Master of Science in Engineering and Management

Thesis Title

Application of Risk Management and Monte Carlo simulation on a Construction Project

(Case Study)

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ABSTRACT

One of the Agency Construction Manager's primary roles in fixed priced construction contracts is to ensure that the General contractor delivers the project on time (by monitoring the project schedule) and according to the required quality. However, the complexity and the constant changes in construction projects lead agency construction management companies to find that monitoring the ongoing process is not enough to ensure that the project finishes on time. They need to find a way to look ahead by predicting what activities may delay the project and alarm the owner and the general contractor about them. Also, to propose actions can be taken to mitigate the delay to keep tracking ongoing activities and anticipating any delay and avoid it as possible. This thesis aimed to provide Construction Companies/Project Managers with a methodology to anticipate the delay and tackle it by providing a structured forecasting and mitigation plan. The methodology is an application of risk management on construction projects. Risk management is the process of identifying, analyzing, and assessing risks that may impact the project -schedule in this case- either positively(opportunities) or negatively(threats) and implement a response plan to eliminate or mitigate threads and augment opportunities. A construction project has been taken as a case study. Following the PMI standards, risk management has been applied, which started with a risk initiation plan in which the main project scope and objectives have been defined. This step is followed by the risk identification process in which all possible risk has been identified using different techniques and registered in the risk register. After that, a risk breakdown structure (RBS), qualitative risk analysis has been applied, and semi-quantitative risk analysis has been applied. All risk data and the project's Gantt chart have been imported into RISKYPROJECT Professional to obtain sensitivity analysis using Monte Carlo simulation. In the end, a response plan has been implemented.

The result of qualitative and semi-quantitative risk analysis is represented in the Cross Risk breakdown Matrix (RBM), from which activities are classified according to how much risk is associated with each activity. Also, the most significant risk sources are defined and classified. The sensitivity analysis results in sensitivity charts, which order activities depending on how likely each activity would fall into the critical path.

This thesis's results recommended that the application of risk management in the early stages of the construction has a significant impact on project success, and more effort should be made to apply it. It is proposed to be integrated into the project management process.

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INTRODUCTION

Construction is indeed an important sector that makes a significant contribution to the economic development of a country. The construction industry is an investment-led market in which the government has a large degree of involvement. Government contracts with Construction Industry to build projects relevant to the wellness, transport and education sectors. Construction Industry is essential to the growth of every country

Nowadays, the complexities of the market in every field are highly challenging, the degree of competitiveness is very strong, and the construction industry is no exception. The construction sector is adjusting to the shifts and demands of the environment, companies and companies and their approach to executing a design project is evolving with time.

Private or public companies, stakeholders, investors are demanding more than ever for assured results before agreeing to participate or finance a project. This particular request refers to the heritage and expertise acquired in the construction market, where the connection between success and disaster is incredibly similar. A good construction project is a challenging phase because, on the other portion, it is possible to count the project as a failure because of the number of objectives and the goals that the project can achieve at the end.

A successful project, regardless of the form of project or company, is deemed to be executed on a set budget, time and quality basis. The completion of these three elements, which make up the framework of the project, is a dynamic task owing to the number of risks involved with each of these three components.

Construction is a dangerous endeavor. -- construction project is special and has its own set of obstacles and opportunities. Identifying and handling building project risks can be tricky, but not impossible, with proper preparation and delivery. When a risk becomes a fact, it may interrupt and derail a project, which is why developing risk control is so critical. In order to prevent hazards, once established, you need to be able to adequately identify, manage and track risks.

Risks are not necessarily harmful. Being able to efficiently recognise and handle risks will contribute to improved revenues, strong partnerships with customers that result in further contracts, and the potential to broaden the company to different markets and sectors.

BACKGROUND

Risk management (RM) is a practice that is applied in all sectors, from the IT, manufacturing and pharmaceutical industry to the building business. Every sector has developed its own Unique requirements, but the general principles of the definition generally stay the same regardless of the industry. According to the Institute of Project Management (PMI) (2004),

Project RM is one of the nine most important aspects of project commissioning. This suggests a solid relationship between risk management and project performance. While RM is defined as the most challenging field of construction management (Winch, 2002; Potts 2008)

its use is favored in all projects in order to avoid negative repercussions (Potts, 2008).

One term that is commonly used in the field of RM is called the Risk Management Process (RMP) and comprises of four key steps: identification, evaluation, action taking and risk control (Cooper et al., 2005). In each of these different stages, there are a variety of approaches and strategies that promote risk management.

Many businesses have been more involved and mindful of the usage of analysis methods in projects. Similarly, RM has been a crucial topic frequently debated through sectors. However, risk management is not widely employed in the building sector (Klemetti, 2006).

More construction companies have started to become aware of the RMP but are still not using risk management models and techniques. This undermines the reality that the company is striving to be both cost-effective and time-efficient, as well as to gain both leverage over programs. Risk is Involved with any project, independent of the sector, RM could be of concern to any project manager. Risks vary between projects since each project is specific, particularly in the construction industry (Gould and Joyce, 2002) . However, there are so many professionals who have not understood the value of incorporating risk management in the project implementation process (Smith et al., 2006) . And if there is a knowledge of these Risks and their implications, certain companies do not address them using proven RM approaches.

The construction sector works in a very volatile world where circumstances which vary due to the complex nature of each project. (Sanvido et al., 1992)

The goal of each company is to be efficient and that can be supported by RM. However, it should be noted that risk management is not a method that assures success, but rather a method that can maximize the chances of success. Risk management is also a proactive instead of a reactive approach.

Multiple past researches (Klemetti, 2006; Lyons and Skitmore, 2002; Zou et al., 2006) have been undertaken in the field of RM, but each of them offers a different approach to this topic. This thesis focuses on the construction industry and how the subject is practiced in day-to-day activities. The definition of RM is addressed in an existing project during the construction phase, as it provides the practical application of quantitative research.

AIMS AND OBJECTIVES

This thesis aims to help experts in the field of construction project in the decision-making process. The objective is to provide the construction companies such as RECCHI-ENGINEERING with a methodology to forecast schedule and anticipate any potential delay and plan to avoid it as well as provide a response plan to its clients. This thesis would apply a risk management and sensitivity analysis on an existing construction project to come up with a list of all tasks ordered from most risky to least risky and most significant risk sources. Also, List of each task propensity to fall into critical path. Which both would help in decision making to priorities more risky activities to others in case both are not critical. Which at the end would lead to implementation to a risk response plan.

LITERATURE REVIEW

THE CONCEPT OF PROJECT AND PROJECT MANAGEMENT

Project Management Institute (PMI) (2013) has described a project as a "a temporary endeavour undertaken to create a unique product, service, or result." It is temporary since it has a specified start and finish date; it is unique, implying that it is not a common process, and the product / service will be different from other related products / services. Examples of projects may be regarded as the creation of a new product and the construction of a new system, device, construct a new shopping center.

Financial capital, human resources and equipment are arranged as part of a scheme to carry out specific work, taking into consideration a number of restrictions, such as time and cost (Turner, 1992). The various elements of the project should therefore be carefully handled in order to meet the goals of the project within schedule and within the budget, and it is also necessary to establish specific objectives for the project. Because of the one-off nature of the project, the data relevant to each particular project, requires to be collected for its management. Project management as described in PMI (2013) is "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements."

Other than the time, cost and scope of the project that needs to be specifically specified, the quality (specifications) of the key parties regarding the specifications and risks involved in the project should also be clearly established. In addition to the coordination between them, each of these parameters should be managed. A project typically occurs in an organizational context (including other projects), is affected by this background (environment) and can, in turn, often affect it.

There are various professional bodies and national associations involved in the development and transmission of project management around the world. The International Project Management Association (IPMA) is an international non-profit agency that seeks to establish a project management discipline and establishes criteria and requirements for the practice of project management practitioners (IPMA, 2013). Project Management Institute (PMI) is another non-profit organization based in the United States to advance project management, and the Project Management Body of Knowledge (PMBOK) is a book presenting project management standards and published internationally (PMI, 2013). Similar to IPMA and PMI, the Association of Project Managers (APM) is a UK-based organization that exists to promote the science of project management (APM, 2013). The PRINCE2 (Projects in Managed Settings, version 2) (PRINCE2, 2009) is another project management technique introduced by the UK Government as the standard used for public projects. Other standards developed to improve the science of project management have been provided by GAPPS (Global Alliance for Project Performance Standards), which is a unique alliance that presents this information to be freely used by institutions and associations (GAPPS, 2013).

The standards presented for project management refer to the concepts of project management that are widely agreed upon for all forms of projects; nevertheless, some of the technical bodies deal with particular types of projects, such as the Chartered Institute of Buildings (CIOB), which focuses on project management and facilitates and advances the science and practice of construction and building projects.

The PMBOK Construction Extension Guide is another manual that includes a sector-relevant (construction business) implementation field and was published by PMI in 2003 to help project management professionals in relevant business sectors. This extension explains the widely recognized standards for building projects that do not apply to all forms of projects. Aim of this document as defined in the Guide to PMBOK (2000) Edition (cited in Construction Extension, 2003) is "Application area extensions are required because there are commonly agreed knowledge and procedures for a group of projects in one application area that is not generally accepted across the full range of project types in other application areas." The explanation of why PMBOK is given the construction extension is that the management and practice of the project are not generally accepted across the full range of project types. The concept was then broadened to include all forms of schemes, though, as it does not adequately include existing standards for project management in the building sector; an extension has been provided by PMI in order to improve the efficiency of construction projects on a stand-alone basis and to include applicable construction-specific materials (PMI-Construction Extension, 2003).

All these professional bodies and associations provide their own standards and guidance for project management and present frameworks related to the different aspects of the projects. Risk is one of these aspects, which is the focus of this study, and specific standards have been set for it, such as the Practice Standards for Project Risk Management presented by PMI in 2009 (PMI, 2013). The danger is also one of the seven themes on which the PRINCE2 technique is based (PRINCE2, 2009). The definition of danger is explored in detail in this chapter.

It should be remembered that whilst the project management process is being addressed, the Life Cycle Project should not be associated with the Life Cycle Product. The Project Life Cycle as stated by PMI (2013) is “the series of phases that a project passes through from its initiation to its closure”; however, the Product Life Cycle is the duration (which is divided into stages) from which a product is launched in the market until it leaves the market and comprises four stages: introduction, growth, maturity, and decline (Baines et al., 2008).

In Project management, a project life cycle that determines the start and completion of the project may be separated into separate stages to have greater management control. There is no one perfect framework that can be generalized to all projects and, depending on the nature of the project, the separation of these stages can be different but typically includes conceptual / feasibility, planning, design, implementation, and completion stages (Chapman and Ward, 1997). It was at The conceptual process of the information is at the initial stage, as the availability of details improves as the project continues. In the first step, however, the goal would be to provide strategic preparation, which would then be followed with more detailed strategies, while the volume of details needed would expand in subsequent stages. However, since change is an unavoidable feature of any project, the proposals should be updated periodically in order to take account of any adjustments (Mills, 2001).

There are various types of projects, and, based on the features of each type, they can be handled differently. Each of these forms is the "construction project" explained below.

CONSTRUCTION PROJECT

A construction project is a form of project that deals with the process of constructing physical structures, such as residential buildings, industrial and commercial buildings, highways, and utilities. Phases (stages) of the building process are more or less like all other forms of schemes, and various authors/institutes have proposed their own separation of phases leading to identical project life cycles. Zou et al. (2006) divided the phases of the construction project into the feasibility, planning, construction, and service, while Liu and Zhu (2007) divided the phases of the construction project as follows: conceptual, planning, tender, Preconstruction, then create it. The phases of the construction project, as defined in PMI (Construction Extension) (2003), are Concept, Planning (& Development), Detailed Design, Construction, and Start-up and Turnover.

As seen in the various divisions presented above, they usually remain the same, though often they are synonymous terms that are substituted for each other in calling the same phases. The number of phases can also vary depending on the point of view of the managers, as they may subdivide one process in order to concentrate on the specifics of each process individually and more carefully.

Generally, each construction project begins with a feasibility stage to verify whether or not this project can be run and result in a decision going / no-go after the period. However, this process can be iterative if a project needs adjustment before a decision can be reached. If a proposal is feasible, the planning process will be accompanied by the project's construction according to the specification. And finally, the actual planning process and the planning of the scheme will take place. Other stages, such as tendering, pre-construction, and handover, can also be applied to these stages, but the principle remains the same.

Various parties are engaged with any construction project; typically, the major parties are the client (employer), contractor, and consultant. However, each of these major categories can be made up of various professionals, such as superintendent, project manager, subcontractor, quantity Monitor, and Technical Advisor. All of these parties may engage in the construction project (in various phases of the project) depending on the nature/type of the project, the nature of the contracting procedure, and the type of contract selected for the project.

At the outset of each project, each client tries to create a delivery framework that is suitable for the project, taking into account both the goals of the project as well as the nature of the various delivery processes that influence the time, expense, and efficiency of each project. The delivery system (delivery system), as specified by Love et al. (1998), is an "organizational system that assigns particular roles and authorities to individuals and institutions and specifies the different components of the construction of the project."

Ashworth and Hogg (2007) described the construction delivery approach as the management of the entire procedure involved with implementing the construction project. The distinction between the respective delivery processes is the division of roles, the sequence of operations, the management strategy followed, and the procedures employed in the execution of contracts.

Consequently, delivery processes vary from project to project, and clients can prefer different systems to share their various roles between entities for the effective execution of the project. Morledge and Smith (2013) believe that the construction delivery system is primarily concerned with the human aspects of people who interact with one another in their environment. As a result, their approach is impacted by their human aspects and the social, cultural, and ethical aspects.

It also shows the importance of the assignment of obligations and risks to the stakeholders in the various delivery processes and how they cooperate. There are four major delivery systems defined as:

- Traditional: consisting of three separate sequential phases of design, bidding and building. The client begins the project; the consultant is responsible for the design of the project and then the contractor contracts for the project in order to assume responsibility for the actual work.
- Design and construction: the design and construction phases are the same the company that is the contractor.
- Management contracting: the main contractor, called the management contractor, runs the project on the basis of a series of contracts signed by the subcontractors selected for bidding process.
- Construction management: the preparation, design and construction processes are viewed as integrated tasks and the client, consultant and contractor are combined (Oladinrin et al . , 2013)

.

Other forms of delivery systems, such as Public-Private Partnerships (PPPs) and Private Finance Initiatives (PFIs), concentrate on the cooperative relationship between government and private sector firms. The specification of an appropriate form of contract based on the type of project and its priorities is one of the main procedures in the construction delivery framework. Subsequently, one of the essential explanations for selecting the various types of delivery processes and contracts is the distribution of obligations to the parties concerned and, more precisely, the distribution of risk-free projects to the parties (Davis et al., 2008).

There are various types of contracts available for construction projects, and the selection of each of them depends on the category and scope of a project. Some of the contracts shall be as follows:

- Fixed price / Lump sum price: the contractor is responsible for the activities carried out in the contract and is paid a fixed price by the client.

- Reimbursable / Cost plus: the client gives the contractor
- a portion of the cost of the job as bonus.

- Billed rates / Unit rates: payment to the contractor shall be dependent on the measurement and evaluation of the work carried out based onunit rates.

- Turnkey / Design Building: the contractor is responsible for all aspects of the project, from design to construction.
- Partnership / Joint venture: for a number of purposes (such as scope of project, political issues) the project is being conducted by various firms collaborating together (Avazkhah and Mohebbi, 2010).

Selecting the right contracting method and contract for any project (by the client) that deals with the assignment of obligations and risks to separate parties is of considerable importance for the proper management of the project. Examples can be seen in the United Kingdom's Public Accounts Committee (PAC) and National Audit Office (NAO) reports, which describe how the schemes are handled and what are the different aspects that have affected the project from start to finish. Failure of the Metronet – related company

With the London Underground project initiated in 2007 by the London Public-Private Partnership, the NAO report (2009) reported that "the key cause of Metronet's defeat was its weak corporate governance and leadership."

Management resulted in an inability to plan effectively, and often low quality of the information provided to management created a lack of success of the project. It should be understood how the selection of the contracting method, such as the Public-Private Relationship, in this project, and the manner in which the parties collaborate during the implementation of the project should affect the management of the project. In addition, there were strategic and managerial problems.

Various problems for this sector, such as constant shifts in management, have resulted in inefficient management and coordination for the sector (NAO,2009).

