAT	DMRA	Societal risk	QRA	QADS	CREA	PEA	WRA	HEAT/HFEA	FTA	ETA	RBM
Data collection	√	√	√	√			√	√	√	√		√				√	√	
Representation of the events' chain				√	√											√	√	
Identification of hazardous situations		√		√	√	√	√	√	√	√	√	√				√	√	√
Multidisciplinary experts team for the application		√		√		√					√	√	√	√				
High level of structuring				√		√	√		√	√	√	√	√	√		√	√	√
Applicable to any process or system	√	√				√	√	√	√	√			√			√	√	
Possibility of incorporation in integrated risk analysis schemes	√	√	√	√	√	√	√	√	√	√		√						
Time-consuming				√	√	√	√		√		√	√		√		√	√	
System design	√	√		√					√					√	√	√	√	√
Safety audits			√		√		√	√		√	√	√			√			√
Human orientation				√	√				√			√		√	√			√
Equipment orientation			√			√			√		√					√	√	√
Proactive use	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	
Reactive use					√		√	√	√	√			√	√		√	√	√
Mathematical background							√	√	√	√	√	√	√	√	√	√	√	√
Graphical illustration				√	√			√	√							√	√	
Possibility of incorporation in databases	√	√					√	√		√								
Possibility of incorporation in computer automated toolkits					√		√	√		√						√	√	
Prediction of potential risks					√		√	√	√	√	√	√	√	√	√	√	√	√
Individual risk orientation	√	√	√	√	√	√	√	√		√		√	√		√	√	√	√
Societal risk orientation									√	√	√			√		√	√	√

Figure 59 Evaluation of risk assessment techniques (Marhavilas et al., 2011)

[10] **Abbreviations -** PEA (Predictive, Epistemic Approach), CREA (Clinical Risk and Error Analysis) method, QRA (Quantitative Risk-Assessment) tool, Quantitative assessment of domino scenarios (QADS), Decision Matrix Risk-Assessment (DMRA) technique, Proportional risk-assessment (PRAT) technique, Weighted risk analysis (WRA), Human Error Analysis Techniques (HEAT) or Human Factor Event Analysis (HFEA), Fault-tree analysis (FTA), Event tree analysis (ETA), and RBM Method (Risk-based Maintenance),

As a part of CORE EU project two deliverables dealt extensively with risk assessment methods. One is SCS Reference Framework Specification (SCSRF) [11] and the other is the development of Multi-method Threat and Vulnerability Analysis (MTVA) [12] Suite. SCSRF deals with establishing a consolidated suit of different methodologies addressing different issues related to security in supply chain. This suit is classified into different blocks and risk assessment is one of them (shown in Figure 60). In this block, the relevant risk assessment international standards are presented.

- ISO 73:2009 for notions and definitions of terms in risk assessment
- ISO 31000:2009 for general guidelines of risk assessment process
- ISO/IEC 31010:2009 for having an overview of capabilities of different risk assessment techniques
- ISO28000, ISO/IEC JTC 1/SC 27 for certification of compliance purpose

