

Risk Management Practices in a Construction Project – a case study

Master of Science Thesis in the Master's Programme Design and Construction Project Management

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Department of Civil and Environmental Engineering Division of Construction Management CHALMERS UNIVERSITY OF TECHNOLOGY Göteborg, Sweden 2011 Master's Thesis 2011:47

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ABSTRACT

Risk management is a concept which becomes very popular in a number of businesses. Many companies often establish a risk management procedure in their projects for improving the performance and increase the profits. Projects undertaken in the construction sector are widely complex and have often significant budgets, and thus reducing risks associated should be a priority for each project manager. This master thesis presents an application of risk management in the early stage of a project life cycle of a construction project. In order to examine how risk and risk management process is perceived a case study of a school project was chosen. Moreover, based on the conducted interviews, the research presents how risks change during a project life cycle. All analyses are based on a theoretical background regarding risk, risk management process and project life cycle approach in the construction sector.

Key words: Key words: Risk; Risk management; Risk management process; Risk management methods; Project life cycle

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Preface

In this thesis, risk management have been investigated in a case study which helped to realize how the construction industry works with this concept. The research has been carried out from January 2011 to may 2011, at the Department of Civil and Environmental Engineering, Chalmers University of Technology, Sweden.

The thesis has been carried out with Bygg-Fast, a consultancy company within construction project management, where a school project has been investigated in order to do this research. The research has also been supervised by Sven Gunnarsson at Chalmers University of Technology and an examination of the thesis regarding the language and formatting was made by Nancy Lea Eik-Nes. We appreciate for their help and support in this thesis. We would also want to thank all respondents in the school project for their involvement in the interviews which we could support our research on.

Göteborg May 2011

Ewelina Gajewska and Mikaela Ropel

1 Introduction

Risk management (RM) is a concept which is used in all industries, from IT related business, automobile or pharmaceutical industry, to the construction sector. Each industry has developed their own RM standards, but the general ideas of the concept usually remain the same regardless of the sector. According to the Project Management Institute (PMI) (2004), project risk management is one of the nine most critical parts of project commissioning. This indicates a strong relationship between managing risks and a project success. While RM is described as the most difficult area within construction management (Winch, 2002; Potts 2008) its application is promoted in all projects in order to avoid negative consequences (Potts, 2008).

One concept which is widely used within the field of RM is called the risk management process (RMP) and consists of four main steps: identification, assessment, taking action and monitoring the risks (Cooper et al., 2005). In each of these steps, there are a number of methods and techniques which facilitate handling the risks.

Many industries have become more proactive and aware of using analyses in projects. Likewise, RM has become a timely issue widely discussed across industries. However, with regard to the construction industry, risk management is not commonly used (Klemetti, 2006). More construction companies are starting to become aware of the RMP, but are still not using models and techniques aimed for managing risks. This contradicts the fact that the industry is trying to be more cost and time efficient as well as have more control over projects. Risk is associated to any project regardless the industry and thus RM should be of interest to any project manager. Risks differ between projects due to the fact that every project is unique, especially in the construction industry (Gould and Joyce, 2002). However there are still many practitioners that have not realized the importance of including risk management in the process of delivering the project (Smith et al., 2006). Even though there is an awareness of risks and their consequences, some organizations do not approach them with established RM methods.

The construction industry operates in a very uncertain environment where conditions can change due to the complexity of each project (Sanvido et al., 1992). The aim of each organization is to be successful and RM can facilitate it. However it should be underlined that risk management is not a tool which ensures success but rather a tool which helps to increase the probability of achieving success. Risk management is therefore a proactive rather than a reactive concept.

Many previous studies (Klemetti, 2006; Lyons and Skitmore, 2002; Zou et al. 2006) have been conducted within the field of RM but each presents a different approach to this concept. The research in this master thesis focuses on the construction industry and how the subject is practiced in the everyday operation. The concept of RM is presented in a systematized project life cycle (PLC) approach to show differences between elements of RMP in different project phases.