Another example is the London 2012 Olympic and Paralympic Games, where the spending rose nearly fourfold from 2.4 billion pounds to around 9.3 billion pounds in 2007. As described in the PAC (2010) 'one of the key reasons for the rise in the budget for the Games declared in March 2007 was the addition of a sponsored contingency, but three years later there is still no such contingency for LOCOG (London Organizing Committee of the Olympic and Paralympic Games).'

Political and administrative problems that could contribute to a client's unreasonable schedule and expense forecast that could contribute to a rise in the project budget that is not always feasible to add (PAC, 2010).

Consequently, each construction project has its own unique characteristics that influence the approach adopted and the manner in which the project is handled. There could be several interdependent practices where each operation has its own time, expense, quality requirements, and risks (Gunhan and Arditi, 2007). Of all the considerations relevant to construction projects, the definition of "risk" has been selected as the subject of this analysis and will be discussed below.

THE CONCEPT OF RISK

"If you are sure you understand all that's going on, you're hopelessly confused. "Walter F. The Mondala

The Italian verb "Rischiare," which means "to dare" or "to have the cheek to do something," is where the term "risk" comes from, indicating that risk is not a destiny but an option (Bernstein, 1996). All life choices entail risk, and risk stems from ambiguity, resulting from a lack of information, expertise or experience (Jannadi and Almishari, 2003). After the Revival, the risk analysis began, and since then, individuals and organizations have suggested different concepts of risk, some of which have been discussed below. Before addressing risk, though, it is important to describe some other words that can often be used interchangeably: uncertainty, threat, and vulnerability.

As described by Flanagan and Norman (1993), uncertainty is 'a situation in which there are no historical data or previous experience of the circumstance being considered by the decision-maker.' Similarly, risk refers to the same fundamental definition – an unpredictable future, but the probability of an occurrence occurring can be measured by the decision-maker when the action is made under danger regardless of the presence of an event. There is, therefore, still ambiguity and no risk without ambiguity, but the distinction is the capacity to predict the likelihood of the occurrence (either intuitively or rationally) for the risk and not for the uncertainty.

Another difference between uncertainty and risk, as discussed by Hillson and MurrayWebster (2004), emerges from the analysis of the implications, since uncertainty without implications does not give rise to risk. They also assume that risk can only be identified in relation to the goals and the effects that it could have on them as "uncertainty that may have a positive or negative impact on one or more goals."

The Health and Safety Commission (1995) describes the hazard as "the potential to cause harm." There is a possibility that this potentially dangerous occurrence will occur, and, as a result of exposure to it (danger), there will be a degree of damage called vulnerability (Brimicombe, 2003). Consequently, the danger and the degree of damage it can inflict (vulnerability) may be called risk components.

Willet (1951) defined risk as "a phenomenon that is objectively associated with the subjective uncertainty of an adverse occurrence." Loosemore et al. (2006) further enhanced the concept of risk as "a possible future incident that is unpredictable in probability and outcome that, if it happens, may impact the ability of an organization to achieve its project objectives."

To accomplish the goals of the project. People also see risk as only "negative" outcomes of an incident, although it often has "positive" outcomes. Project Management Institute (PMI) No concept of risk considers the presence of both positive and negative effects of risk to be an unpredictable occurrence or situation that, if current, has a positive or negative impact on one or more goals of the project, such as scope, timeline, expense, etc.

Quality and quality "(PMI, 2013). These potential (negative/positive) consequences of a probable and unidentified occurrence will be defined as "threat" in the occurrence of negative effects and "opportunity" in the event of positive effects (Figueiredo and Kitson 2009). Defining the risk posed by the PMI is what the researcher means by risk in this thesis.

RISK IN CONSTRUCTION PROJECTS

Akintoye and Macleod (1997) described construction risk as "a variable in the construction project phase that results in uncertainty about the final expense, length, and quality of the project."

Construction is one of the most competitive, unpredictable, and demanding markets, both project-based and multi-organizational (Mills, 2001). Owing to the scope and novelty of construction projects, not only does the amount of risks present inevitably go beyond those seen in other sectors, but risks often vary from one construction project to another (Panthi et al., 2009).

Risk is an inherent occurrence in a sector that is as competitive as design, regardless of the scale of the project. It is subject to heightened risks due to distinctive building characteristics such as financial strength, complicated processes, long duration, harsh climate, and diverse organizational structures. Many other aspects affect the level of risk, including the business environment, the level of competition, the scale of the project, the political situation. Economic variation, the expertise of the parties (Flanagan and Norman, 1993; Akintoye and MacLeod, 1997; Smith, 2003) (PMI, 2004; Smith et al., 2006)

These risks are scattered over the whole life cycle of the project, and some of the risks may arise in more than one process. There are arguments about the amount of risk in the various phases of the construction process. Hayes et al. (1986) and Godfrey (1996) assume that the biggest danger occurs in the early phase of the project, where the information available on the project is the least. This is in accordance with those such as Chapman and Ward (1997) and Hassanein and Afify (2007), who have claimed that the risk is at its highest in the conceptual process. However, it is in comparison to Zou et al. (2006) who did so Find the construction phase to be riskier than the feasibility (conceptual) phase. Besides, other theorists assume that construction project risks escalate as the project continues, and this suggests that each phase of the construction project entails more risks than the previous phase (Wang et al, 2004).

However, the researcher considers that this depends very much on the type of project, the type of contract, and also the type of risks (risks that are being compared) that decide which phase will entail more risks (mainly because certain risks may occur at more than one stage). Otherwise, this is not something accurate and absolute to be measured, ranked, and then assigned to the various phases of the construction process for comparison.

Various organizations and scholars have categorized construction risks into various categories and hierarchies. Flanagan and Norman (1993) have suggested a broad classification of pure/static risks that apply only to possible losses with no potential gain and dynamic/speculative risks with potential gains and losses. Smith and Bohn (1999) found the internality and externality of the risk to the project regarding the benefits and costs associated with the risk for its classification. They also divided risk into two categories of internal and external risks; internal risks are produced inside the project and are more likely to be regulated, while external risks originate outside the project and are thus mostly uncontrollable. Looking at another grouping proposed by Smallman (1999), it can be seen that commonality can often be realized in classifications with separate names. Its classification includes two broad categories of direct risks, including individual, operational, and technical (HOT) and indirect risks, including regulatory, infrastructural, and political (RIP). Comparing the two current categories, it can be concluded that all direct and indirect definitions have parallels with internal and external definitions, all reflecting the degree to which risks are unique to the project.

Risk has also been commonly categorized as being situational or objective. Subjective risks are those evaluated on the basis of the expertise and understanding of the observer (qualitative), whereas analytical risks are evaluated by measuring their impact and probability (quantitative). Adams (2008) claims that the bulk of the project construction risks are hypothetical because there are not adequate historical records for their objective analysis and should be evaluated according to the judgment of the observer. Risks may be further subcategorized into smaller classes by their form and effects. Examples of this are vulnerability Wiguna and Scott (2006) are divided into four categories: economic and financial risks, external and site-related risks, technical and contractual risks and management risks; and PMI (2004) is classified into four categories: technical risks, internal risks, project risks and external risks (TOPE risks). As discussed earlier, correlations can be identified in the various classifications, such as technological threats or external risks posed in both recent cases.

Risks, irrespective of their type, should be handled to minimize or avoid harmful consequences and to find the potential to maximize the rewards realized from them as soon as possible. At the start of the project, all risks rest with the client but based on selecting the contracting method and the contract with the construction project; the risks may be passed to parties other than the client during the project

.

In the conventional contracting system, where the parties share responsibility for the different stages of the project, the aim is to coordinate the risks between the parties, whilst in the design and construction market, where the contractor assumes responsibility for both design and building, the bulk of the risks are imposed on the contractor. In contract management and construction management delivery schemes, the client assumes a substantial amount of risk, as the contractor often only has management experience (Oladinrin et al., 2013; Davis et al., 2008). However, the type of contract preferred for the project under each of the selected contracting schemes will also decide the risk ratio transferred to the people involved. In the fixed-price contract, because the contractor is responsible for the bulk of the activities, the risks are often passed to the contractor rather than to the client, while in the reimbursable contract, since the contractor is paid a percentage of the expense of the job, it is common for the contractor to attempt to increase the cost of the project in order to make a profit.

More benefits and hence the client deals with the majority of the risks (especially financial risks) in this contract. The contractor is responsible for the management of most of the phases of the project, and the client pays only the contractor, and the contractor is also responsible for handling the rest of the risks.

Partnership arrangements will, however, provide a balance of risk-sharing between the partners on the basis of the details of the arrangement (Avazkhah and Mohebbi, 2010).

It can also be seen that the extent of risk passed to the parties differs in the different mechanisms of contracting and contracts; but no matter which party is more responsible for the risks than others, the risks should be routinely handled. Risk assessment, which is a crucial aspect of project management, is addressed in the next section.

RISK MANAGEMENT

Owing to the project's particular design and the modifications or even issues that arise over its lifespan, there are inherent complexities and threats involved with the project. These risks are complex to address and make risk control an integral part of project management essential (Ward, 1999). The characteristics of construction projects, such as environmental reliance, transitory nature, and inter-sectoral nature, make risk management challenging but necessary in construction projects.

Hitting the goals of the project (Zou et al. 2007).

Project risk management is all about making decisions to enhance project efficiency and meet project goals (Loosemore et al., 2006). The much more difficult aspect of the risk management process is not seeking methods for detecting and handling risks but understanding that life is unpredictable and cannot be overlooked so that it is best understood.

Risk can be viewed as a factor of all decision-making processes (Skorupka, 2008). Risk management techniques and approaches are helpful in making the decision, but it is essentially the human being whose risk threshold (the level of risk he/she is prepared to tolerate/accept) differs who makes decisions, not tools. Any decision includes two components: a biased view/interpretation and empirical evidence about the possibility of a loss or loss of benefit due to a decision taken. The illusion of certainty can be believed to be a major cause of poor decisions, and thus, as far as possible, similar information should be obtained for any decision to be made (Flanagan and Norman 1993).

Related to the successful involvement of a project manager with the requisite experience, skills, knowledge and ability to handle a project; the involvement of a risk manager may be beneficial to managing the risks of a project because he / she has the unique capacity and expertise to manage the risks effectively. The broader and more complex the project, the more critical it is for the individuals who share the roles related to the different facets of the project.

Have the skills required; project-related risks are no different and need dedicated risk management to handle them. The unique term used for this role in project management manuals and guidelines is 'Risk Owner's Appointment; however, the common perception of people from the term 'Boss' as the person responsible for managing various fields has contributed to the usage of 'Risk Manager's Appointment for this role by most of the people who are responsible for managing various fields Participate in the management field. The Risk Owner as described in PRINCE2 (2009) is "a designated person who is responsible for handling, tracking and controlling all aspects of the specific risk entrusted to them, including the execution of chosen responses to fix or exploit opportunities." Thus, while the title is right, the title of the risk Owner is not the same.

For the person responsible for handling the risks, the expression 'risk owner' has been used in the questionnaires, and interviews of this study in order to eliminate any misunderstanding for the participants.

Uher (2003) described risk management as a "systematic way of looking at-risk areas and actively deciding how they can be handled. It is a management technique that helps to identify the causes of risk and uncertainty, assess their effect, and establish effective management responses.

The contingency plan can be viewed as a core element of this process. The Contingency Plan, as described by Gray and Larson (2008), is "a plan that protects future identified project threats that could materialize over the life of the project." The risk management process is divided as follows: risk classification, risk identification, risk analysis, and risk response, and risk response separation into avoidance, mitigation, preservation, and transfer (Berkeley et al., 1991; Flanagan and Norman, 1993). The risk management process can be divided into different processes, and risk response activities can vary from other individuals.

Risk management must be part of the Project Life Cycle (PLC) and continuing operations, as the project and the environment can differ over its duration. Chapman and Ward (1997) believe that risk management should really be deemed an add-on to the project management process as a whole, not an add-on. They argue that the risk management process can be discussed in all stages of the project life cycle, and the planning phase was perceived as the starting point for this process. This is in comparison to what was discussed earlier in this chapter regarding the risk and phases of the construction project. There is usually a feasibility process before planning and is known to be one of the risky stages of any construction project. The Risk Management Process (RMP) must then discuss all stages of the proposal, including the feasibility Phase, to handle the uncertainties involved with a new project about to launch. The feasibility phase is where a decision is made to launch a new project. Therefore, RMP's importance in this phase should never be overlooked since it could result in a decision not to be made in the event of a very risky project that leads to a disaster.

Hastak et al. (1994), Brown and Chong (2000), and Skorupka (2003); identified risk management as a set of techniques and actions to minimize disruptions that could occur during the life cycle of the project and ensure the achievement of the goals of the project. They believed that this phase's purpose was to define and analyze risks and then incorporate practical mitigation steps. Flanagan and Norman (1993) also referred to Risk management as a practice for dealing with the probability of detrimental consequences triggered by future events.

What has been clarified in the last two concepts of risk management suggested above indicates that the authors have only considered the adverse effects (threats) of the risk. The term "disturbances" applies to the presence of nothing but threats in the project that contribute to the execution of "mitigating" actions. The second concept also considers the probability of an "adverse" impact on possible issues. The Project Risk Analysis and Management (PRAM) Guide offered by the Association of Project Managers (APM) (2000) discusses how the risk management process is related between the level of the project and the organizational level and is described as "a process structured to eliminate or reduce risks that endanger the achievement of the goals of the project" (APM, 2000). Similarly, this guide has addressed only the negative part of the risk, which is not consistent with the PMI risk concept, taking into consideration both the positive and negative aspects of the risk. If the risk may result in either negative or positive consequences, risk control means managing all forms of impacts and not just negative ones.

In this study, the researcher adopts the concept suggested by PRINCE2 (2009), which refers to risk management as "the systematic application of procedures to the risk identification and assessment tasks, and then to the preparation and execution of risk responses."

Risk management, except for assistance in completing the project on schedule and under the budget, has seen more advantages for any project, such as:

- Allow the decision-making process to be less arbitrary and more comprehensive.
- Addressing the importance of risks, minimizing costs, and optimizing
- Opportunity.
- Improving understanding of the project by recognizing risks and caring about Actions to respond.
- Impact management by raising awareness of the future consequences of the project.
- Improve coordination

Such risk management recommendations are also provided by other associations for presenting structured risk management processes (considering all facets of risk) through organizations, such as the ISO 31000:2009 issued by the International Organization for Standardization. As specified in the ISO official website (2013), "ISO 31000:2009, Risk management – Guidelines and instructions, lays out concepts, frameworks and risk management processes." Other similar specifications come with this standard and offer more comprehensive information on the risk management process: ISO Guide 73:2009, offering definitions for risk management and ISO / IEC 3110:2009 Based on risk management strategies. One of the main improvements in ISO 31000 applies to the conceptualization of risk defined as "the impact of uncertainty on goals" and is no longer defined as a probability of failure and thus shows how this standard extends to both positive and negative possibilities. Subsequently, the risk management system covers universal concepts for defining, reviewing, and measuring opportunities and threats to apply acceptable risk responses. ISO 31000 has not been established for any single sector or community, but it initiates the risk management process for any activity dealing with risk management by developing a structure that includes the goals of the enterprise, its environment, and stakeholders, which helps to define the essence of the risks and to create risk management mechanisms in conjunction with the enterprise. This structured risk management process is widely adopted by Enterprise Risk Management (ERM) organizations.

ERM, as specified by the Committee of Sponsoring Organizations of the Treadway Commission (COSO) (2004), is a procedure, carried out by an agency of the Board of Directors, Management and other personnel, implemented in strategy settings and across the company, designed to recognize potential events that may impact an organization and mitigate risk to be within its risk appetite, to provide fair certainty as to whether or not an entity has a risk appetite. The mechanisms and elements used with both of these systems help mitigate risks associated with the objectives of the organization, depending on the risk appetite defined by the company and stakeholders. Therefore, the parties participating in any construction project must consider the degree of risk involved with each project they are about to conduct and decide whether or not it is appropriate for them to sustain the associated risks. For example, an analysis of the risk exposure of a specific project may be considered may Result in the inability of the contractor to take a decision at the feasibility point in the event that the contractor acknowledges that the uncertainties involved with the project are not below the appropriate degree of danger to be handled by the company, taking into consideration the accomplishment of the goals.

The risk assessment process should also be part of every construction project. This method cannot eliminate all (negative) risks from the project, but it allows the company to take the right risks and ensure that the risks are handled acceptably. It seeks to set up an organized framework to help decision-makers professionally handle risks. This argument should be emphasized that risk control is not a one-off task, and there should be ongoing risk management over the life cycle of the project (Mills, 2001). The risk management process division into more processes, and each process's details are argued in the following segment.