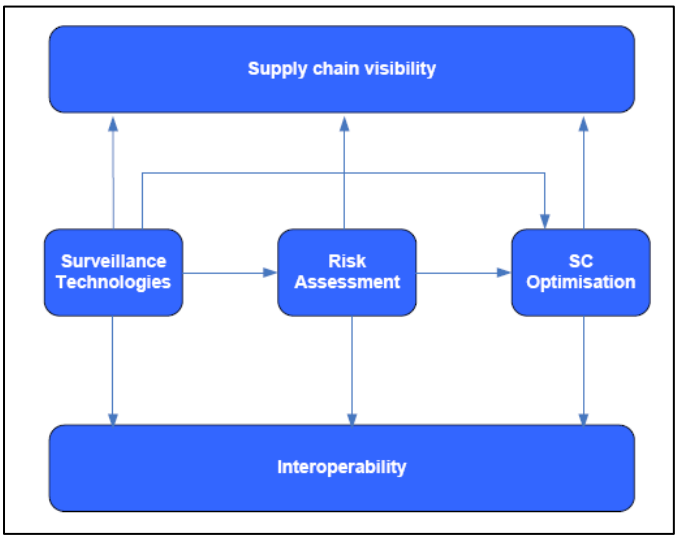


Figure 60 Risk Assessment as one of the building block of SCSRF

Further, the main risk assessment methodologies covered are check lists, consequence/ probability matrix, cause and effect, Threat and Risk Analysis Matrix (TRAM) and bow-tie. According to the document, check lists are widely used in daily process of the supply chain. Consequence/probability matrix is similar to risk matrix but not in a multi-actor context. Cause and effect technique is used to identify the causes of a threat in a structured way. TRAM is used to identify the risks and recommends measures to mitigate the risks. It can be used in decision making related to allocating resources, planning and scheduling. Bow-tie is particularly useful to locate the barriers for causes and consequences. Having discussed each of these methods briefly, this deliverable refers to MTVA document which captures all the state of art risk assessment techniques and methods used across the supply chain.

The deliverable document of Multi-method Threat and Vulnerability Analysis (MTVA) Suite presents a list of techniques and develops a selection criteria to choose from these techniques those ones which could be incorporated in the suite. Different risk assessment techniques that are discussed in the document are in Table 25. Based on the selection criteria developed in the document (results shown in Figure 61) it accepted check lists, consequence/probability matrix, TRAM, Bow-tie, and Data Mining.

[11] Document D6.31 - SCS Reference Framework Specification (v1)
[12] Document D3.11 Multi-method Threat and Vulnerability Analysis (MTVA) Suite

Table 25 MTVA Risk assessment techniques

1. Check-lists	2. Threat and Risk Analysis Matrix (TRAM)
3. Hazard and Operability Analysis (HazOp)	4. Bow-tie diagram
5. Failure Mode and Effect Analysis (FMEA)	6. Markov analysis
7. Consequence / Probability Matrix	8. Monte Carlo simulation
9. Decision Trees	10. Cause and Effect Diagram
11. Data Mining on Bill of Lading and Package List information	12. Bayesian networks
13. ALARP	14. Data analysis on container routes

	Ease of Use / Skills requirements	Low Cost to implement / maintain	Scalable	Suitable for all SC Modes & Nodes	Does it enhance present SC risk management practices?		
Options \ Weight	20	20	5	25	30	100	Comments
Check list	10	10	10	10	5	850	Extensive checklists are contained in the MTVA
HAZOP	5	5	5	5	5	500	The MTVA Threat Library can replace
FMEA	1	5	5	5	10	570	Suitable for defined, measured processes
Consequence / Probability Matrix	10	10	1	10	1	685	TRAM provides a better comparitive analysis between risks
Decision Tree	5	5	5	5	5	500	Quality of risk analysis depends on the modelling effort
ALARP	5	10	10	10	1	630	Features are contained in TRAM
TRAM	5	10	10	10	10	900	TRAM is part of MTVA
Bow-Tie Diagram	5	5	10	10	10	800	BowTie is part of MTVA
Markov Analysis	1	1	1	1	10	370	Not appropriate where processes are not documented
Monte Carlo Simulation	1	1	1	1	10	370	Not an operational tool. More appropriate for offline analysis
Cause & Effect Diagram	5	5	5	10	10	775	Features are contained in BowTie
Data Mining & Analysis	5	5	10	5	10	675	Data mining is beyond the remit of the SME's but is a very valuable tool for Customs
Bayesian Networks	1	1	10	5	10	515	Powerful but costly to implement
		Weight relates to the importance to the CORE demonstrators and stakeholders					
Scale:							
High 10	(Easy to implement, deemed to be a significant improvement)						
Medium 5	(Deemed to be of medium level of difficulty to apply or value)						
Low 1	(Deemed to be difficult to implement or have low level of benefits over present practices)						

Figure 61 Evaluation of techniques as a part of MTVA document

Having seen that there are different kinds of risk assessment techniques in the shipping domain, the main sections of the report referred to two of them often. It was mentioned that a bow-tie diagram

is a combination of fault tree and an event tree analysis. They are Fault Tree Analysis and Event Tree Analysis. They are briefly discussed below.