The research for this study was conducted together with a consultancy company working with construction project management, which consults a variety of construction projects. This organization works with risks in a way that they are aware of risks, but do not use any specific structured methods to handle them. However, they believe that a project's performance can be improved by implementing risk management methods. At the time when research was conducted, the company was working on a school project in the western part of Gothenburg, which is the case study in this thesis. The project was chosen in order to investigate the practices of risk management across project organization.

1.1 Purpose

The purpose of this master thesis is to evaluate how the risk management process is used in the construction industry and how the practitioners are managing risks in everyday situations. The theory of the risk management process will be compared to the actual practice in order to investigate similarities and differences. In other words, the main idea is to see if the construction industry is working with risk management as it is described in the literature regarding the methods and techniques presented.

In order to achieve the purpose, the following research questions have been formulated to support the investigation:

- How are risks and risk management perceived in a construction project?
- How is risk management process used in practice?
- How do risks change during a project life cycle?

The objectives are to understand the concept of RM and the RMP, investigate how the sector manages risks and facilitate the use of RM focused on the construction industry.

1.2 Limitations

The research focuses on the construction industry and is based on theories of risk management described in the literature. The research was complemented by a study of a construction project in Goteborg in cooperation with some of the stakeholders involved in it. Due to the limited research time of the thesis, the project was investigated during the planning and design phase only.

1.3 Outline of the thesis

The research starts with a literature overview in order to provide the theoretical context about the project in general terms with the focus on the project life cycle. Further, a description of how the construction industry is operating in the field of risk management is provided. RM, including the definition of risk, a descriptive part of the steps of the RMP, is then presented in order to establish the foundation for this thesis. Subsequently, results from conducted interviews are presented to show how the industry works with risks. In the discussion part, the results from the interviews are analyzed and compared to the theoretical framework. Finally the final recommendations are drawn up in the conclusion section. In Figure 1, a more illustrative picture of the research structure can be found.

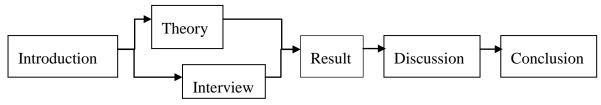


Figure 1 The outline of the thesis

2. Theoretical framework

The theory part is divided into three parts. The first part is a description of a project organization structure. Its purpose is to provide a reader with general information about a construction project and its organization. The second part introduces concept of risk management and provides definitions of terms used in this process. Finally, the theoretical concept of risk management process and methods used for risk assessment are presented. Some risks which occur commonly in the construction industry are, for example weather, design issues, problems with material, accidents, labor issues etc. Risks can vary in character and have different impacts on a project. In spite of this, risk management is not widely used within the construction industry.

2.1 Project life cycle

Each activity or process, regardless of the area of business domain, has a beginning and an end. Similar concepts are used in the engineering world to systemize projects over time. The term project life cycle is used as a management tool to improve a project's performance. The scope of life cycles differs among industries and diverse terminology with a various number of phases is used depending on the sectors. However, several terms are often used within one particular sector even though a number of phases can vary (Smith *et al.*, 2006). Therefore, it is difficult to systemize and provide one common scope and definition of a project life cycle.

Smith *et al.* (2006) concluded that various forms of PLC frameworks described in the literature are a result of variety of project types. For construction projects, for instance, the PLC model can consist of eight succeeding phases including pre-feasibility, feasibility, design, contract/procurement, implementation, commissioning, handover and operation (Smith *et al.*, 2006). In contrast, Pinto and Prescott (1988) present a four stage PLC developed by Adams and Brandt, and King and Cleland as the most widely used framework, where conceptualization, planning, execution and termination are the main phases. A similar model is used by Westland (2006) who identifies initiation, planning, execution and closure as principal project steps.