RISK MANAGEMENT PROCESS

Risk management is the discipline for coping with the probability that future incidents can have adverse consequences (Flanagan and Norman 1993). Globally, risk management is a process that, as applied, means that anything possible is achieved to meet the goal of the project, under the limits of the project (Clark, Pledger and Needler, 1990). The primary aim of project management is to realize the project within the projected timeline, the estimated costs, and the acceptable nature of the project. Contrarily to this, project execution is under conditions of instability, and the consequences of all expected activities cannot be forecast with confidence. That is what makes it possible to transform uncertainty into risk and to handle that risk.

Risk management is a continual process that can encompass all stages of the project (Smith, 1999). Risks and their impact on all main decision-making sites in the project, and all participants in the decision-making process should be studied. Through the life cycle of the project, it is essential to continually recognize causes that could have a negative impact on the project, evaluate their probable adverse effects, and formulate a solution to them. The investor and his project manager have the greatest responsibility for detecting, assessing, and reacting to threats. Project management should do whatever they can to carry out a project, perform practices that minimize or remove risk or uncertainty impact. Risk management is thus inseparable from project management and cannot be treated as a distinct practice.

The risk management process can contain more or less closely elements.It's linked. The risk management process, according to Perry and Hayes (1985), consists of three phases:

1- Risk identification.
2- Risk analysis.
3- Risk response.

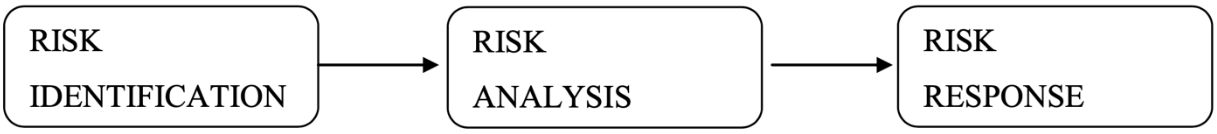


Figure 1 Linear risk management process, Perry and Hayes (1985)

As during the whole life cycle of the project, a qualitative or quantitative review is carried out for each identified danger, and an appropriate response is prepared. This style of the process is sequential in nature and a strong starting point for effective risk management.

However, any activities conducted as a risk solution could result in new risks, which, in turn, should be detected, evaluated, and tackled. Some scholars, therefore, see risk management as a cyclical process.

As per Carter et al. (1994), the risk management process consists of 6 steps that are cyclically repeated. (see fig 2)

Figure 2 Cyclical risk management process, Carter et al. (1994)

Kliem and Ludin (1997) had subdivided the risk management process into 4 phases

1. Risk identification.
2. Risk analysis.
3. Risk control.
4. Risk reporting.

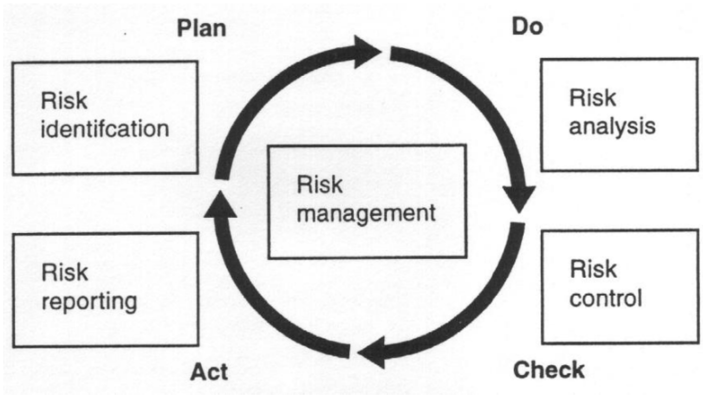


Figure 3 Cyclical risk management process, Kliem and Ludin (1997)

Instead, Baker, Ponniah and Smith (1998) divided the risk management process into 5 phases:

1. Risk identification.
2. Risk estimation.
3. Risk evaluation.
4. Risk response.
5. Risk monitoring.

Figure 4 Cyclical risk management process, Baker, Ponniah and Smith (1998)

It is suggested by Chapman (1997) that the generic risk management process divided in 9 phases:

1- Define.
2- Focus.
3- Identify.
4- Structure.
5- Ownership.
6- Estimate.
7- Evaluate.
8- Plan.
9- Manage.

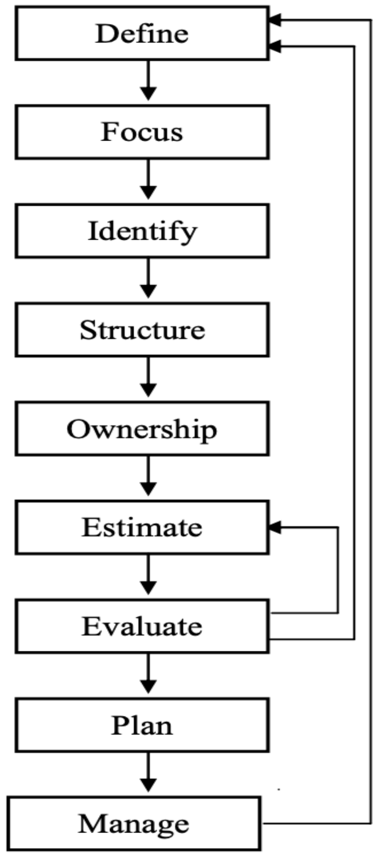


Figure 5 Generic risk management process, Chapman (1997)

Grammer and Trollope (1993) had realized the cyclical risk management process divided in 5 phases:

1. Identify risks.
2. Analyse risks.
3. Reduce risks.
4. Plan against and manage risks.

5. Review risks.

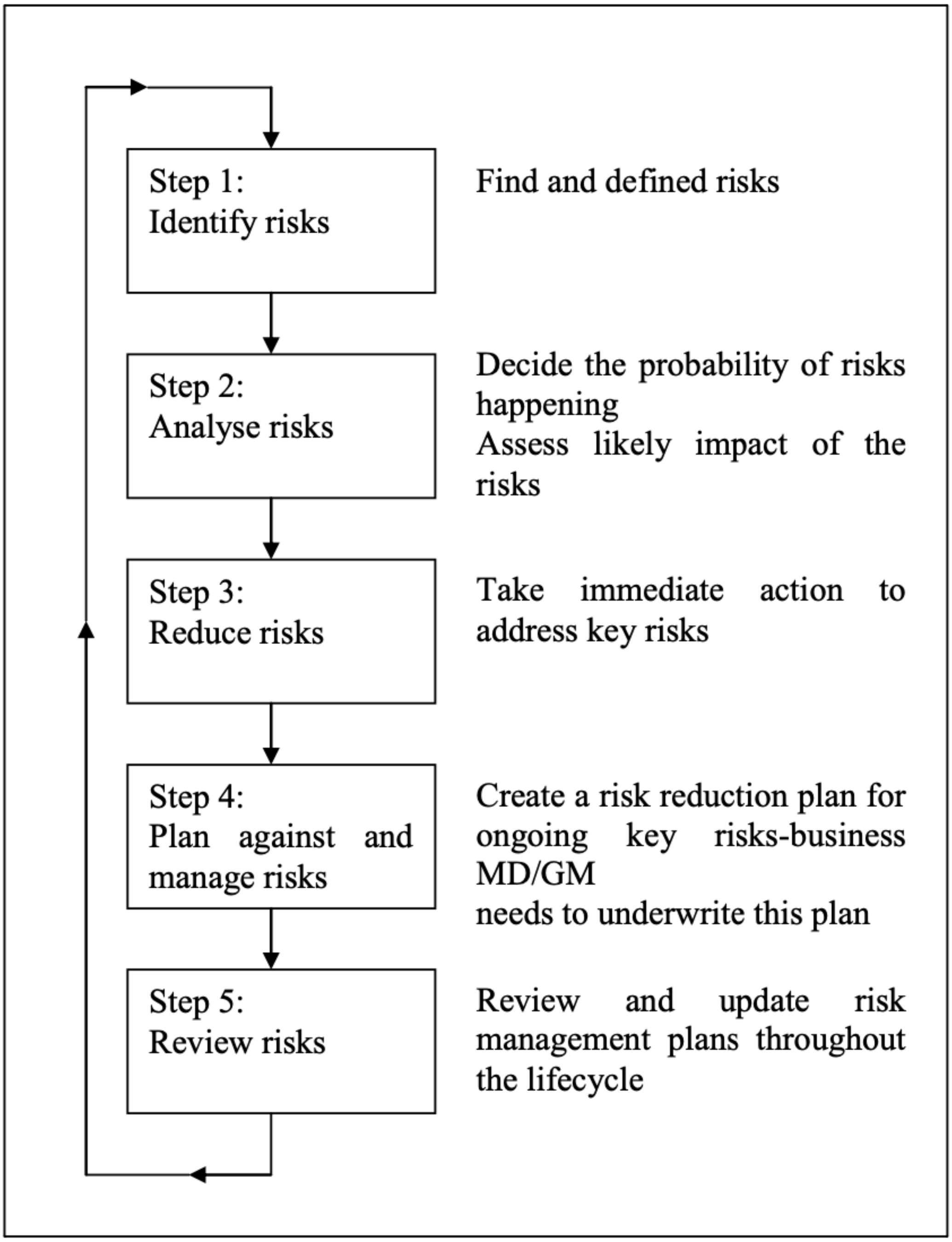


Figure 6 Cyclical risk management process, Grammer and Trollope (1993)

The continuation would carry out in depth all the aspects of the cyclical risk management mechanism proposed in this work, which served as the basis for the proposed risk management system during the life cycle of the project.

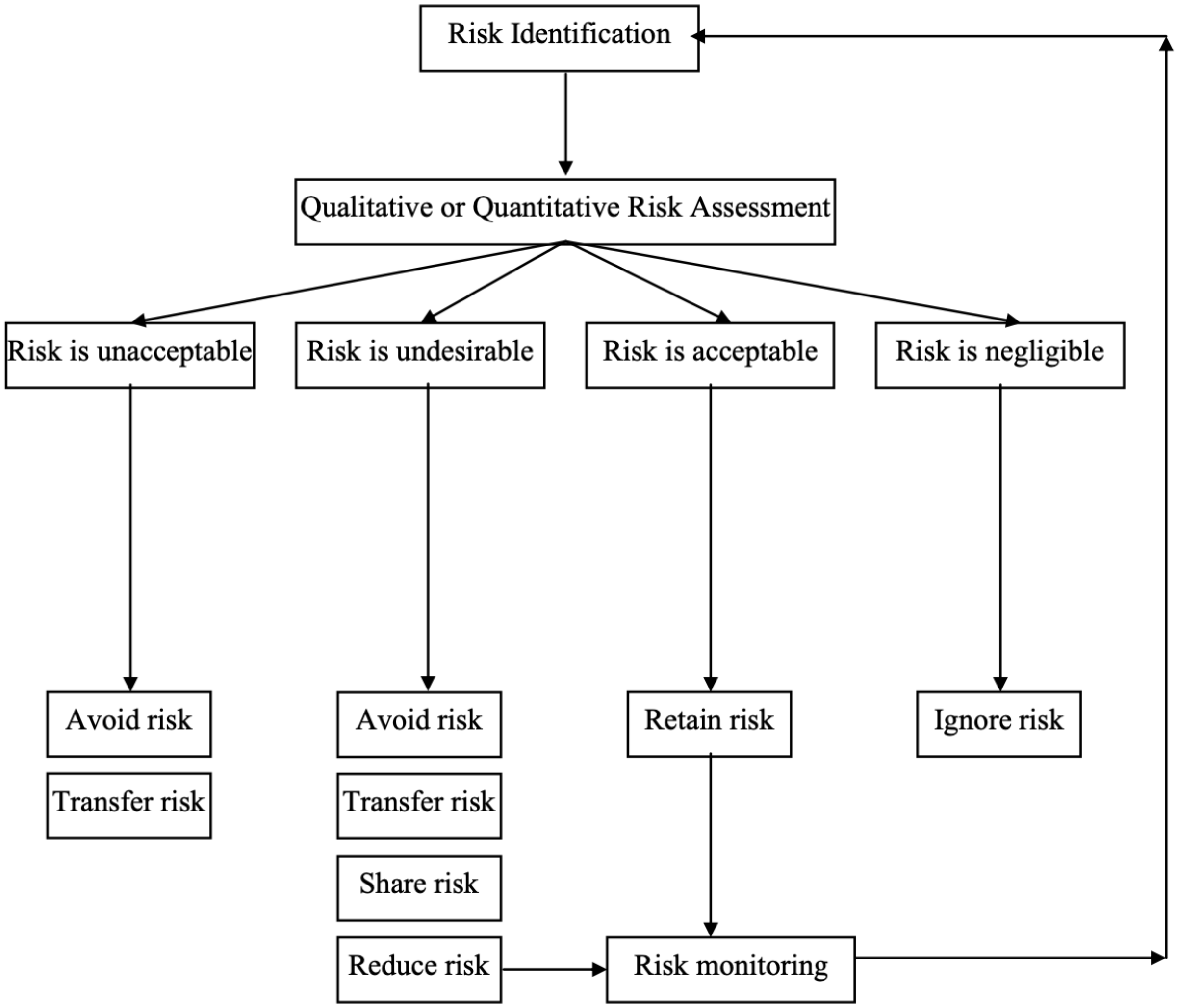


Figure 7 Proposed cyclical risk management process

The proposed cyclical risk management process contains the same elements as the published risk management processes shown and adapted to computer programming. The process begins by risk identification, followed by qualitative or quantitative assessment of risk probability and risk impact, and calculation of the corresponding risk exposure. Depending on the value of risk exposure, a decision is made about risk acceptability, which serves as the basis for one of the risk response methods. The application of risk response is followed by risk monitoring, and if new risks appear, the process returns to the beginning, that is, to their identification.

PMI (2016) grouped RM phases into RM planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response formation, and risk monitoring and control. However, during the RM's planning phases, a comprehensive plan is drawn up by the project management for how to handle the RM operations during the project. The key goal is to notify all stakeholders of the risks involved and to build consensus for and adherence to a specific RM strategy. This preparation phase is significant to the completion of the project and, if planning is undertaken thoroughly and includes the appropriate fields, there is less risk of a failure of the project. These procedures must be begun before the project planning is finalized and completed before the start of the project.

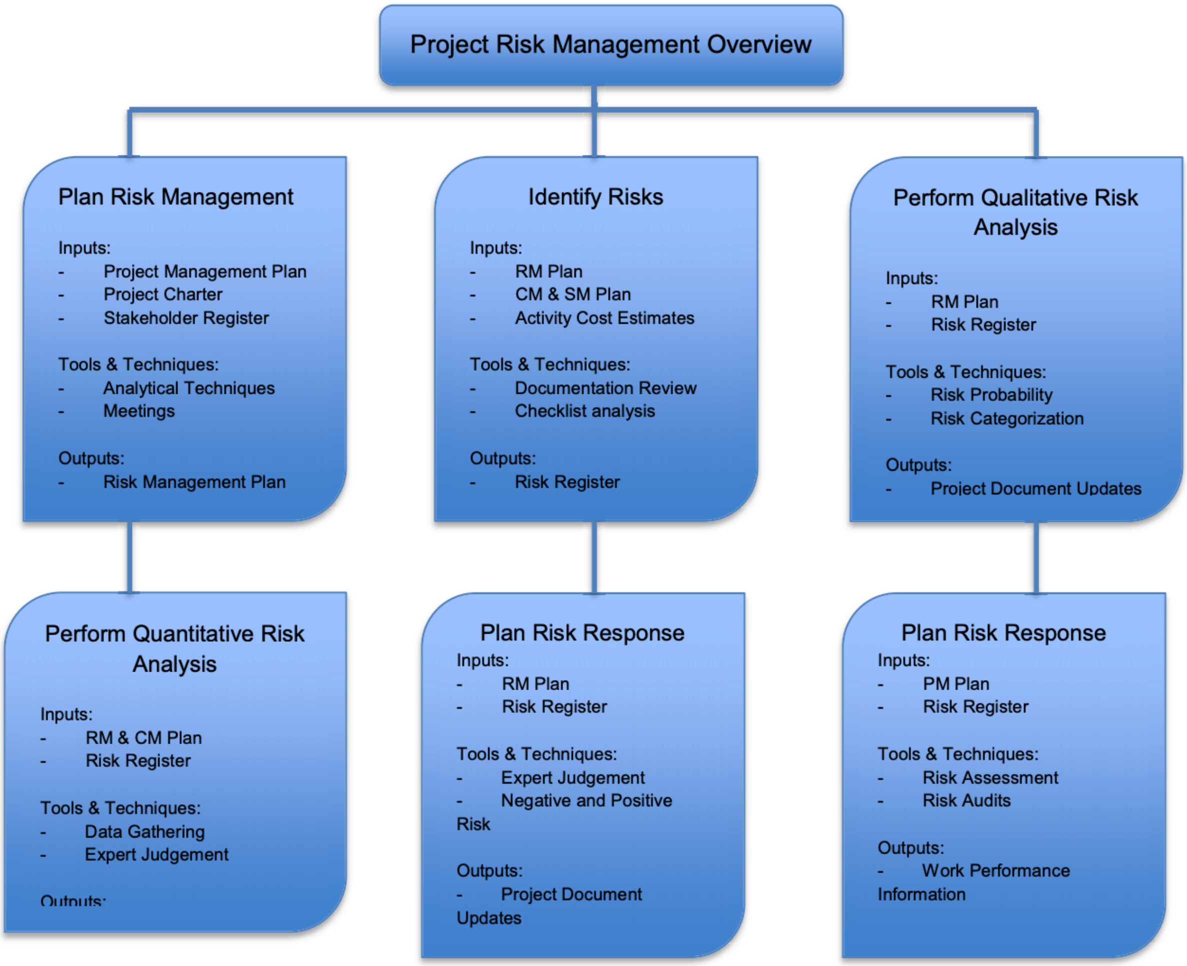


Figure 8 Project risk management steps (Adapted from: PMI, 2016)

RISK MANAGEMENT PLANNING

1- Plans are nothing; planning is all. Napoleon Bonaparte The planning process determines how the risk management system should be applied and implemented by sub-processes. Without planning supervisors, they don't know precisely what to do, what and how to do. This method trains the organization for risk management, such as the formulation of strategies, the assessment of the measures to be followed and their order, any resources that may be needed, how long it may take, who is responsible for particular processes and may also provide instruction and courses to improve the expertise of risk management skills (PMI, 2016).