Fault Tree Analysis (FTA)

In a typical FTA the multiple causes lead to an event of failure or accident through paths constructed by inductive reasoning following Boolean operations. The main components of FTA are listed below (Ericson, 1999; Marhavilas et al., 2011).

- Top event is the risk event. This is represented by rectangle in the FTA diagram.
- Basic event is a main root cause of the risk. It is represented by circle.
- Intermediate event have a successor event and a predecessor event. These are also represented by rectangle.
- Undeveloped event is an event with incomplete information. This is usually located at the end of the tree like basic event and is represented by a diamond.
- Boolean logic comprising of Boolean operators.
- Transfer symbols which maintain the continuity of the flow of the FTA diagram.

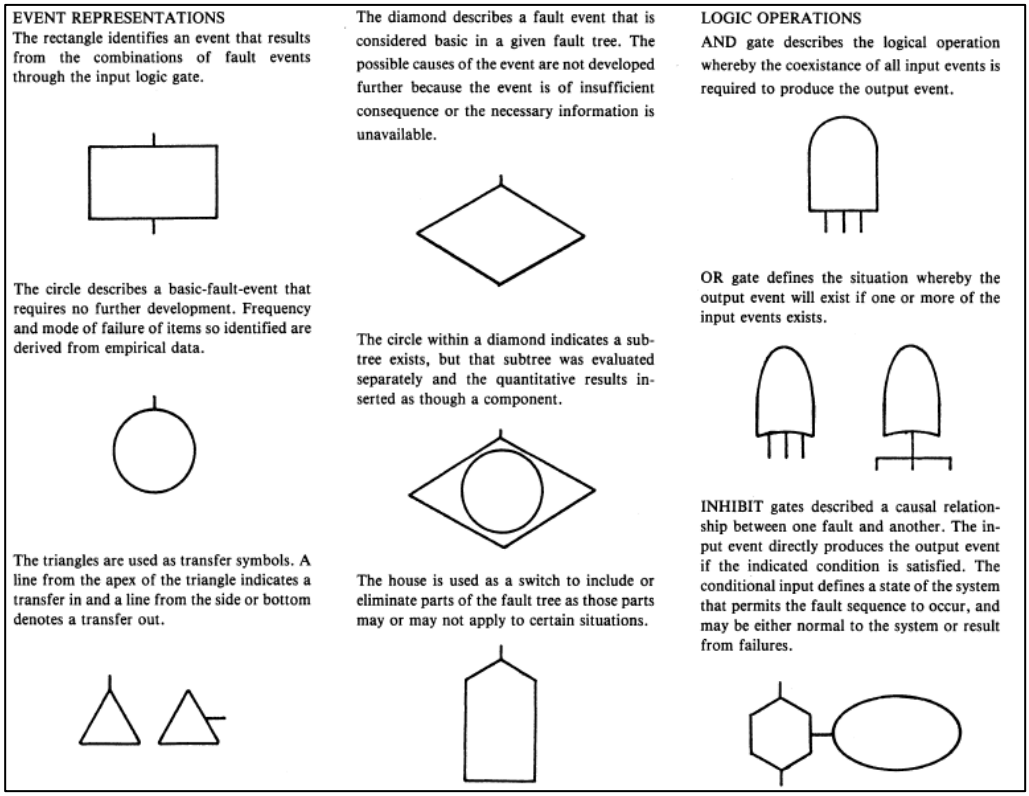


Figure 62 Representations in FTA (W.-S. Lee, Grosh, Tillman, & Lie, 1985)