Yet another model was developed by Ward and Chapman (1995) which sets up concept, planning, execution and termination to constitute PLC. The same authors in another publication make a further division of each of the four phases into another number of stages and steps. Such fragmentation of the activities provides easier and more accurate potential risk identification and makes risk management processes more effective (Chapman and Ward, 2003). Due to the variety of project types, PLC requires adjustments and an individual approach. A number of further stages within each phase should be adjusted to a particular project depending on its scope and structure. Since each project is unique, a framework used in one project can turn out to be completely inapplicable in another. Therefore the model, as the one proposed by Chapman and Ward (2003) that is shown in Table 1, should be used as an example and not as ready-made template.

Phases	Stages	Steps
Conceptualization	Conceive	Trigger event
	The product	Concept capture
		Clarification of purpose
		Concept elaboration
		Concept evaluation
Planning	Design	Basic design
	The product	Development of performance criteria
	strategically	Design development
		Design evaluation
	Plan	Basic activities and resources basic plan
	The execution	Development of targets and milestones
	strategically	Plan development
		Plan evaluation
	Allocate	Basic design and activity-based plan detail
	Resources tactically	Development of resource allocation criteria
	uctically	Allocation development
		Allocation evaluation
Execution	Execute	Co-ordinate and control
Production	Monitor progress	
		Modification of targets and milestones
		Allocation modification
		Control evaluation
Termination	Deliver	Basic deliverable verification
	The product	Deliverable modification
		Modification of performance criteria
		Deliver evaluation
	Review	Basic review
	The process	Review development
		Review evaluation

Support	Basic maintenance and liability perception
The product	Development of support criteria
	Support perception development

From the literature research emerges the most common PLC model which consists of four main project phases. The presented examples of PLC are applicable to a general project concept, and their scope can be adjusted depending on the industry. To make project planning in the PLC more convenient, some authors describe PLC's which are typical for a certain industry or sector.

Bennett (2003) presents a PLC framework which is typical for construction projects. The framework differs from those general models mentioned above, and distinguishes phases and steps characteristic for the construction project. It consist of six phases of different lengths and starts with Pre-project phase followed by Planning and design, Contractor selection, Project mobilization, Operations, and Close-out and Termination phase and its graphic illustration is presented in Figure 2. The construction industry requires a special approach due to the complexity of projects undertaken and thus such modified PLC should bring benefits to project management and its performance (Bennett, 2003). It is also this approach which will be used in this paper.

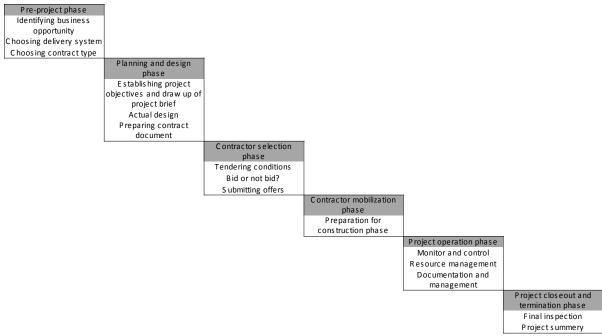


Figure 2 PLC for a construction project

2.1.1 Pre-project phase

The purpose of the initial phase in a PLC is to develop an idea for a potential project (Bennett, 2003). Westland (2006) describes this step more in detail as developing a business opportunity which includes identification of a subject matter or problem which could be further developed into a project. Identifying business opportunities requires a number of assessments and discussions which should result in creating a project idea. Initial problem description, its scope, time frames and an outline of a plan for activities and steps in next

phases of the PLC, are some of the factors which should be determined by the time the proposal is presented to a potential sponsor (Westland, 2006).

Moreover, in the pre-project phase a project delivery system is chosen. It establishes relationships between main actors in the project: the owner, the designer and the construction organization. Previous studies show that the choice of procurement system has a great impact of how risks are managed in the construction industry; this indicates that there is a relation between these factors. Chege and Rwelamila (1999) emphasized the correlation between risk response in the RMP and the procurement system.

2.1.2 Planning and design phase

The second phase in the PLC, presented by Bennett (2003), is the planning and design phase which is relatively longer than the others. This project development process consists of three sequential stages for more convenient phase completion and project delivery.