RISK IDENTIFICATION

Risk management often begins with risk identification, which can be perceived to be the most critical step of the risk management process (Baker, Ponniah, and Smith, 1998). Its goal is to compile a list of risks that are relevant to a specific project. In order to fill up this list, it is first essential to examine the possible causes of risk, the adverse events that require risk, and the adverse effects of the unfavorable scenario. For example, the weather is a source of risk, exceptionally bad weather is an adverse occurrence, and due to terrible weather conditions, the impact is operating behind schedule. Risk detection depends heavily on the expertise of the manager. If his familiarity with specific risk identification tools and approaches is strong, he will continue to use them, while poor practice contributes to the prevention of earlier approaches. Managers use numerous risk assessment methods, the best known of which are: brainstorming, assessments, questionnaires, Delphi technique, expert systems, etc

INTERVIEWS

The interview is a method in which the respondent prepares questions and addresses the topics involved (Carter et al. 1994). The interview aims to register the responses to the questions and then use them as a basis for analysis. Questions can be unstructured, openly formulated, encouraging the participant to respond to them; however, he wishes. Structured questions ask for a yes or no response from the respondent or for him to consider one of the many alternatives offered. The project or risk manager, who frames the questions and performs the interview, must have a great deal of expertise and experience, primarily in implementing and formulating questions, but also in conducting interviews. There are two styles of the interview: one to one and many to one. A one-to-one interview allows for greater detail in the detection of each danger, whereas a few-to-one interview makes it easier to address the information of the respondent from many perspectives.

This approach is very time-intensive since the outcomes of the interview can be systematized and evaluated.

QUESTIONNAIRES

Questionnaires are probably the quickest and most efficient way to learn all project team stakeholders' viewpoints and evaluate and compare these viewpoints (Godfrey, 1996). Questions can be formal or unstructured. The most significant disadvantage to this approach is that it does not stimulate imaginative thought. The consistency of the question depends on the person who collected the questionnaire, but unlike the case of the interview, the respondents are unable to discuss their responses or provide any facts beyond the questions.

BRAINSTORMING

Brainstorming is a meaningful and interactive dialogue in which participants explore their perspectives on possible causes of danger in the project, how uncertainty is represented and how to turn it into risk, risk probability, potential risk effects, and possible risk response (Smith, 1999). The project or risk manager chairs typically the session, and progress relies mostly on his expertise in holding such discussions. This approach is reliable and also results in a very detailed list of risks. The participation of a very oppressive and hierarchical personality that controls others and imposes its status can be a concern. The number of participants is also essential because conversations with a large number of participants are becoming inefficient and long-lasting.

DELPHI TECHNIQUE

Delphi is an attempt to derive empirical conclusions from a subjective conversation (Powel, 1996). The risk manager would begin by passing out a questionnaire to all project team members who will answer the questions and give back the questionnaire to the risk manager. The risk manager then gives out the answers to all team members who use them to revisit their strategy, provide new answers to the same questions, and return them to the risk manager. The updated findings are again circulated to the team members, who are again asked to rethink their views and provide new responses. This iterative process continues until the risk manager has agreed that a consensus has been achieved and that it is no longer necessary to discuss all the team members' roles. This approach's biggest drawback is that the project team members are autonomous, and there is no predominance of "strong personalities." The downside is that a vast number of iterations are required.

QUALITATIVE RISK ASSESSMENT

Moreover, once significant risks are already identified, and the risk list collected, a qualitative risk evaluation must be carried out and reported in a document called the risk register (Patterson I Neailey, 2002). The first step in setting up a risk register is a short explanation of each unique risk, which should be explicit and unambiguous to prevent confounding risks. As mentioned, the risks should be classified according to their source. The definitions should include as many points of risk as possible. One such categorization was introduced by Hillson David (2009):

RBS LEVEL 0	RBS LEVEL 1	RBS LEVEL 2	
0. ALL RISKS	1. TECHNICAL RISK	1.1	Scope definition
		1.2	Requirements definition
		1.3	Estimates, assumptions & constraints
		1.4	Technical processes
		1.5	Technology
		1.6	Technical interfaces
		1.7	Design
		1.8	Performance
		1.9	Reliability & maintainability
		1.10	Safety
		1.11	Security
		1.12	Test & acceptance
	2. MANAGEMENT RISK	2.1	Project management
		2.2	Programme/portfolio management
		2.3	Operations management
		2.4	Organisation
		2.5	Resourcing
		2.6	Communication
		2.7	Information
		2.8	Health, Safety & Environmental (HS&E)
		2.9	Quality
		2.10	Reputation
	3. COMMERCIAL RISK	3.1	Contractual terms & conditions
		3.2	Internal procurement
		3.3	Suppliers & vendors
		3.4	Subcontracts
		3.5	Client/customer stability
		3.6	Partnerships & joint ventures
	4. EXTERNAL RISK	4.1	Legislation
		4.2	Exchange rates
		4.3	Site/facilities
		4.4	Environmental/weather
		4.5	Competition
		4.6	Regulatory
		4.7	Political
		4.8	Country
		4.9	Social/demographic
		4.10	Pressure groups
		4.11	Force majeure

Figure 9 Risk breakdown structure (risk sources) by hillson, david, M. r. p. (2009)

After the sources have been identified, it is essential to decide, with each risk, the adverse event that will cause the risk. This is particularly important for the subsequent development of a risk response. Risks are also interlinked and should also be described. For example, an operation conducted as a risk response can give rise to a different risk. At this stage of risk management, it is necessary to allocate the person or team responsible for each identified risk.

The risk list can be assembled according to the priority and based on the risk acceptability, the strategy of response specified after assessing the likelihood and effect of each risk and, thus, its exposure.

Once the threats have been qualitatively evaluated, and action taken to respond to them is tracked, and new risks are likely to be found as a result of the risk response. Since new risks need to be handled in the same way as the original risks, risk management becomes a cyclical operation.

QUANTITATIVE RISK ANALYSIS

Risks are quantitatively evaluated whether it is possible to measure the probability of an event based on relevant information on comparable historical events or information gathered in some manner or on the basis of personal experience.Many techniques of quantitative risk analysis are widely in use. The famous example is simple assessment, probabilistic analysis, sensitivity analysis, decision-making trees, and Monte Carlo Simulation (Evans and Olson, 1998; Baker, Ponniah and Smith, 1998; Vose, 2000).

SIMPLE ASSESSMENT

This is a reasonably straightforward arithmetic approach that discusses major risks independently and explores the possible overall impact (Powell, 1996). The assessment is based on the calculation of the potential effect of each major risk. The impacts are then integrated, and the sum impact is used as the basis for the contingency plan. This technique is adequate for small and basic projects.

PROBABILISTIC ANALYSIS

This is a mathematical approach that allows the measurement of exposure for each individual risk or for the project as a whole (Powell, 1996). First, optimistic, most likely, and pessimistic cost and time estimates are assigned for each event. E.g., an optimistic estimation of the price for constructing a block of flats could be 500 / m, the most probable cost of construction is 750 / m, and a pessimistic estimation of the price is 1000 / m. Then, the likelihood for each assessment is subjectively established. E.g., let the likelihood for the optimistic assessment be 0.3, the likelihood for the most likely assessment 0.6, and the probability for the negative assessment 0.1. the sum of all probabilities must be equal to 1. Multiplying the projected construction costs with the associated probabilities and adding up the products gives rise to exposure, i.e., the predicted value (EV). In the case above, EV = 500 * 0.3 +750 * 0.6 + 1000 * 0.1 = 700 / m. The EV ranges from the optimistic assessment by a value of 200 / m, from the most likely assessment by a value of 50 / m, and the pessimistic assessment by a value of 350 / m. This indicates that the pessimistic assessment is the most possible scenario, which is the contingency plan's foundation. Probabilistic analysis is easy to use and very understandable, but contextual judgment makes it based on the expertise and understanding of the risk analyst who makes it.

SENSITIVITY ANALYSIS

The sensitivity analysis indicates each individual risk's effect, i.e., the undesired effect of the incident on the project (Flanagan and Norman, 1993). The parameters that affect the exposure value are varied, and the impact of their modifications on the outcome is followed. The percentage of change in the parameter divided by the percentage of change in the outcome caused by the change in the parameter is called the sensitivity factor. The sensitivity factor is not of great concern if the effect of a single parameter is investigated. It has to do with expression when comparing the sensitivity factors of many parameters influencing the outcome. This method helps find the parameter that most influences the final risk exposure, but it does not demonstrate the likelihood that the parameters will change within the sensitivity analysis context.

DECISION TREES

Decisions are taken, where there are many options (Godfrey, 1996). If each alternative has sub-alternatives and each sub-alternative sub-sub-alternative, it forms a tree structure that displays all possible decision-making routes. If the impact of each alternative on the tree may be measured and its probability measured, either subjectively or in some other manner, this will result in exposure, i.e., in the Expected Value (EV), determine the risk level of each alternative.

MONTE CARLO SIMULATION

Monte Carlo Simulation is a method of mathematical simulation (Wall, 1997). Each parameter that affects a specific risk exposure is viewed as a random variable with the corresponding value rank and probability distribution function. The distribution function is calculated from the current datasets or assessed based on experience. One value of each parameter is selected randomly, and the distribution function calculates its probability. The values of the selected parameters and the corresponding probabilities are used to determine the corresponding exposure. This random selection process is replicated from 100 to 1,000 times, where the exposure is still a random variable. It is now possible to quantify the Potential Value, the highest possible risk, the likelihood of exposure to assume a value within a given range, etc. Despite the vast number of measurements, this approach involves the use of a computer.

RISK MANAGEMENT SOFTWARE TOOLS

While risk management is a human-centered method, in order to optimize planning and avoid replication of procedures, particularly in complicated and large programs, it is better to pursue similar risk management tools. If the project is programmed and directed from the start by current software, it is easy to monitor the success of the projects and the strengths and limitations of the project that can be tracked and defined in the software. The next ventures will be as successful as possible. Falling down the error and producing a special project template. The most important commodity is human-processed risk management, thoughts, and information, but human tracking, maintenance, and control are time-consuming and often difficult it must first be understood what needs to be achieved in terms of project management and risk management. Then, according to these observations, we use risk control or project management tools. Some of the risk management software available are as follows:

- Orcanos ALM 2.0
- Purpose-built (Essential ERM)
- RiskyProject (INTAVER)

RISKYPROJECT

RiskyProject is an innovative risk assessment software for automated risk analysis. Most projects have several unknown parameters: length of assignments, start-up and completion dates, cost and resource uncertainties, efficiency uncertainties, protection, infrastructure, and others. RiskyProject analyzes project timelines for threats and uncertainty, measures the likelihood for tasks to be finished within a specified period and budget, ranks risks, and delivers findings in ways that are easy to read and understand. (RiskyProject Professional User Guide 2019).

RiskyProject also helps you to perform project risk management:

- Identify project risks
- Rank risks

- Identify mitigation and response plans
- Manage risk properties, including descriptions, probabilities and impacts, costs associated with risks, mitigation strategies, and all other information about risks
- Facilitate risk reviews, opening, and closing risks, conversion of risks to issues and lessons learned
- Save risk history. (RiskyProject Professional User Guide 2019)

RiskyProject conducts qualitative and quantitative risk assessments. When both the risk register and the project plan are filled, RiskyProject conducts a computational risk analysis. If there are no project details (cost or schedule), RiskyProject performs a qualitative risk analysis. RiskyProject combines easily with the Microsoft project or can operate as a standalone program. RiskyProject combines with other project management applications, such as spring oracle. RiskyProject uses event chain methods to evaluate project uncertainties identified by several threats (events). An example of an event would be a delay in the mission due to changes in requirements. In several cases, one event can trigger another incident or several incidents, which can have a major effect on the project timeline. RiskyProject recalculates the project timeline at multiple intervals to measure the distribution of potential results and the probability of reaching specific objectives. These facilities may display differences in managing risks manually or by using the software.

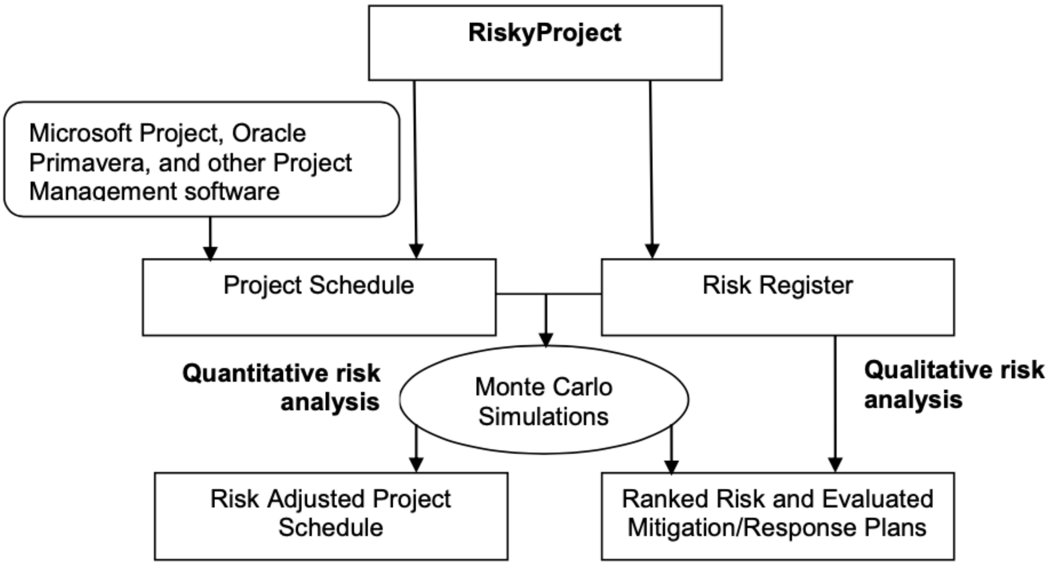


Figure 10 How the RiskyProject software works (from RiskyProject Professional User Guide 2019)

RiskyProject executes two main functions:

- Risk management: identification, documenting, ranking and review of risks, prevention and response strategies, and all related risk information.
- Risk analysis: to decide how risks could impact your project.