The Boolean operators used in FTA are usually AND gate, OR gate, XOR Gate, PAND gate, and Inhibit gate. AND gate operator indicates that the output event is triggered only when all the input events are triggered. OR gate signifies that the event occurs when at least one of the inputs is triggered. XOR gate indicates that the output occurs only when one input is triggered. Inhibit gate is an AND gate triggering output only under presence of a condition. The condition acts as an inhibitor to the AND gate. Some of the frequently used representations are reproduced in the Figure 62 from the work of W.-S. Lee et al., (1985).

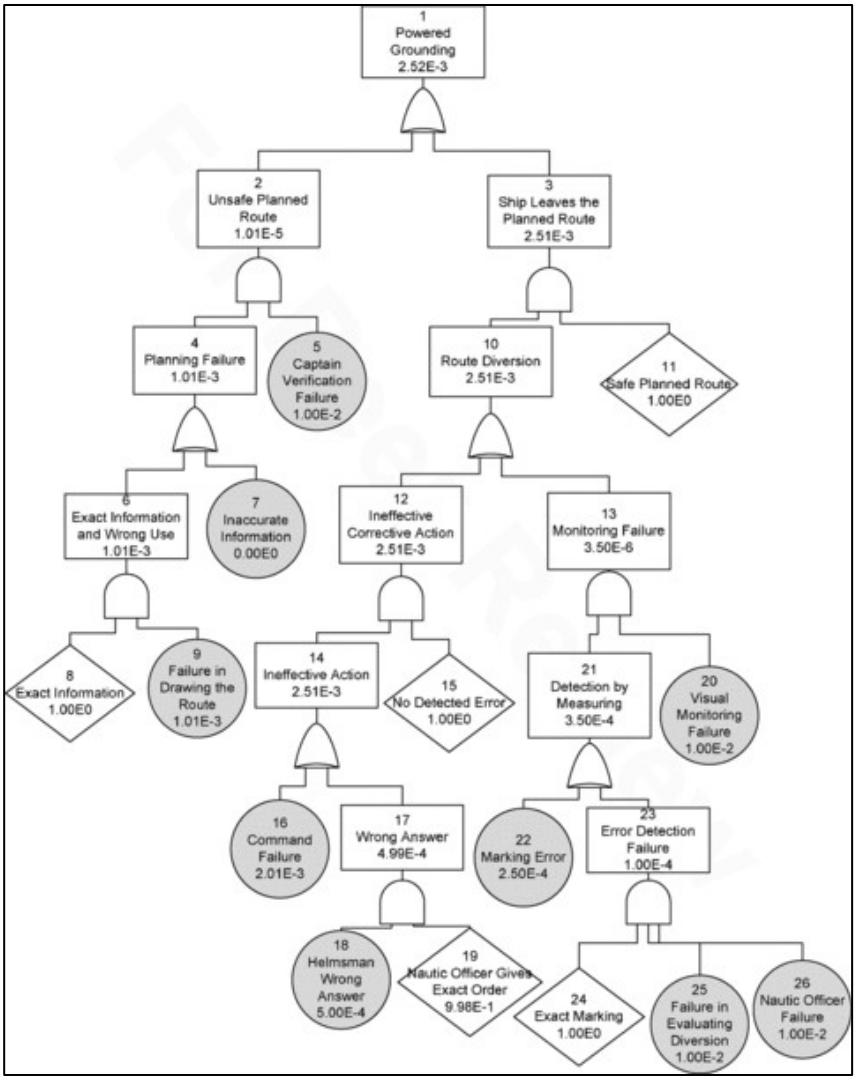


Figure 63 Example of FTA (Martins & Maturana, 2010)

Event Tree Analysis (ETA)

ETA begins with an initiating events and by using decisions trees, it develops the logic towards the possible outcomes. Each outcome could further be analysed leading to a tree like structure. The main elements of an event tree are as follows.