In the first step, project organization starts to be formulated. Main actors in the project and their roles are defined along with competences which are assigned to each position in particular (Bennett, 2003). After appointing the project team, a project brief is written which in detail describes the scope of the project and its objectives. In a construction project, first the needs of the stakeholders must being identified and then the design team makes initial sketches of each idea separately (Bennett, 2003). It helps to identify potential risks associated with proposed solutions. As a result of this examination, all identified ideas are ranked and the most feasible one is chosen for further development (Westland, 2006).

Further on, in the planning phase, site investigation and constructability analysis should be undertaken. A number of potential sites should be examined in respect to soil conditions, topography, location and price. A constructability analysis determines whether a proposed structure is easy to build and what effect will it have on schedule, budget or safety. In a planning phase, it is vital to determine whether potential investment is financially feasible. Thus the cost estimator should prepare a preliminary budget of a project where all types of possible costs and the price per unit or activity are determined (Bennett, 2003).

When all options in the feasibility study are analyzed, the project team chooses the best alternatives and proceeds to the next step in the PLC which is the design process. All assumptions made in previous stages are put into practice. In other words, schematic drawings drawn up under planning phase are developed into actual detail plans. Every technical aspect such as structure calculation or accessory planning is developed by a small specialized group of engineers. As a result of the whole design process, a clear vision of the investment emerges.

The last activity in the planning and design phase is development of a contract document. The contract document includes technical specifications, up-front documents and drawings. Its format can be based on standards issued by various institutions such as FIDIC, which is a standard widely used in international projects. This document sets form as well as instructions and invitation to tender. Established tendering processes enable the project team to proceed to the next stage which is contractor selection (Bennett, 2003).

2.1.3 Contractor selection phase

In this stage a contractor is selected (Bennett, 2003). However it is not always price which decides who will be awarded the contract (Potts, 2008). In a selection process, a number of criteria are taken into consideration such as qualifications, resources held or bid price and compiled in a criteria matrix. Such collected data are evaluated and the offer which scores highest is usually awarded the contract if no other criteria have been set. For the selection phase to be completed, a legally bidding contract agreement is signed between the owner and contractor (Bennett, 2003).

2.1.4 Project mobilization phase

In between choosing contractor and beginning of construction there is a number of activities which need to be considered. It is in the contractor's responsibility to apply for any type of necessary permits and licenses prior to construction works initiations. Moreover, detail schedule, initially drawn up in the planning phase, is developed with help of computer software in this phase. It is further used to plan employment and other resource utilities over time (Bennett, 2003).

2.1.5 Project operation phase

During the operation phase, there are three key activities in addition to the construction itself: monitor and control, resource management, and documentation and management. Monitor and control covers supervision of, among others, time, cost and quality (Bennett, 2003). The project manager is usually the person who undertakes this management process to keep track of undergoing activities. As previously mentioned, time, cost and quality are key aspects of each project and hence managing them is an important activity. Time management is used to log actual time spent for execution of certain tasks. It also helps to allocate resources more effectively and control schedule of performing works (Westland, 2006).

The actual schedule and work progress is compared to the schedule drawn up in previous phases. If any discrepancies are detected, a person responsible should take an appropriate action in order to bring the project back into conformance (Bennett, 2003). Keeping track of the time aspect makes it possible to manage other key issues, finances and quality. Cost control is used to record all actual expenses within the project and gives control over a budget and out-of-pocket expenditures. Whereas quality monitoring is performed in order to deliver what was promised to the client (Westland, 2006), it also controls whether the work performed is in compliance with technical requirements stated in tender documentation (Bennett, 2003).

Undertaking the second activity, resource management, results in better project performance. Personnel supervision consists of ensuring that workers perform their tasks in a right manner and comply with officially set working hours. Other resources, such as materials or equipment need to be tracked along with personnel. Any irregularity in these matters may negatively impact the schedule, budget or quality, causing delays or cost overruns (Bennett, 2003).

Document management is the last activity in the operation phase, but its importance should not be ignored. It treats communication within the project and grandness of other documents. As in previous examples, proper management of this matter will make the project proceed in a timely, cost-effective and quality assurance manner (Bennett, 2003).