RiskyProject is useful for managers who want to conduct risk analysis on their projects without advanced experience or training in risk analysis. RiskyProject allows managers to easily evaluate diverse project plans and related costs, with various projects and dependencies. It is a user-friendly framework with an elegant gui that masks advanced statistical equations and lets managers make smart decisions. (from RiskyProject Professional User Guide 2019)

RISK RESPONSE

Based on the degree of risk exposure, each defined risk is classified as unacceptable, undesirable, acceptable, or negligible. This grouping influences the judgment about how to respond to it (Baker, Ponniah and Smith, 1999). If a risk is classified as unacceptable, a risk-avoidance or risk-transfer solution may be needed. If the risk is classified as undesirable, risk prevention, risk transfer, risk reduction, or risk-sharing with adequate risk monitoring may be adequate. If the risk is classified as acceptable, the risk retention with adequate risk control can be deemed acceptable. If the risk is classified as negligible, no response is required.

RISK AVOIDANCE

In reality, risk avoidance is a reluctance to accept risk whatsoever (Flanagan and Norman, 1993). The qualitative assessment showed such high-risk exposure that the risk should clearly be removed. Research is required to remove the risk if the possible cause of risk may be avoided, the adverse case in which the risk is inherent. The most dramatic way to escape risk is not to sign a deal to give up the project. Risks may also be avoided by adding a binding provision whereby such risks, i.e., their effects, are not acknowledged.

RISK TRANSFER

This response implies the transition of risk to every other party in the project except to an investor by a contract (Carter et al. 1994). The investor can pass the risk to the contractor or the architect, the contractor to the subcontractor or the investor, the contractor or the subcontractor to the insurance provider, and the contractor and the subcontractor to guarantee the risk. When choosing a risk transfer approach by contracting, an account should always be taken in which project partner is ideally able to monitor incidents that can contribute to the presence of the risk. It should be taken into consideration which participant will better manage the risk if it happens or presume a risk that cannot be managed.

RISK SHARING

If a project team member cannot control risk exposure, it can share it with other participants (Barnes, 1991). Part of the risk can be moved, but part of the risk response can be inferred, and one of the risk solutions added.

RISK RETENTION

If the project member estimates that the risk likelihood is minimal or that its effect is appropriate, the risk will be kept, and no response will be given (Powell, 1996). This does not mean that the risk is ignored; it is regulated and monitored, and the exposure is continuously monitored.

RISK REDUCTION/MITIGATION

Most risks do not need to be avoided or shifted, they do not need to be discussed with other project partners, or they actually need to be maintained and not handled (Baker, Ponniah and Smith, 1999). Specific steps may be taken to reduce the risk exposure, that is, to reduce the possibility of an event having adverse consequences or to reduce the impact of those consequences on the project. Risk mitigation requires some initial investment. This investment should be less than the costs of the adverse case. For example, tunnel excavation in the low rock mass is subject to a risk of loss of rock mass stability due to insufficient substructure or water penetration. Additional analysis is an expense, but it dramatically eliminates these risks. If caving happens, the cost of further testing may be lower than the cost of reconstruction. Risk avoidance also offers new awareness of the project and the circumstances under which it is being carried out.

METHODOLOGY

This chapter describes how risk management has been applied to a construction project. A case study has been chosen to apply risk management to it. Firstly, it started by describing the case and then lists all steps taken to achieve the result.

CASE STUDY

RECCHI-ENGINEERING was assigned to provide its services as a consultant (agency construction manager) to the owner in a fixed-priced construction project to ensure the general contractor delivers the project on time and up to the required quality.

The project is a construction of two residential buildings in Milan.

During the construction phase, RECCHI-ENGINEERING wanted to find a way to predict upcoming activities' delays and provide recommendations to the owner and general contractor to monitor the project performance better and ensure the project will be delivered on time. For this reason, risk Management was suggested and was applied at that phase, as these are the steps to risk management in practice:

- Risk management plan.
- Risk identification.
- Qualitative risk assessment.
- Semi-Quantitative risk assessment
- Cross Risk breakdown matrix.
- Setup RiskyProject professional/ Monte Carlo simulation and Sensitivity Analysis.
- Response plan

DELIVERY SYSTEM OF THE PROJECT

The delivery system was agency construction management, where RECCHI-ENGINEERING was responsible as a construction management agency as an owner technical advisor to ensure work is delivered at quality and on time and keep tracking of project performance, they communicate with general contractor informally or formally through the owner. Contract with the general contractor was a fixed-price contract, which means the general contractor take the risk.

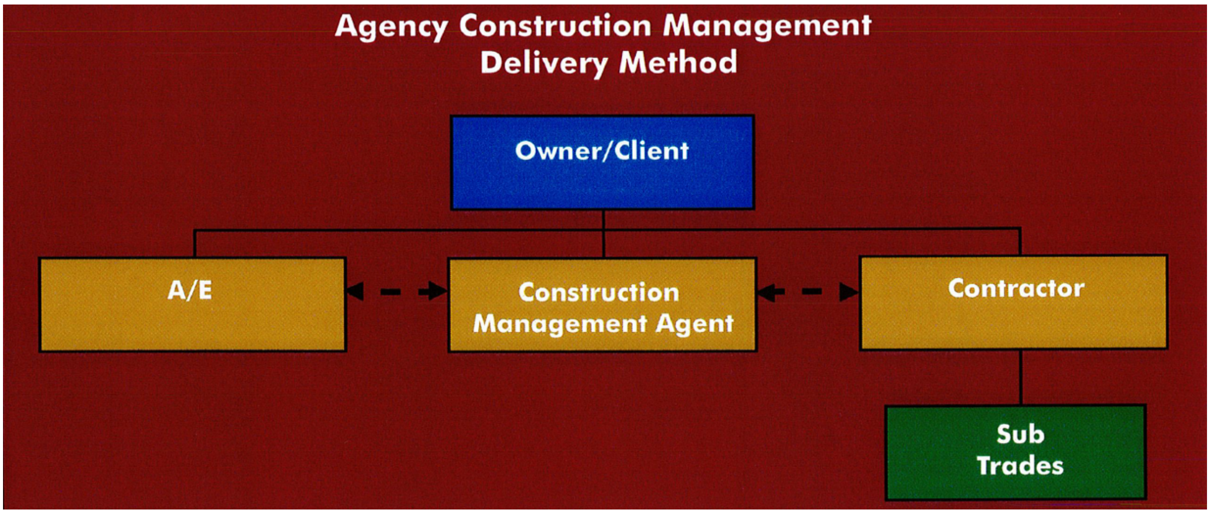


Figure 11 project delivery method. adopted from Best Construction Software Guide 2017

RISK MANAGEMENT PLAN

to prepare the risk management plan, meetings and interviews have been held with experts and key stakeholders. Data was also collected from the contract to define the following:

1- **project description:** There is a full description of the project where main stakeholders are introduced, and the main objective of the project is defined.

2- **contract type and the main objectives of RECCHI in this project**: from data collected, it is a fixed price contract. The primary responsibilities of RECCHI-ENGINEERING are to ensure the General contractor follows the guidelines of schedule and quality.

3- **objectives, the scope of the risk management:**
There is no risk without objective since the risk is the uncertain event that if it occurs, it will affect our objective either positively or negatively, so this is a crucial step in the risk management plan.

- The objective of risk analysis is the schedule, so any event that may delay the project tasks may be considered risk .so all risks would be considered upon that objective.
- Scope: The scope of risk analysis is the scope of the project, where stakeholders are the client, general contractor, RECCHI-ENGINEERING, and the design firm.

4- **setting tools and techniques**: tools used in each step in the process: starting from risk identification to qualitative risk assessment to risk response plan, all tools and techniques that would be used are briefly defined as follows:

- For Risk identification: checklists, Delphi technique, interviews, and brainstorming would be used as tools.

- For risk assessment, qualitative and semi-quantitative would be applied as the result of semi-quantitative would be an input for the risk breakdown structure matrix.
- For quantitative analysis, Monte Carlo simulation would be applied using RiskyProject professional software, which would result in the sensitivity analysis.

5- Setting the project-specific definitions of probability and impact(risk matrix):

this is an essential step as thresholds are being defined. Where meetings with different stakeholders were taken place to understand the owner tolerance. For example, according to the owner the impact of being delayed over 8 weeks is considered very high, on the other side probability ranging from 70% to 99% is considered as very high as well. both probabilities and impact on time were given rank which ranges as VERY LOW (VLO) , LOW (LO), MEDIUM (MED), HIGH(HI), VERY HIGH(VH) , which would be used in qualitative risk assessment later on. Again, probability and impact have been given an index from 1 to 5 to be used later on semi-quantitative risk assessment. The definition of probability and impact varies from one project to another, but for this for example any impact or probability is ranked as HIGH it means it has an index of 4 and vice versa. The below table describes only the two components of risk which are impact and probability separately. To have a risk matrix the two components must be multiplied. As Risk=probability x impact.

probability and impace matrix			
RANK	PROBABILITY	INDEX	impact on time
VHI	70-99%	5	>8 weeks
HI	50-70%	4	6-8 weeks
MED	30-50%	3	4-6 weeks
LO	10-30%	2	2-4 weels
VLO	0-10%	1	<2 weeks

Figure 12 probability and impact matrix

The figure below illustrate the risk matrix:

		IMPACT				
probability		VLO	LO	MED	HI	VHI
%	Risk index	1	2	3	4	5
70%-99	5	5	10	15	20	25
50%-70	4	4	8	12	16	20
30%-50	3	3	6	9	12	15
10%-30	2	2	4	6	8	10
0%-10%	1	1	2	3	4	5

Figure 13 Risk Matrix

6- setting the risk breakdown structure:

setting the risk breakdown structure (RBS)has been driven from the work breakdown structure (WBS). The same concept of building the WBS was applied to risk sources to get the RBS. It would be useful later on to act as a prompt list when risks are being identified and to know which activities in the project are associated with most significant risk. Below is general RBS example:

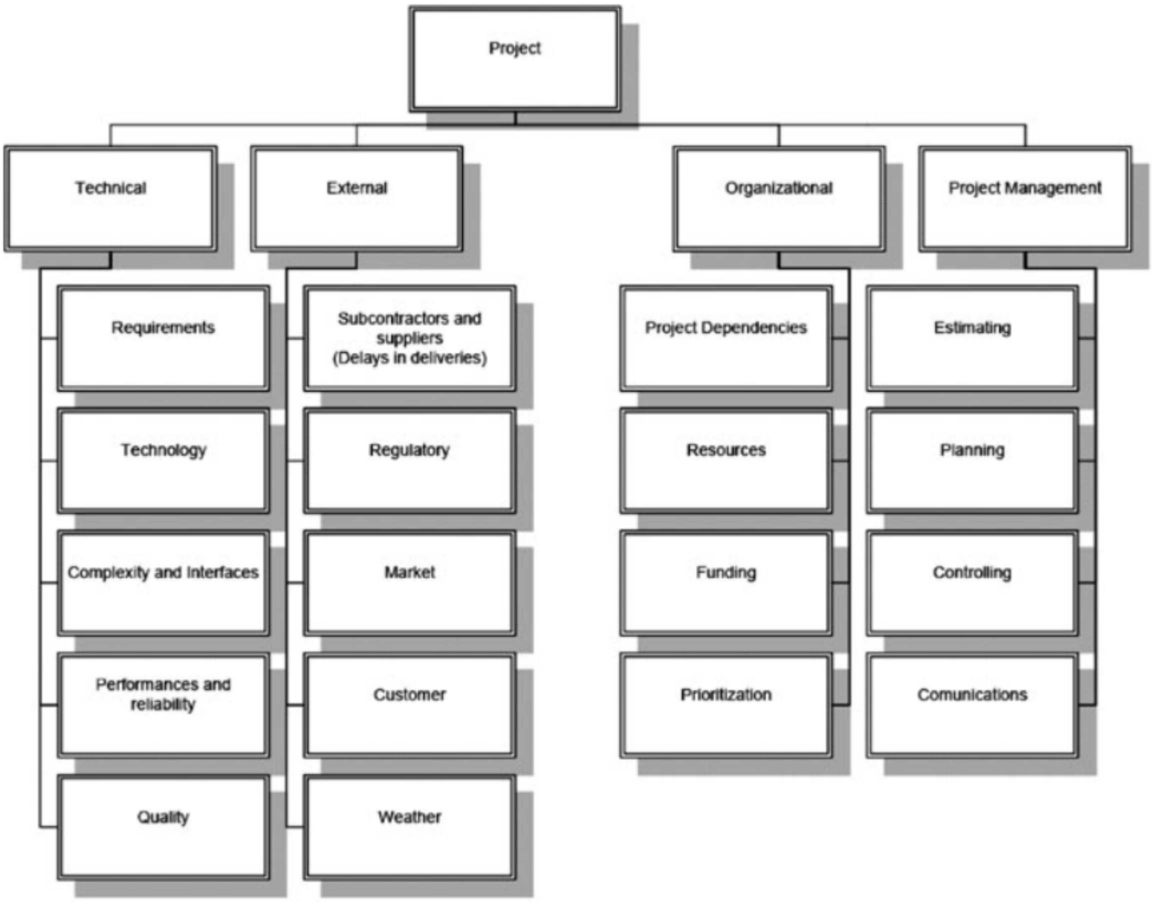


Figure 14 Example of a risk breakdown structure for a construction project. adopted from De Marco 2011, "Project Management for facility constructions"

By the end of the Risk management plan, all the main aspects of the risk management process had been pre-defined, and it is possible to proceed to the next step, which is risk identification.

RISK IDENTIFICATION

since it is not possible to manage risks without identifying them, risk identification is the most important step in the process. Everything from here on would depend on the output of this step. In the case study, there were more than 2000 tasks. To identify risks for each of them seemed impractical.so, a higher level of WBS has been taken into consideration, so the number of tasks had been reduced to 36 summary tasks, and risks have been identified, taking advantage of the fact that the construction project's tasks are repetitive. A mix of Different techniques have been used, which are:

- structured brainstorming workshops.
- Interviews with experts and key stakeholders.
- Delphi technique.
- Checklists.

The RBS has been used as a framework in the risk identification process. Whichsoever technique was used, Risk Meta Language was used as a description for risks to separate between causes(facts), risks (uncertain events), and effects (effects on objectives).

All identified risk is imported into the risk register. This step's outcome is a list of risks, an input to the qualitative risk assessment step.

Interviews:

Interviews have been held with project key participants and experts to have a general idea of risk sources and extract as many possible risks. Relatively it was about taking into consideration the current situation and identify problems which might be sources for upcoming unlikely events.

BRAINSTORMING SESSIONS

Many experts conflict between risks and risks, their sources, and their effects, as they consider them all as risks, which is not true and makes a huge difference; for that reason, before starting a brainstorming session, a presentation had been done to explain these concepts clearly. Brainstorming helped in generating the most unpredictable risks and their sources as wells. Relatively it was about generating future and unpredictable risks.

CHECKLISTS

Since RECCHI-ENGINEERING has never applied risk management in a structured way before, there was no risk register to take as a checklist, so generic checklists with all possible risks in the construction project industry has been taken into consideration to see all the common risks that might occur regardless of the type of the project. Relatively it was about learning lessons from the past.

DELPHI TECHNIQUE

1- After implementing the risk breakdown structure in which primary sources of risks were defined.

2- A questionnaire was made trying to explore all possible risks considering different sources that were previously defined in the RBS.

3- Different responses were gathered.

4- A meeting with experts/stakeholders had taken place to discuss different responses.

5- list of risks was sent to all experts/stakeholders.

6- A final meeting was held to discuss and finalize all identified risks

QUALITATIVE RISK ASSESSMENT

risk identification has produced a list of risks, but not all risks are the same or should not receive the same attention due to limited time and resources. Since risk=probability(P) x impact(I). Each risk assigned to each activity has been assessed by evaluating their probability and impact.

probability and impact values:

P: very high, high, medium, low, very low

I: very high, high, medium, low, very low

Several meetings were held to develop these evaluations, and different experts were involved in this step.

SEMI-QUANTITATIVE RISK ASSESSMENT:

this step is very similar to qualitative risk assessment, but the descriptive levels are classified numerically. the table of risk matrix in risk management plan explains.