- Initiating event: The event tree begins with an event which when occurred would lead to a possible chain of events and when does not occur could lead to possible chain of events.
- Line of Assurance (LOA): The probability of the outcomes occurring depends on the safety barriers in place. The safeguards are referred to as lines of assurance (Refer Figure 65).
- Accident Scenarios: The final outcomes of different paths are generated give rise to different probabilistic scenarios. This probability is obtained by multiplying the probabilities of different successive paths leading to the final outcome (Refer Figure 64).

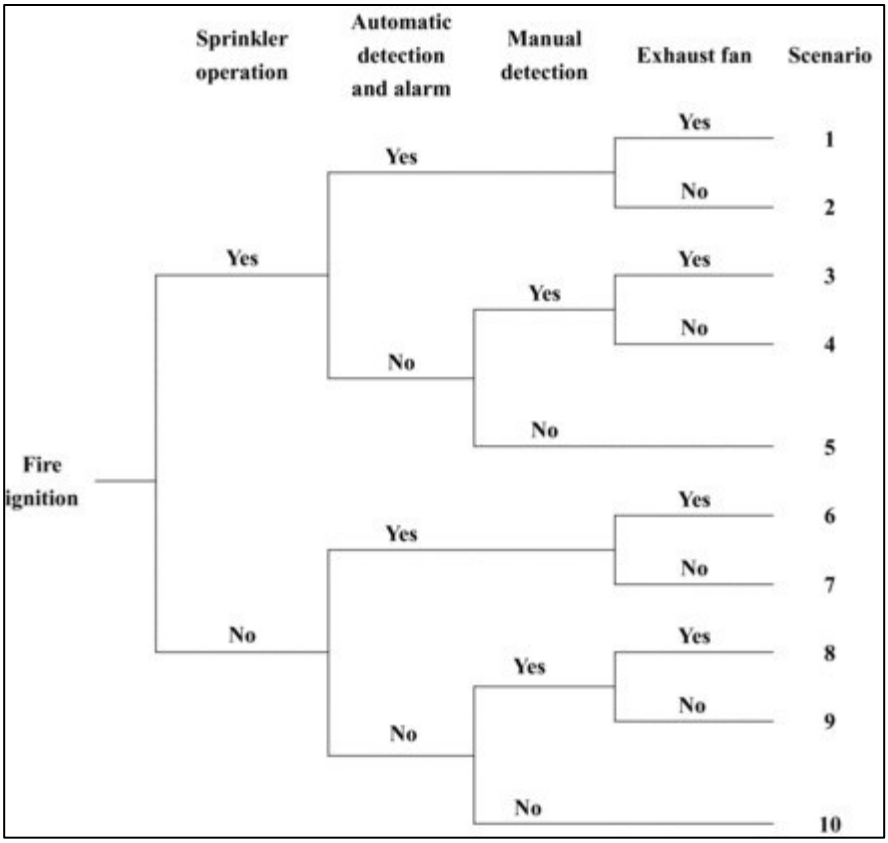


Figure 64 Scenarios of an Event Tree

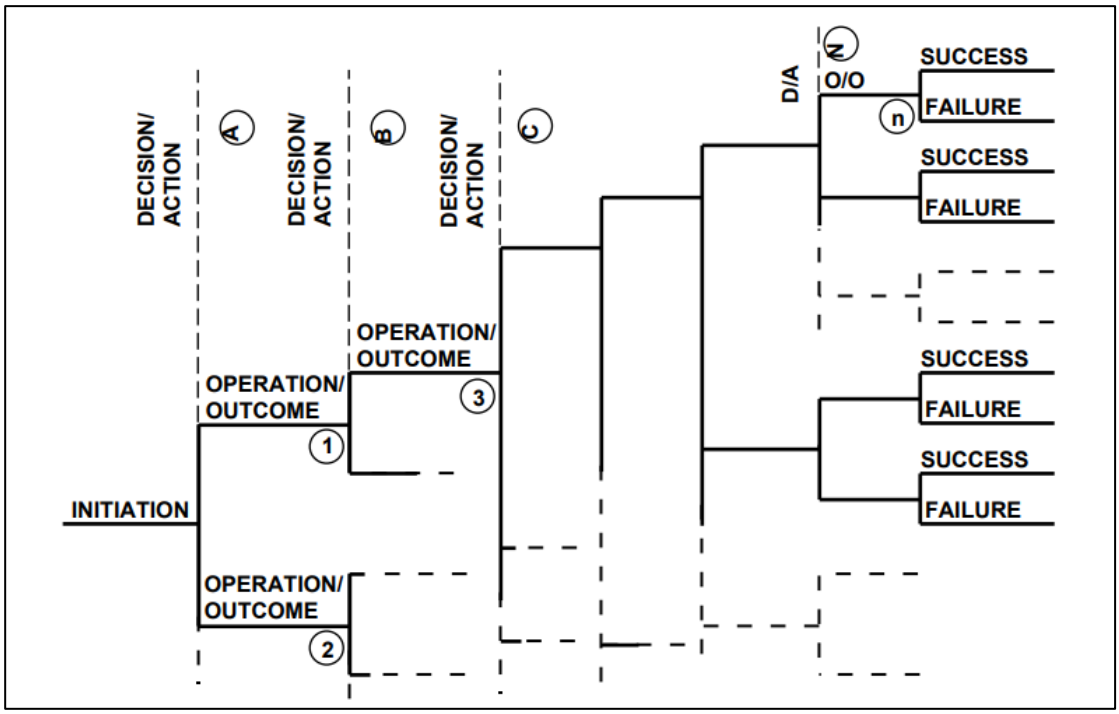


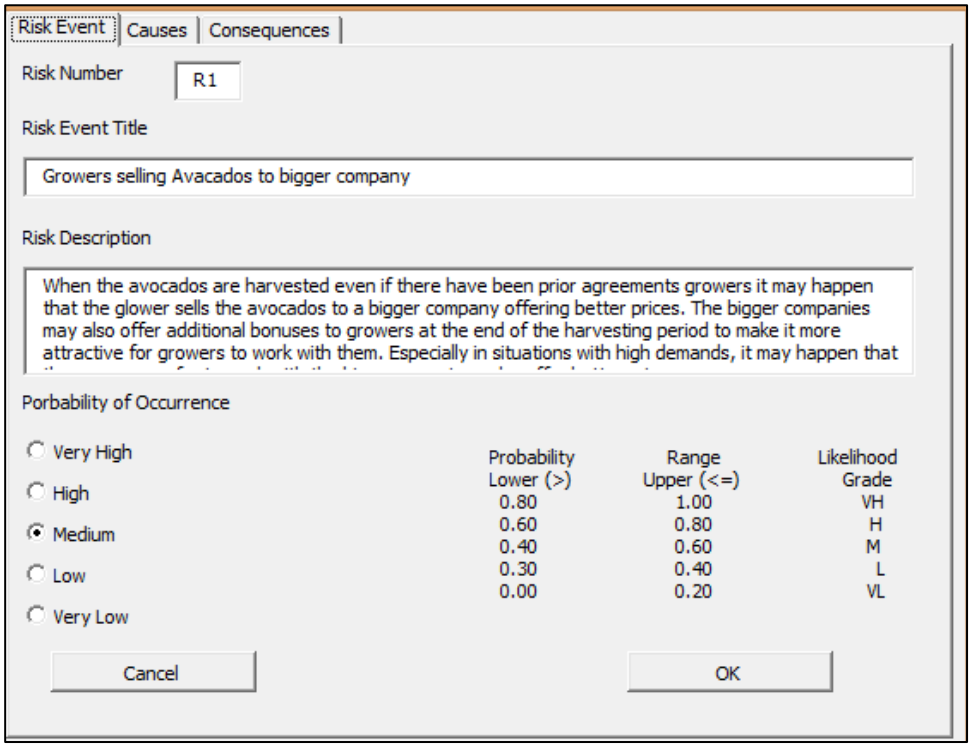
Figure 65 Decision actions forming LOA in ETA