2.1.6 Project close-out and termination phase

Most of PLC's end up at the execution phase where the final product is handed over after being accepted by the client. Performing a project summary requires additional resources, time and money, which investors tend to prefer to spend on new investments instead (Westland, 2006). However, project close-out and termination is important, among others, from a legal perspective. Before installation works can be considered as completed, there are still activities which must take place. The main ones are final clean up, inspections, handover to the owner and project closure (Bennett, 2003).

The final procedure in the PLC, as suggested by Westland (2006), is to review the project completion. In this step the overall project assessment is performed. It gives possibility to draw conclusions for next projects to improve their performance. All initially planned activities such as budget, schedule or scope are compared with the completed activities to assess how the product was delivered in comparison to the plan. Such a review can be performed some time after the project handover in order to be able to assess all benefits (Westland, 2006).

2.1.7 Risks in the PLC

To make sure that everybody connected with a project is aware what a risk is, one common definition should be drawn up for the purpose of the particular project. To quantify identified risks, Westland (2006) uses a tool where likelihood of occurring risk is rated. This method is described later in this paper along with other assessment models, in the section 2.5.2.2. When risk plan is completed the risk management process execution starts, which is a tool to track and control previously identified risks (Westland, 2006).

Risks are associated with every project and should be identified in order to avoid negative impacts on the overall performance. Many problems which are faced in later phases of the PLC result from unmanaged risks from the earlier stage (Chapman and Ward, 2003). This indicates how important it is to carry out accurate analysis especially in an initial phase of a project. Raz *et al.* (2002) perceive RM as a process which starts at project definition and continues through planning, execution, control and closure phase. However, a study conducted by Lyons and Skitmore (2002) proves that planning and execution are the two phases where RM is most widely used. In contrast, Elkington and Sallman (2002) found that the conceptualization phase is the most important in the RMP.

Westland (2006) identifies project steps where more attention should be directed toward risk management. In the initial project phase, the feasibility study is undertaken, which is a thorough analysis of a project proposal. At this stage, a number of solutions are identified and assessed and the study is conducted to identify potential risks associated with proposed solutions. Further in the planning phase, a risk plan is drawn up where potential risks related to project planning are identified. All the stakeholders should contribute in drawing up this plan to make sure that every potential risk has been identified. In addition to identifying risk, the risk plan assigns the type of action which should be taken in order to respond to a particular problem. Performing this stage in the planning phase aims at mitigating risk before the execution phase, during which any occurring risk is very costly if no action is taken in advance (Westland, 2006).

Westland (2006) suggests that risk assessment should be performed during the review of each phase of the PLC. At the beginning of a project, a high level of uncertainty is expected which

decreases along with project progress. Doubts which rise at any point make it necessary to go back and revise controversial issues from their origin. Such a procedure will require going back to previous steps and discussing them with the new assumptions. While making decisions while moving further in the PLC raises a need for adjustments in previous steps. In other words, decisions made at a certain point of time may result in changing concepts of steps further up in the PLC which were made at the initial phase.

In the execution phase of the PLC, monitoring and control are performed in order to make sure that the process is going according to the plan and all identified risks are being handled. Such monitoring should be done under the whole project process, starting with the point in time when the risks were recognized. At the project closure, where the whole project is summarized, the project's objectives, benefits and deliverables are evaluated. All parties then have a chance to list all activities or risks which were not fully managed within the project. Those unmanaged risks can be a subject of further discussion and be used as warning for next projects (Westland, 2006).

2.2 Project manager/project organization

A construction project is characterized not only by its size and complexity, but also by various events and interactions which take place during the life cycle of a project. The work environment is constantly changing due to the number of participants involved, the project duration and the events along the way (Sanvido *et al.* 1992).