CROSS RISK BREAKDOWN MATRIX:

In this step, WBS and RBS are linked into one matrix, risks identified are imported in this matrix, and their semi-quantitative assessment, where every risk at a given cell has a score, and each work package (WP) has a score as well. Figure below explains

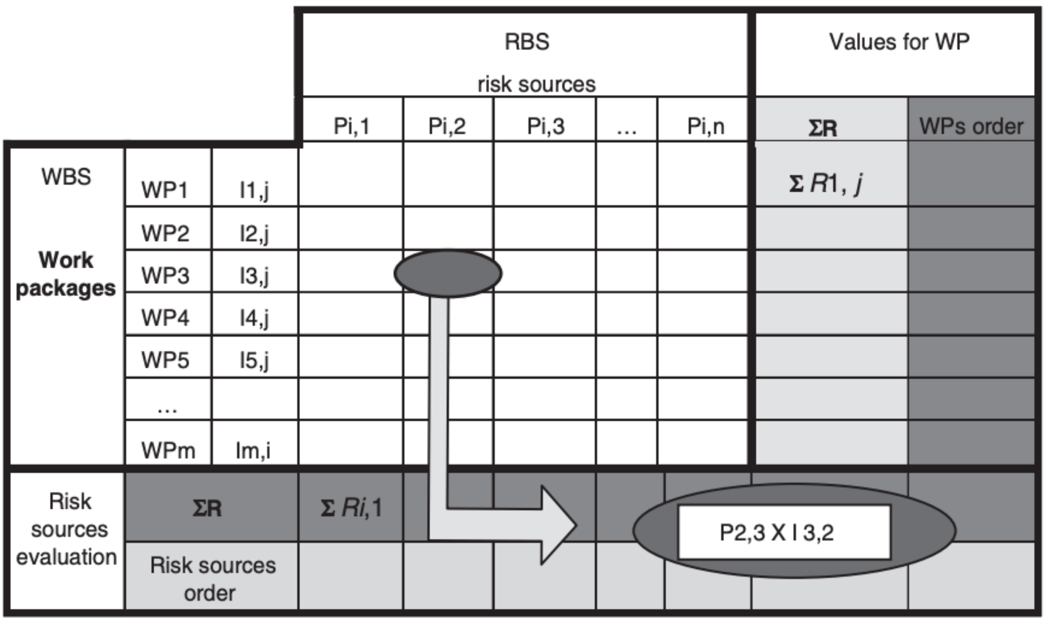


Figure 15 Risk Breakdown Matrix (RBM) with sample evaluation., Hillson, 2005," Managing Project Risks Using a Cross Risk Breakdown Matrix"

Considering risks for every WP, an evaluation of the criticality of each WP can be obtained by:

$$R_{WP,\ i} = \sum_{j=1}^{n} P_{i,\,j} * M_{i,\,j}$$

where M= impact, P= probability, Rwb= risk of work package.

A similar approach can be used to analyze risk resources by considering each column separately by:

$$R_{ris,\,i} = \sum_{i=1}^{m} P_{i,\,j} * M_{i,\,j}$$

where Ris=is the total effect of a single resource on the whole project.

SETUP RISKYPROJECT PROFESSIONAL/ MONTE CARLO SIMULATION AND SENSITIVITY ANALYSIS:

This step's purpose was to obtain sensitivity analysis, which is a result of the Monte Carlo simulation. To run the Monte Carlo simulation, few setups had to be made before. Firstly, the updated Gantt chart was imported into the RiskyProject, Risk Matrix, and probability, and impact thresholds were set according to project needs. Then risks were created in the risk register and were assigned to tasks.

Note that the tasks' durations were kept constant as there was no assumption in three points of duration values because of the lack of historical data. RiskyProject runs Monte Carlo simulation and provides quantitative data without the need to assume the three points of the duration, as it depends only on risk data that was entered. So, the result of the Monte Carlo simulation obtained would depend only on risk evaluation. This feature is considered essential in the case of this project since the historical database lacked.

Monte Carlo simulation was run with 10,000 iterations, and sensitivity analysis was obtained. Below figure describes the flow the process:

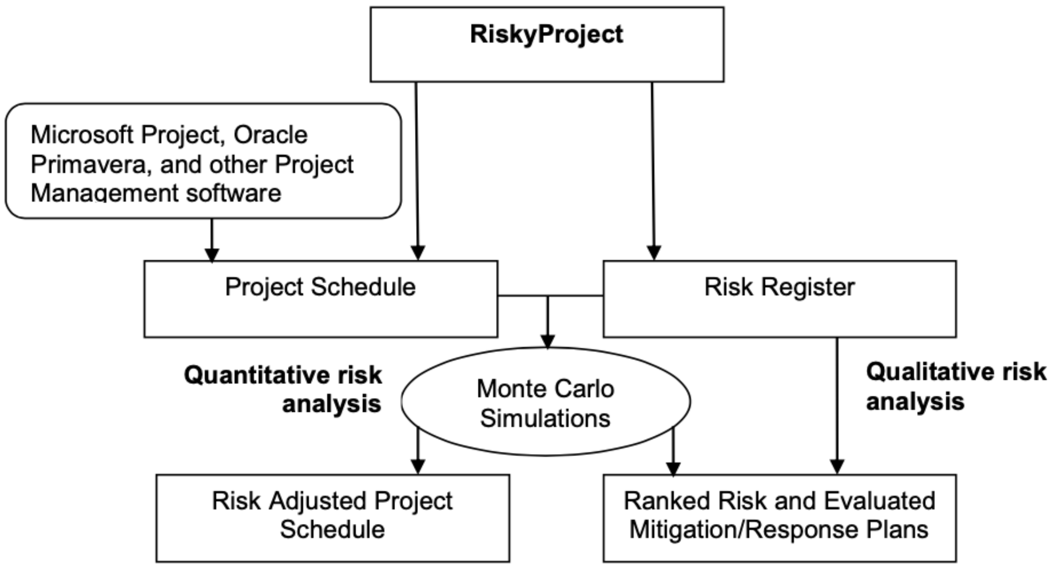


Figure 16 risk management process in risky project, from RiskyProject Getting Started Guide 2019

To set up RiskyProject the following steps has been followed:

- **Importing project schedule:** an updated Gantt chart created in Microsoft Project was imported to RiskyProject.

- **Set risk matrix:** in this step, all thresholds of probabilities and impacts and their relevant percentages have been customized according to the risk management plan mentioned earlier.

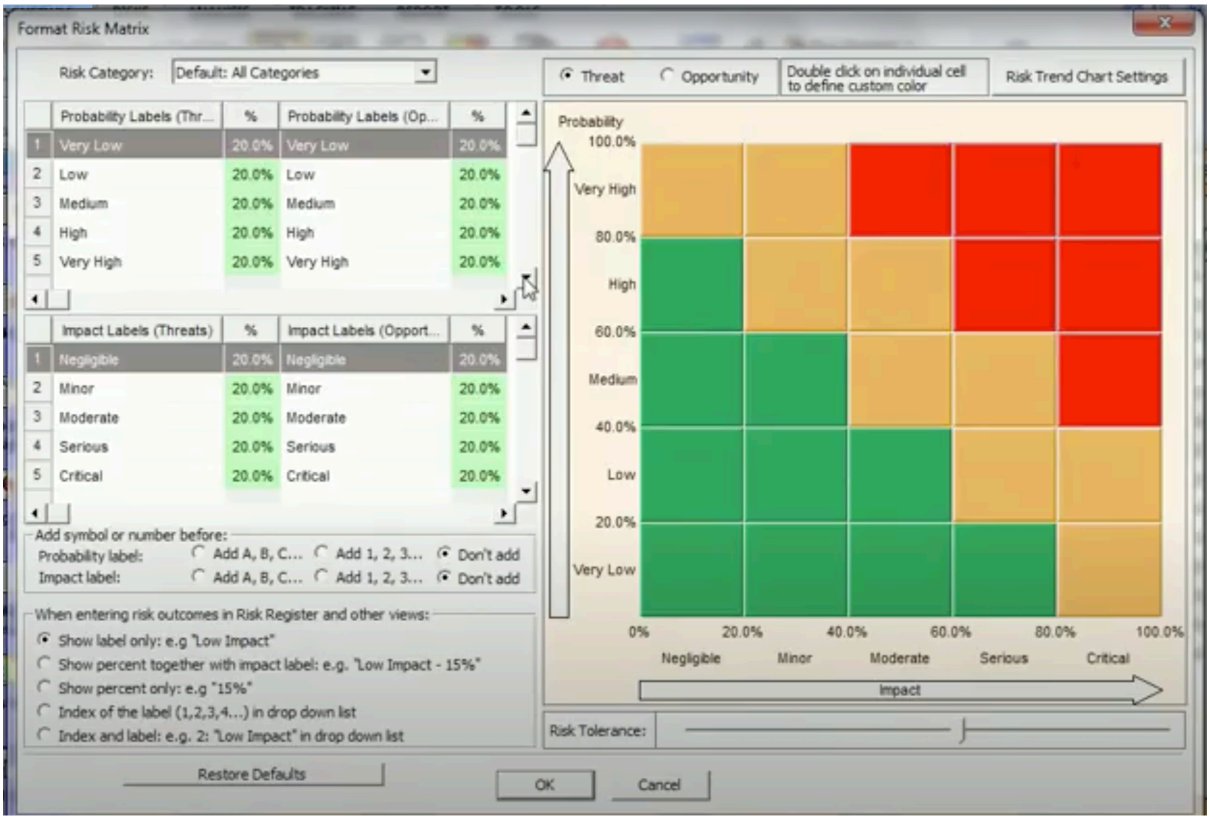


Figure 17 setting probabilities and impacts from RiskyProject software

As from figure above probabilities and impact and their percentages are configured.

- **Import risks to risk register**:

  The risk register includes all identified risks that are obtained from the risk identification step. Risks were imported manually and had been created in the risk register,

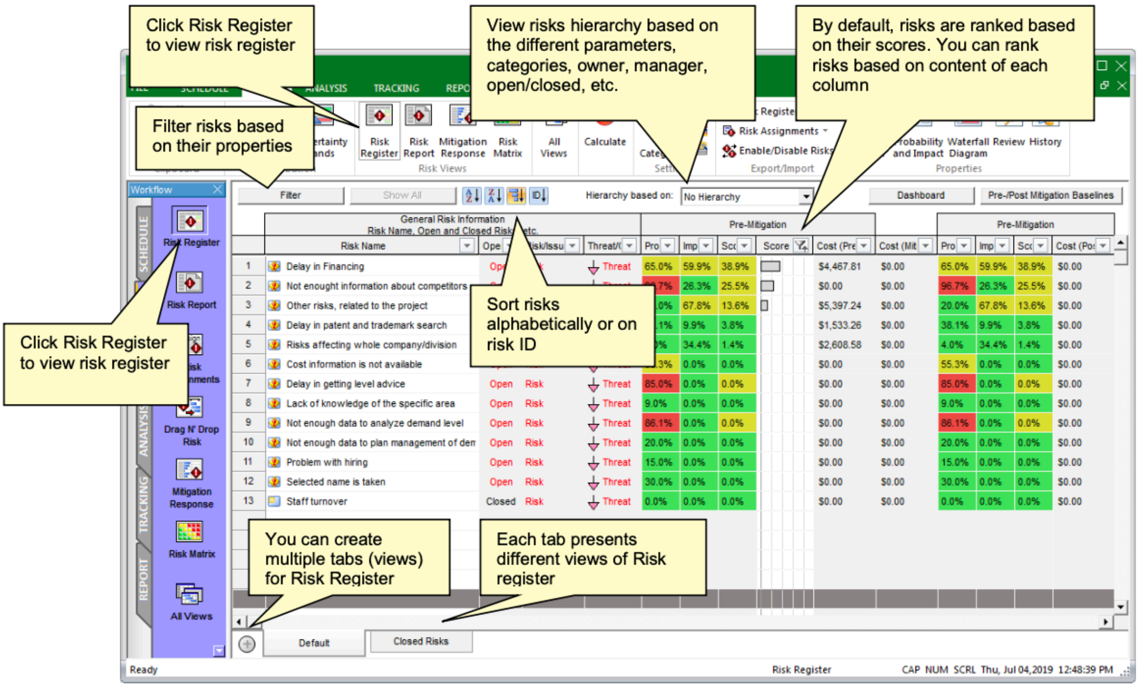


Figure 18 Risk register, Project Risk Management Software - User's Guide (2019)

- **Assess risks in RiskyProject:**

Risk is assessed in a risky project by assigning them to tasks with a probability of occurrence and an impact of the given objective. Assigning risks to tasks can be done simply by dragging risks and drop them on selected tasks, as illustrated in the figure below.

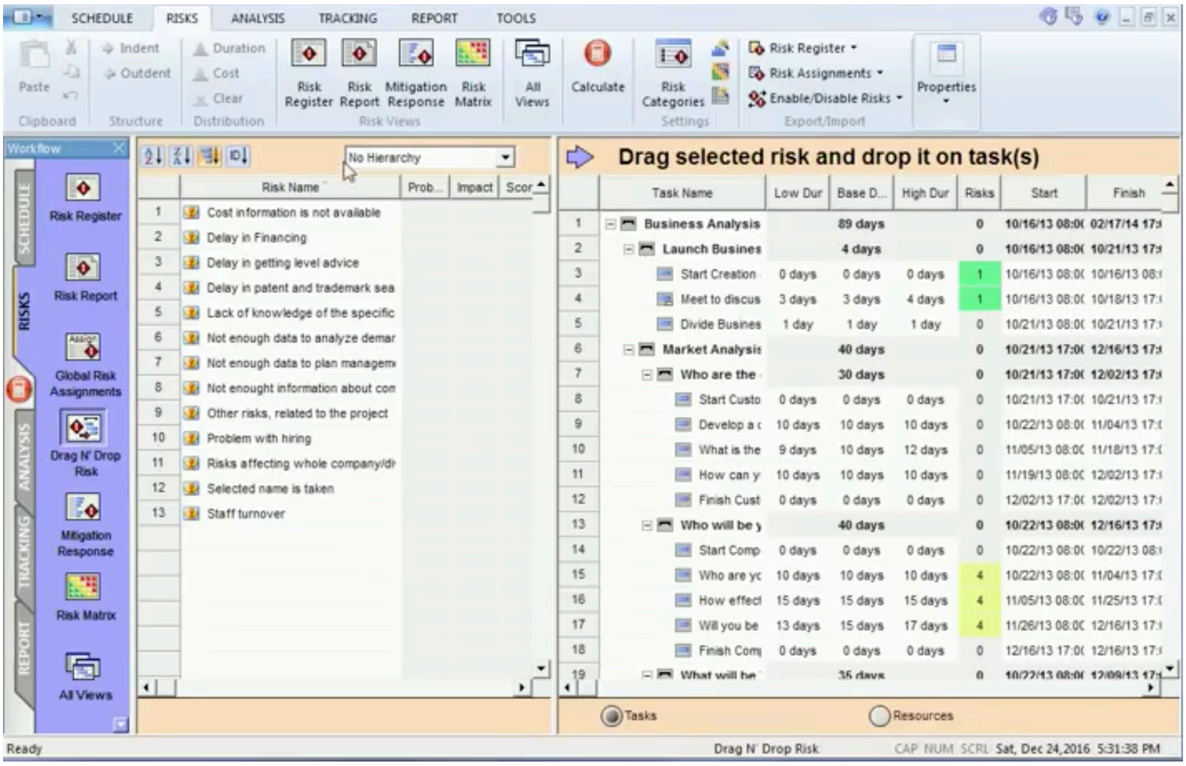


Figure 19 Assigning risks to tasks. from RiskyProject software

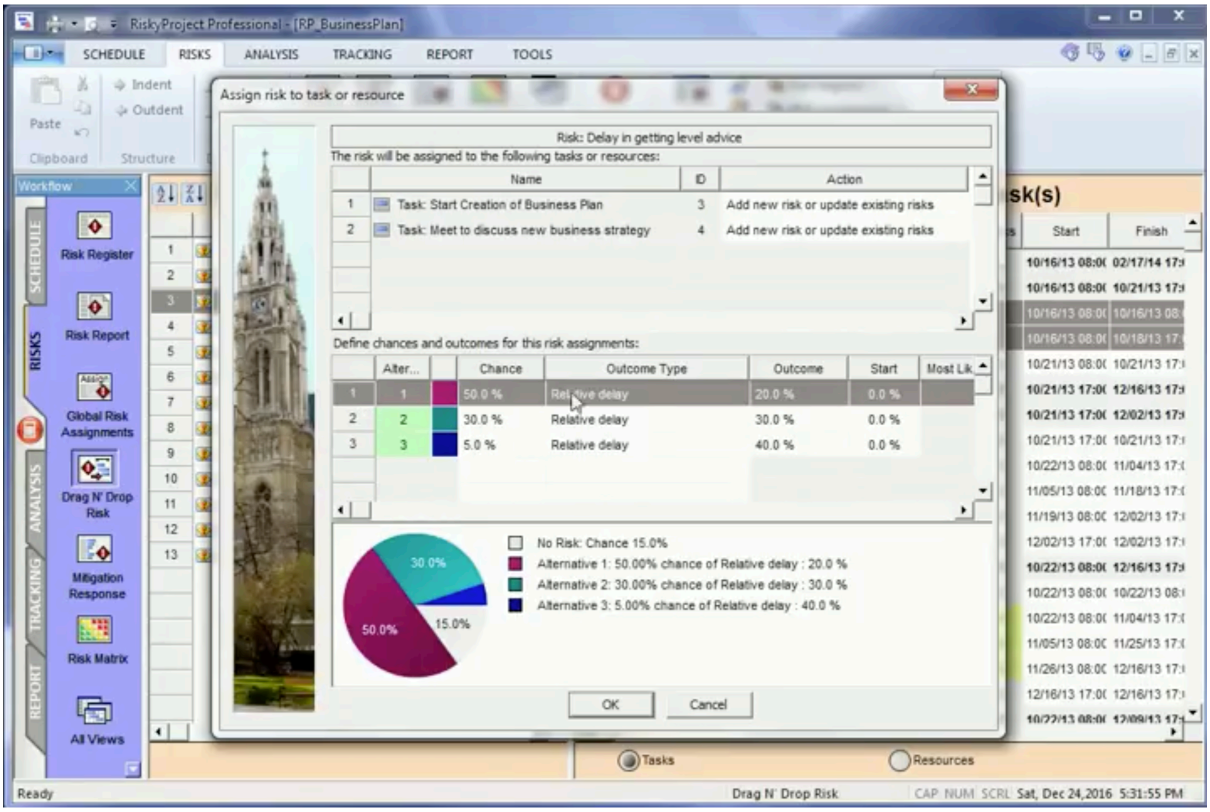


Figure 20 Setting probabilities and impacts. from RiskyProject software

After configuring risk matrix, creating and assigning risks to tasks with their probability and impact, RiskyProject is ready to run Monte Carlo simulation.