Appendix E. RBDM TOOL

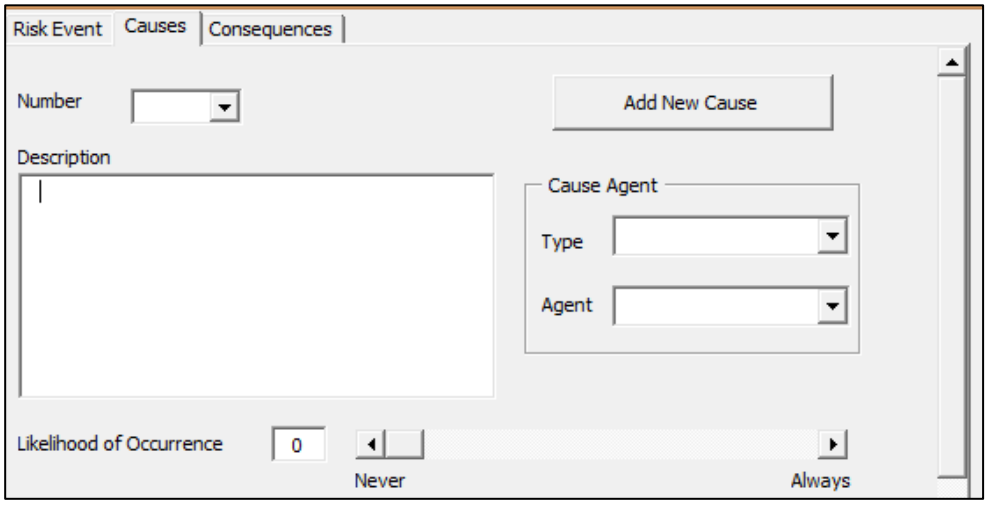
User Forms as GUI for Data Input

User forms are used to gather basic information about the risk event. These include risk details, cause details, consequence details, preventive action details, and corrective action detail. The following screenshots are the different user forms used in the RBDM tool