In the construction industry, the most common way of working is within project teams, which often are only temporary organizations. Winch (2002) describes a project as relying on human and equipment resources. This constellation will be different in each project, since all projects are unique. Human resources, the actors, working in the project form a project team. The aim of such a group is to achieve the objectives set for the project. Dependencies between members can be compared to a hierarchical structure. In such an organizational form, a formal leadership is executed by a project manager (Winch, 2002) who has the overall responsibility for the project, and organizes its structure and operation (Sears *et al.* 2008). Within the project team, the tasks are divided among the members, depending on their areas of expertise (Winch, 2002).

The main task for a project manager is to ensure that the project is properly managed in order to complete it in time, within budget and with required performance. These most important project factors are exposed to risks and uncertainties. The project manager should use an RMP in order to ensure that the risks have been identified, analyzed and managed. (Perry, 1986) Some companies have a separate risk management department which is a highly specialized unit within the field of risks. Their role is to assist project managers in handling risk associated to the project. It means that risks are managed in the organization and the responsibilities are shared within the company.

2.3 Decision making process from risk management perspective

Each of the phases of the PLC has certain purpose and scope of work assigned. At the completion of each phase there is a decision point where risk assessment takes place. Based on the risk assessment, an appropriate decision is made regarding further actions or proceeding to the next phase (Smith *et al.*, 2006). For project management to be effective, an evaluation should be made including all phases of the PLC. Ward and Chapman (1995) use 'go', 'maybe' and 'no go' options in a decision making process. A 'go' status will constitute a green light for proceeding on to the next phase while 'no go' will stop the project. Evaluation

resulting in a 'maybe' decision will lead to return to a previous phase or even phases for further improvements and minimizing risk (Ward and Chapman, 1995). The further on in the stages the 'maybe' decision is made, which takes the process back to the initial phases, the more problems it causes. According to Chapman and Ward (2003) it is possible to go back in phases within a PLC, however this undermines decisions which were made in previous stages and leads to waste of resources, usually both time and money (Chapman and Ward, 2003). Decisions which are made at the end of each stage should be made after a careful study of the possible risks and hindrances which might be encountered.

2.4 The risk management

Many explanations and definitions of risks and risk management have been recently developed, and thus it is difficult to choose one which is always true. Each author provides his own perception of what risk means and how to manage it. The description depends on the profession, project and type of business (Samson, 2009). Risk management in general is a very broad subject and definitions of risk can therefore differ and be difficult to apply in all industries in general. For the purpose of this thesis one definition of risk and risk management will be chosen, in order to have a clear understanding of these concepts in construction industry.

2.4.1 Risk definition

Risk and uncertainty are the two most often used concepts in the literature covering RM field. Although these terms are closely related, a number of authors differentiate between them (Samson, 2009). Also practitioners working with risk have difficulty in defining and distinguishing between these two. Often definitions of risk or uncertainty are tailored for the use of a particular project. To make it more systematized, a literature research was done. The findings of this search resulted in a number of definitions of risk and uncertainties. These have been compiled and are presented in Table 2.

Author:	Risk definition	Uncertainty definition
Winch (2002)	A stage where there is a lack of information, but by looking at past experience, it is easier to predict the future. Events where the outcome is known and expected.	Uncertainty is a part of the information required in order to take a decision. The required information consists of the amount of available information and uncertainty. The level of uncertainty will decrease the further a project is proceeding throughout the lifecycle.
Cleden (2009)	Risk is the statement of what may arise from that lack of knowledge. Risks are gaps in knowledge which we think constitute a threat to the project.	Uncertainty is the intangible measure of what we don't know. Uncertainty is what is left behind when all the risks have been identified. Uncertainty is gaps in our knowledge we may not

Table 2 Definitions of risk and uncertainty

		even be aware of.
Smith <i>et al.</i> (2006)	Risks occur where there is some knowledge about the event.	There might be not enough information about the occurrence of an event, but we know that it might occur.
Webb (2003)	Risk is a situation in which he possesses some objectives information about what the outcome might be. Risk exposure can be valued either positively or negatively.	Uncertainty is a situation with an outcome about which a person has no knowledge.
Darnall and Preston (2010)	Risk is a possibility of loss or injury.	
Cooper <i>et al.</i> (2005)	Risk is exposure to the consequences of uncertainty.	