Run Monte Carlo simulation:

Usually, the Monte Carlo simulation depends on three-point estimates. However, the Risky project allows us to run Monte Carlo simulation and get quantitative results based only on the analysis of defined risks and their estimation of probabilities and impacts, which was the main reason to choose RiskyProject as simulation software. The number of iterations in the Monte Carlo simulation was set to 10,000 iterations. Monte Carlo simulation generates various impressive results in RiskyProject, from Sensitivity analysis, which was the main reason for running the simulation.

RISK RESPONSE PLAN

Once risks were understood, identified, and quantified, a risk response plan was implemented to manage them. Risk responses that were implemented are four types (avoid, mitigate, transfer, and accept) depending on the risk's probability and impact. risk strategy was built as shown below.

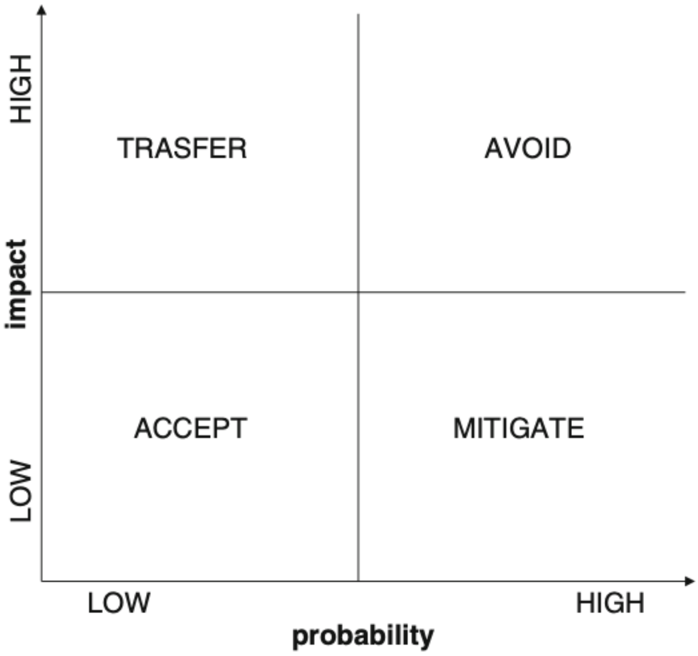


Figure 21 Main types of risk control strategies. De Marco, 2011,"Project Management for Facility Constructions"

		IMPACT						risk reponse general guidance
probability		VLO	LO	MED	HI	VHI		AVOID
%	Risk index	1	2	3	4	5		TRANSFER/MITIGATE
70%-99	5	5	10	15	20	25		MITIGATE
50%-70	4	4	8	12	16	20		ACCEPT
30%-50	3	3	6	9	12	15		
10%-30	2	2	4	6	8	10		
0%-10%	1	1	2	3	4	5		

Figure 22 RISK RESPONSE GUIDE

The risk response plan was implemented towards most significant risks, as it was carried out through meetings with experts. These responses were communicated to the owner and general contractor in terms of recommendation due to the limitation of RECCHI's part.

To implement risk responses, the most significant risky activities have been chosen from the Cross Risk Breakdown Matrix; for these activities, the most significant risks affecting these tasks were considered to implement response for.

RESULTS

this chapter states the obtained results from the application of risk management.

RISK BREAKDOWN STRUCTURE

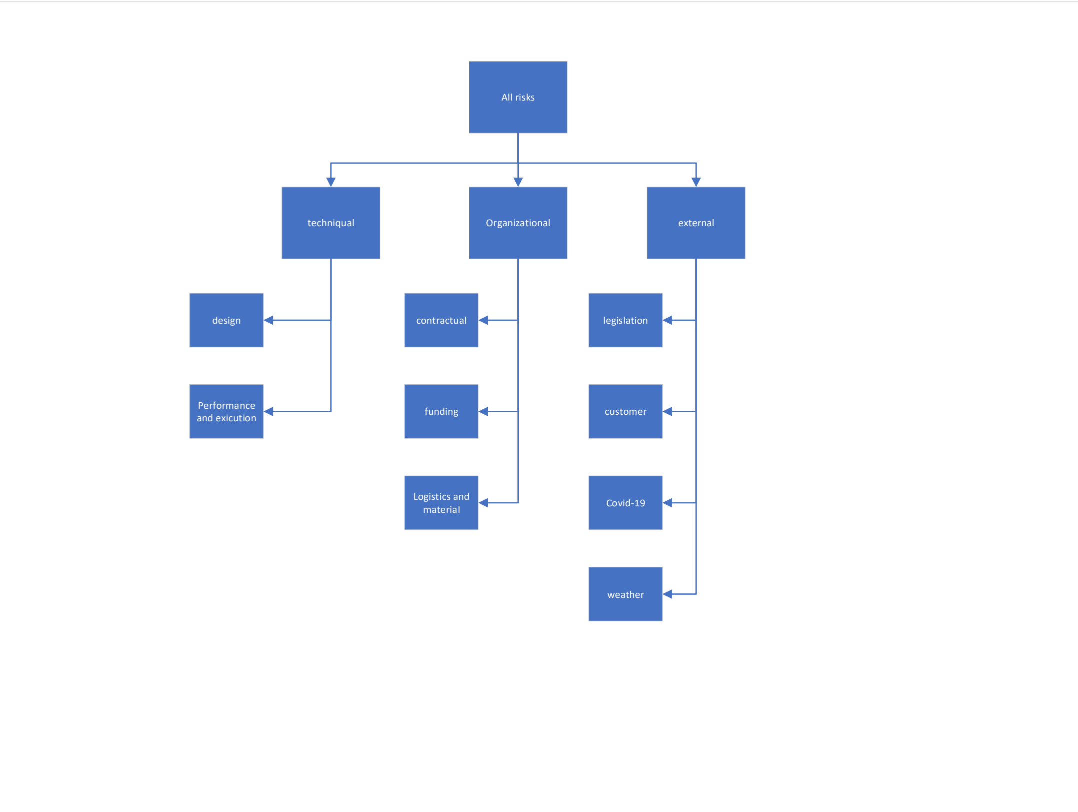


Figure 23 Risk Breakdown Structure

LIST OF RISKS IDENTIFIED

RISKS	code
because if the economic situation of the country because of covid-19 the owner may delay the payment	3.2.1
because the contract was signed 2012 , the contractor may spend a lot of time to find a subcontractor to do the activity	3.1.1
• Contractual disputes between client and contractor or contractor and subcontractor.	3.1.2
errors in detail design	1.1.1
design is over complicated to apply	1.1.2
because of usage of one crane , if the crane is broken , the materials will not be available in time	3.3.1
delivery of wrong materials	3.3.2
Delivery of broken materials	3.3.3
delay in delivering materials to the site	3.3.4
Construction staging (storage) areas are not large enough	3.3.5
Theft from the site by workers or break-ins caused by insufficient security	3.3.6
Because of the economic situation of the project(2012 contract) subcontractors may use less labours	1.2.1
Execution errors that would delay the activity	1.2.2
work performed might be under required standard	1.2.3
the site might not be ready to start the activity immediately (the working space need to be cleaned from the waste of previous activity)	1.2.3
because of covid 19 measure of satying in distance , there may be less workers to do the work	1.2.5
the need of skilled labours(labour specialities) which may delay to spend more time looking for them	1.2.6
Accidents	1.2.7
New or innovative technology is used in the construction which may lead to unforeseen complications and delays.	1.2.8
Working at height and management of associated hazards leads to delays and increased cost.	1.2.9
weather	4.1
Because of covid-19 pandemic one of labour might test positive	4.2
there might be change in normatives	4.3
final customer may require some customisation	4.4
covid-19 may spread again in milan or over italy in general	4.5
delays in getting permits	4.6

Figure 24 identified risks

Each Identified risk had been given a code , that is used to refer to every single risk descricption, to simplify the process.

CROSS RISK BREAKDOWN MATRIX

It concludes results from semi-quantitative risk assessment as well (sample of cross risk breakdown matrix)

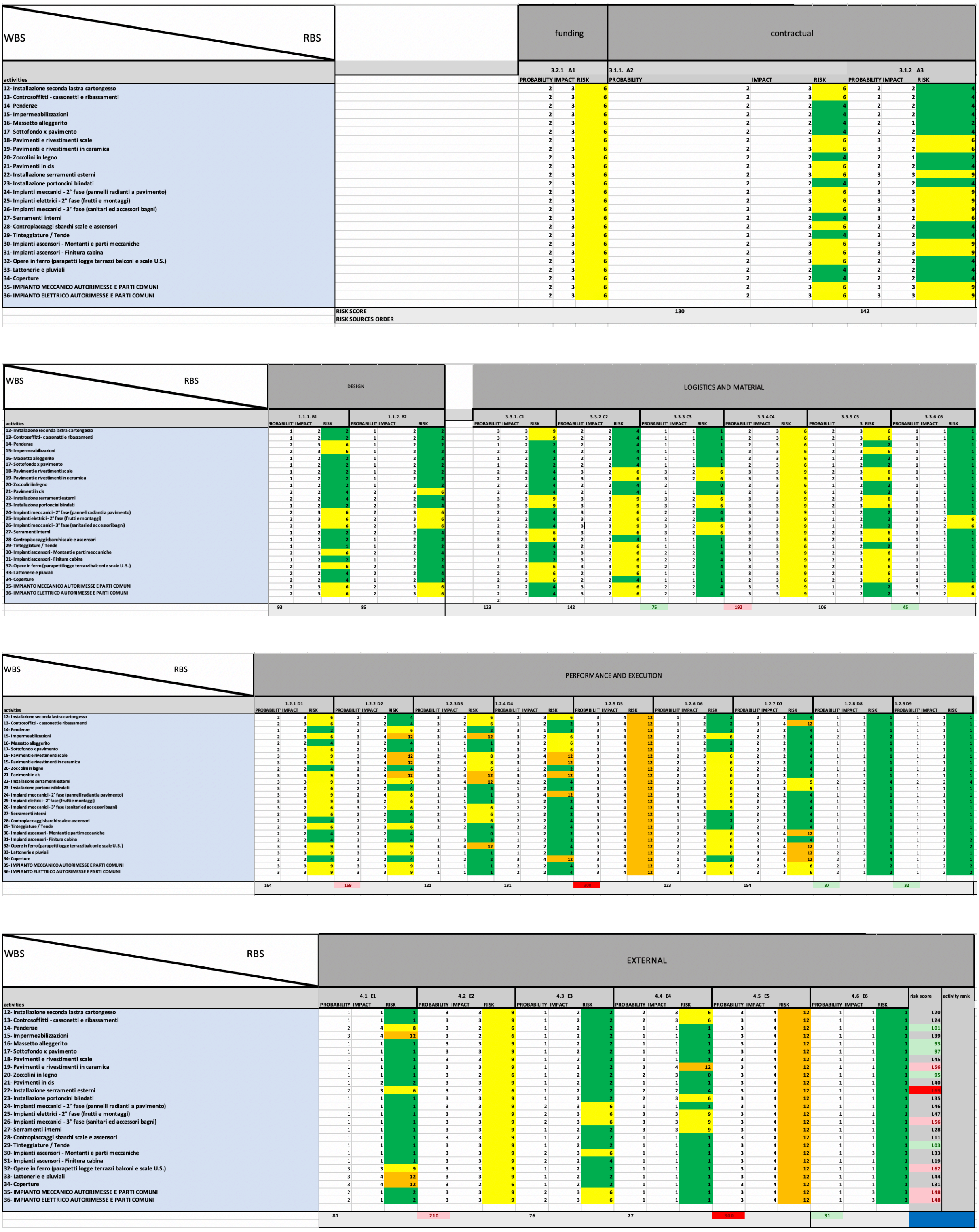


Figure 25 Cross Risk Breakdown Matrix

RISKYPROJECT PROFESSIONAL

RISK MATRIX SETUP

These tables below describe the setting up of the risk matrix and thresholds of probability and impact to make sure they are aligned with what has been agreed on in risk management plan.

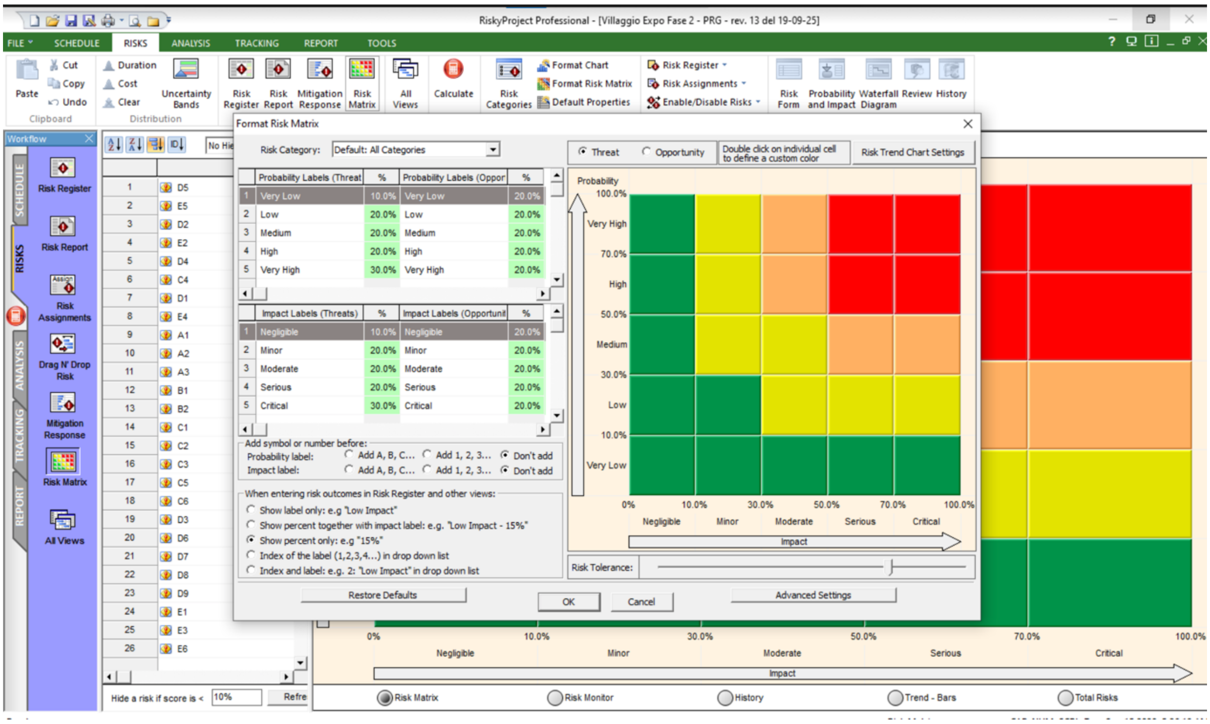


Figure 26 setting thresholds of probabilities and impacts in RiskyProject software