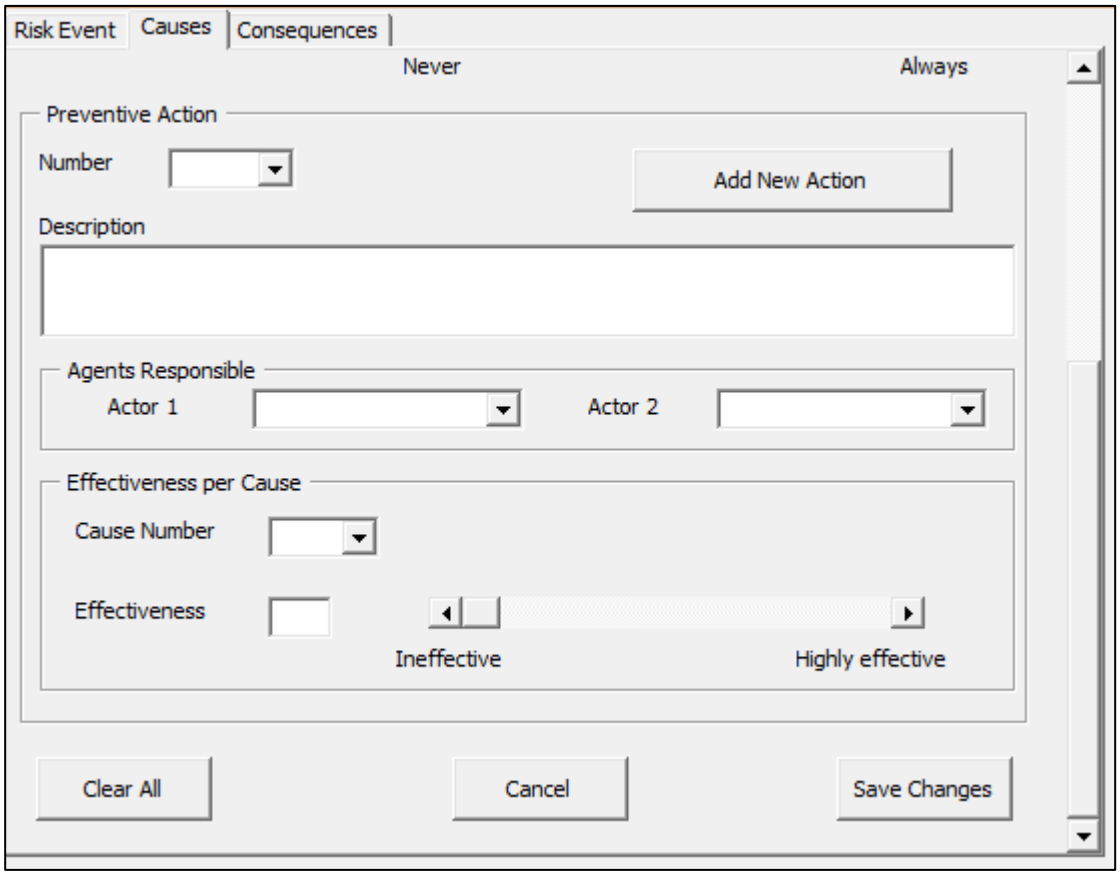
To input basic risk event details



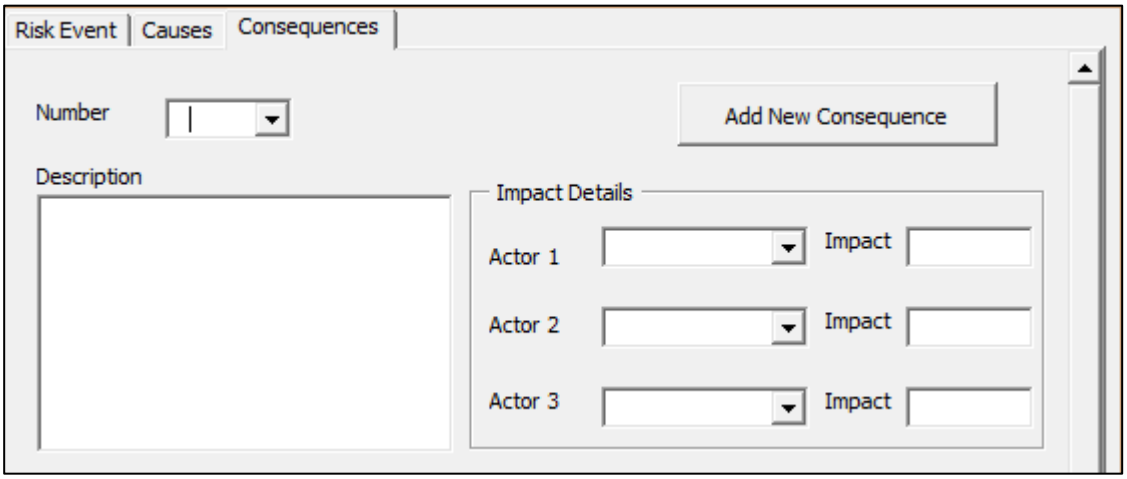
To input Cause details



To input Preventive Action Details



To input Consequences Details



To input Corrective Action Details