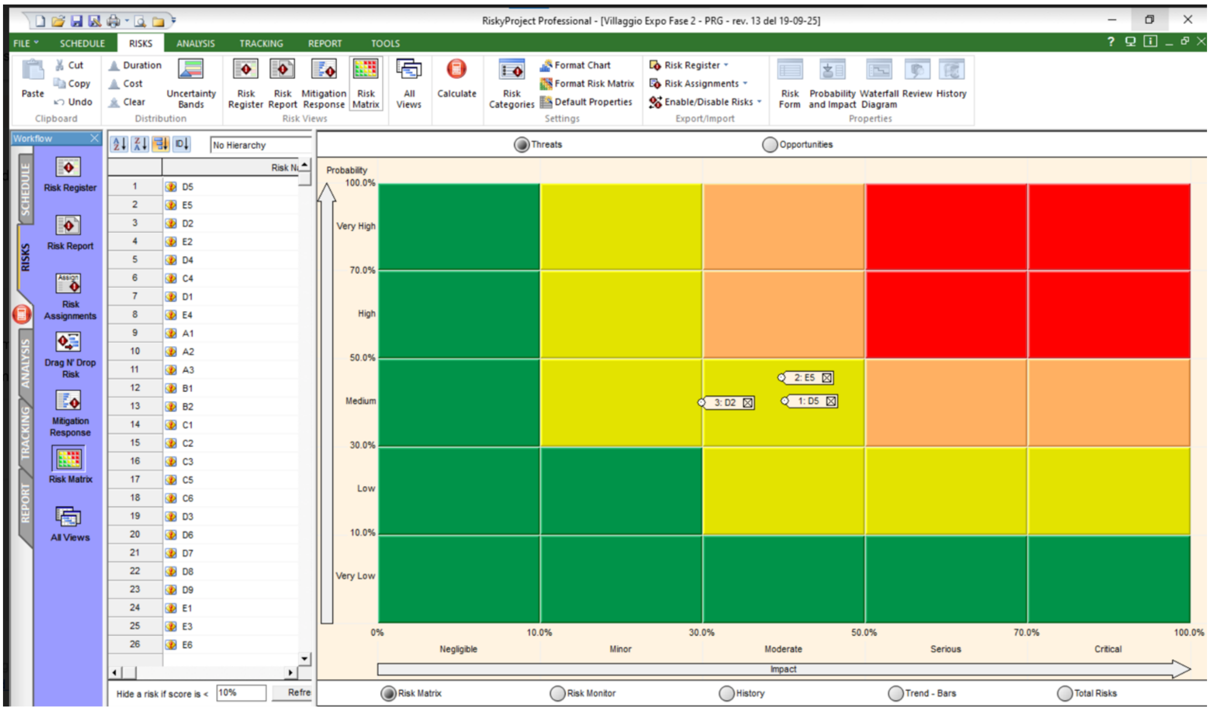
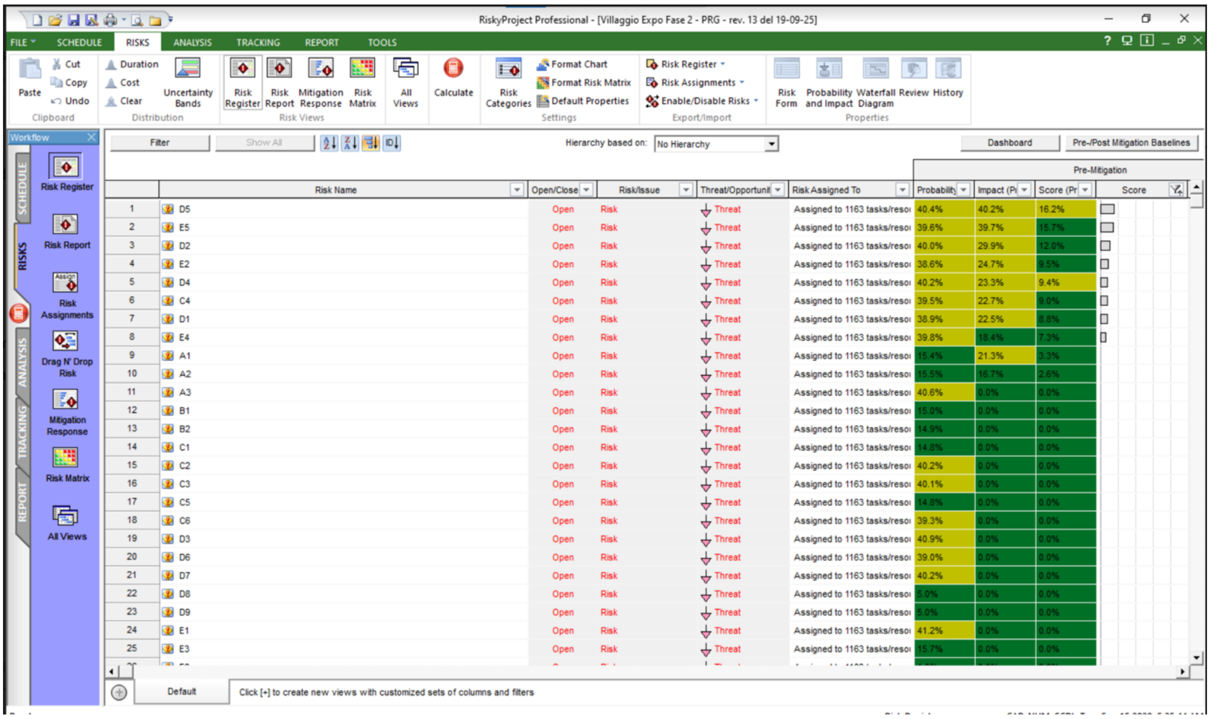


Figure 27 Risk Matrix in RiskyProject software

RISK REGISTER WITH PROBABILITIES AND IMPACTS

The table below shows risk register after importing risks and assigning them to tasks.also their probability and impact.

The last column which is "score" indicates most significant risks



	Risk Name	Open/Close	Risk/Issue	Threat/Opportunity	Risk Assigned To	Probability	Impact	Score
1	D5	Open	Risk	Threat	Assigned to 1163 tasks/reso	40.4%	40.2%	16.2%
2	E5	Open	Risk	Threat	Assigned to 1163 tasks/reso	39.6%	39.7%	15.7%
3	D2	Open	Risk	Threat	Assigned to 1163 tasks/reso	40.0%	29.9%	12.0%
4	E2	Open	Risk	Threat	Assigned to 1163 tasks/reso	38.6%	24.7%	9.5%
5	D4	Open	Risk	Threat	Assigned to 1163 tasks/reso	40.2%	23.3%	9.4%
6	C4	Open	Risk	Threat	Assigned to 1163 tasks/reso	39.5%	22.7%	9.0%
7	D1	Open	Risk	Threat	Assigned to 1163 tasks/reso	38.9%	22.5%	8.8%
8	E4	Open	Risk	Threat	Assigned to 1163 tasks/reso	39.8%	18.4%	7.3%
9	A1	Open	Risk	Threat	Assigned to 1163 tasks/reso	15.4%	21.3%	3.3%
10	A2	Open	Risk	Threat	Assigned to 1163 tasks/reso	15.5%	16.7%	2.6%
11	A3	Open	Risk	Threat	Assigned to 1163 tasks/reso	40.6%	0.0%	0.0%
12	B1	Open	Risk	Threat	Assigned to 1163 tasks/reso	15.0%	0.0%	0.0%
13	B2	Open	Risk	Threat	Assigned to 1163 tasks/reso	14.9%	0.0%	0.0%
14	C1	Open	Risk	Threat	Assigned to 1163 tasks/reso	14.8%	0.0%	0.0%
15	C2	Open	Risk	Threat	Assigned to 1163 tasks/reso	40.2%	0.0%	0.0%
16	C3	Open	Risk	Threat	Assigned to 1163 tasks/reso	40.1%	0.0%	0.0%
17	C5	Open	Risk	Threat	Assigned to 1163 tasks/reso	14.8%	0.0%	0.0%
18	C6	Open	Risk	Threat	Assigned to 1163 tasks/reso	39.3%	0.0%	0.0%
19	D3	Open	Risk	Threat	Assigned to 1163 tasks/reso	40.9%	0.0%	0.0%
20	D6	Open	Risk	Threat	Assigned to 1163 tasks/reso	39.0%	0.0%	0.0%
21	D7	Open	Risk	Threat	Assigned to 1163 tasks/reso	40.2%	0.0%	0.0%
22	D8	Open	Risk	Threat	Assigned to 1163 tasks/reso	5.0%	0.0%	0.0%
23	D9	Open	Risk	Threat	Assigned to 1163 tasks/reso	5.0%	0.0%	0.0%
24	E1	Open	Risk	Threat	Assigned to 1163 tasks/reso	41.2%	0.0%	0.0%
25	E3	Open	Risk	Threat	Assigned to 1163 tasks/reso	15.7%	0.0%	0.0%

Figure 28 risks in risk register in RiskyProject software

SENSITIVITY ANALYSIS

- The ranking column in sensitivity analysis is the Spearman Rank order correlation coefficient. the task shown at the top of the sensitivity chart, indicates that the project duration is very sensitive to the uncertainties in that task duration. Which indicates how likely this activity might fall into critical path.

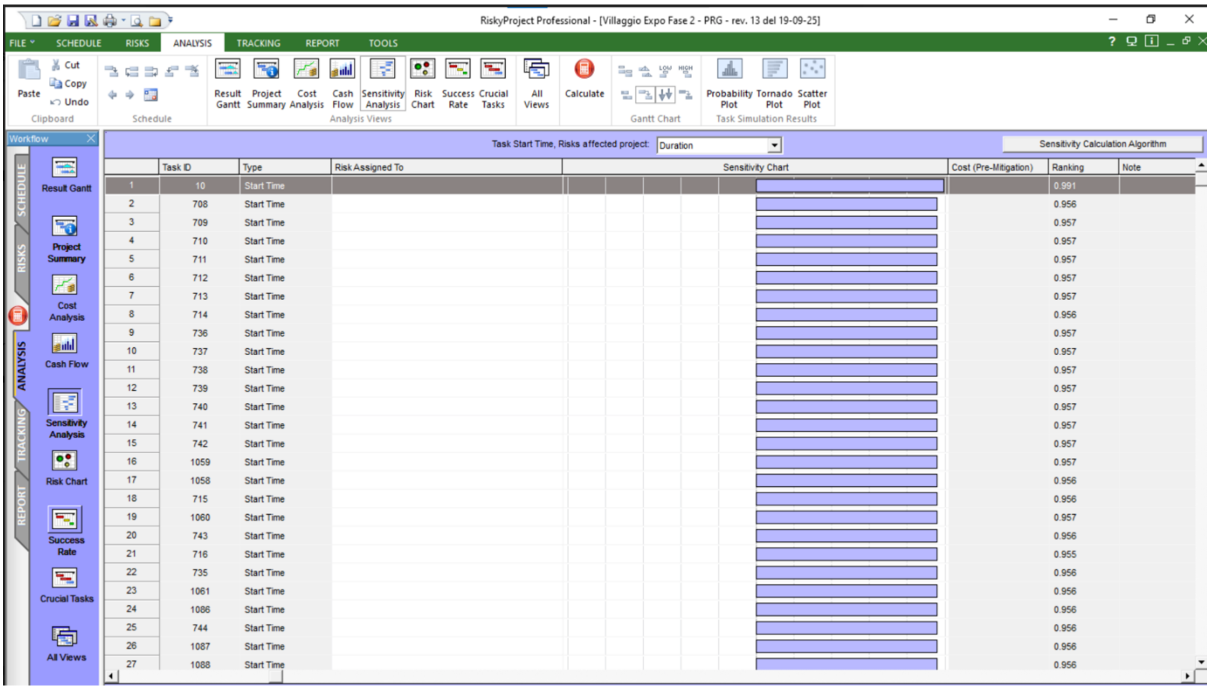


Figure 29 sensitivity analysis chart

RISKR ESPONSE

18- Pavimenti e rivestimenti scale	3.2.1	3.1.1	3.1.2
AVOID		Put pressure on the client who respects payments by limiting the Company's bad debts	
MITIGATE			Monitor correct client payments between general contractors and subcontractors - General contractor could divide processing between multiple subcontractors
TRANSFER	Evaluate the possibility of activating an insurance		

18- Pavimenti e rivestimenti scale	3.3.3	3.3.4	1.2.1	1.2.3
AVOID				
MITIGATE	General contractor could divide the supply among multiple suppliers to speed up new procurement	General contractor could divide the supply among several suppliers in order not to depend on the single delay	General contractor could split the pose between multiple subcontractors to avoid complete lack of teams	Request continuous updating of time schedules and monitor possible places and moments of risk
TRANSFER				

22- Installazione serramenti esterni	3.2.1	3.1.1	3.1.2	4.5
AVOID				Advance production as much as possible to reach the month of October with the largest number of windows installed
MITIGATE		Put pressure on the client who respects payments by limiting the Company's bad debts - Quickly evaluate possible variations of the Company that with the same quality .	Monitor correct payments of the client and between general contractors and subcontractors - General contractor could divide processing between multiple subcontractors	
TRANSFER	Evaluate the possibility of activating an insurance			

26- Impianti meccanici - 3° fase (sanitari ed accessori bagni)	3.2.1	3.1.1	3.1.2
AVOID			
MITIGATE		Put pressure on the client who respects payments by limiting the Company's bad debts - Quickly evaluate possible variations of the Company that with the same quality.	Monitor correct payments of the client and between general contractors and subcontractors - General contractor could divide processing between multiple subcontractors
TRANSFER	Evaluate the possibility of activating an insurance		

26- Impianti meccanici - 3° fase (sanitari ed accessori bagni)	4.4	4.5
AVOID		
MITIGATE	Group the variants as much as possible during construction so as not to lose efficiency on site and make them more economical	Advance production as much as possible to reach the month of October with less material to lay
TRANSFER		

36- IMPIANTO ELETTRICO AUTORIMESSE E PARTI COMUNI	3.3.4	3.3.6	1.2.1
AVOID		Increase control and safety on site - regulate access - Monitor workers movements within the site	
MITIGATE	Ask the general contractor to contact multiple suppliers		Monitor correct payments of the client and between general contractors and subcontractors - General contractor could divide processing between multiple subcontractors
TRANSFER			

36- IMPIANTO ELETTRICO AUTORIMESSE E PARTI COMUNI	4.2	4.5
AVOID	Enforce the anti Covid guidelines as much as possible	
MITIGATE		Advance production as much as possible to reach the month of October with less material to lay
TRANSFER		

Figure 30 response plan

Note that on the top row consists of the activity and codes of risks affecting it.

CONCLUSION

CONCLUSIONS

- Risk management allows main project stakeholders – the client, the contractor or the architect, the consultant – fulfill their obligations and Minimize detrimental impacts on the efficiency of construction projects in relation to cost, time, and quality.

- Applying risk management in practice requires time and effort to get the benefit out of it, as it should be taken as also it has been shown that risk management can be applied during the project and gives a good result that helps in decision-making. Also, using risk management seemed to be better and more efficient in the project's early stages.

- The practitioners in the construction sector are using but are not unaware of the techniques mentioned in the RM literature. Risks are handled in the sector every day, but not in the organized manner mentioned in the literature. As other researchers have also reported, knowledge of structured RM and RMP is very low, even though the idea of risk management is becoming more common in the construction industry.

- RiskyProject proved to be very efficient in applying the risk management process in practice, especially when it comes to base Monte Carlo simulation on experts' experience when lacking historical data, which was the case study's limitation.

- Sensitivity analysis opens experts' eyes to non-critical path activities that might turn critical and impact the overall project schedule because of certain risks associated with them.

RECOMMENDATIONS

- higher is the percentage of confidence in evaluating a certain risk, more reliable and secure the approach to mitigate that risk, and the lower the stress on the project management team to achieve the projects' objectives.

- Risk management process should be built in a proactive approach and not just in a reactive manner to address potential threats.

- Specifying priorities explicitly and in advance among objectives such as time and efficiency helps and enhances the risk identification and analysis process and influences selecting the best strategy to mitigate possible risks.

- Risk assessment is of the utmost significance of developing a risk management strategy that affects the strategy of executing the project because the process requires specific consideration, and the results should be dependent on accurate quality data.

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