All risk definitions complied in Table 2 describe risk as a situation where lack of some aspect can cause a threat to the project. Lack of information and knowledge are those factors which are most commonly mentioned by all the authors as leading reasons for a failure. The description provided by Cleden (2009) will best fit the purpose of this paper; it concerns how risk is defined as a gap in knowledge which, if not handled correctly, will constitute a threat to the project.

Uncertainty is defined in a more abstract way. The descriptions provided in Table 2 are similar to each other and the common factor is again lack of information and knowledge. The biggest difference by definition is awareness. For the purpose of this thesis, the definition of uncertainty provided by Cleden (2009) will be used. These two chosen definitions best show the difference between risk and uncertainty and help to be consistent with terminology in the paper.

Darnall and Preston (2010) find some of the risks to be predictable and easy to identify before they occur, while the others are unforeseeable and can result in unexpected time delays or additional costs. This statement finds confirmation in the definition provided by Cleden (2009) who uses the same arguments defining uncertainty as rather unpredicted, unforeseeable events, while risk should be possible to foresee. The overview of definitions which can be found in literature regarding those two terms implies that uncertainty is a broad concept and risk is a part of it. This confirms close relation between those two concepts but at the same time distinguishes them.

In the following chapters, the focus is on risk itself and how it should be handled. Uncertainty is not a tangible term and thus will not be further developed in the paper.

2.4.2 A concept of risk management

Smith *et al.* (2006) provide a comprehensive description of the concept of RM and how it can be used in practice. According to the authors, risk management cannot be perceived as a tool

to predict the future, since that is rather impossible. Instead, they describe it as a tool to facilitate the project in order to make better decisions based on the information from the investment. In this way, decisions based on insufficient information can be avoided, and this will lead to better overall performance. In the literature, RM is described as a process with some predefined procedures. The scope of its definition differs among the authors, however the core information is the same. From a number of definitions which can be found in the management literature Cooper *et al.* (2005) explanation brings the essence of this concept:

The risk management process involves the systematic application of management policies, processes and procedures to the tasks of establishing the context, identifying, analyzing, assessing, treating, monitoring and communicating risks (Cooper et al., 2005).

Risk management process (RMP) is the basic principle of understanding and managing risks in a project. It consists of the main phases: identification, assessment and analysis, and response (Smith *et al.* 2006) as shown in Figure 3. All steps in RMP should be included when dealing with risks, in order to efficiently implement the process in the project. There are many variations of RMP available in literature, but most commonly described frameworks consist of those mentioned steps. In some models there is one more step added, and the majority of sources identify it as risk monitoring or review. For the purpose of this paper the model of RMP described by Smith *et al.* (2006) will be used for further analysis and will be further explained in the following section.

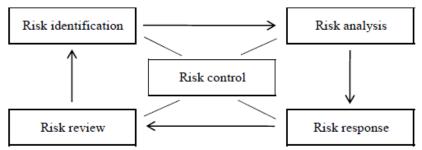


Figure 3 The Process of managing risks (Smith et al. 2006)

2.4.3 Benefits with risk management

To maximize the efficiency of risk management, the RMP should be continuously developed during the entire project. In this way, risks will be discovered and managed throughout all the phases (Smith *et al.* 2006). The benefits from RM are not only reserved for the project itself, but also for the actors involved. The main incentives are clear understanding and awareness of potential risks in the project. In other words, risk management contributes to a better view of possible consequences resulting from unmanaged risks and how to avoid them. (Thomas, 2009) Another benefit of working with risk management is increased level of control over the whole project and more efficient problem solving processes which can be supported on a more genuine basis. It results from an analysis of project conditions already in the beginning of the project. (Perry, 1986) The risk management also provides a procedure which can reduce possible and sudden surprises (Cooper *et al.* 2005).

Different attitudes towards risk can be explained as cultural differences between organizations, where the approach depends on the company's policy and their internal procedures (Webb, 2003). Within the RM, three company's approaches can be distinguished.

The first one is the risk-natural firm which does not invest much in risk management but is still aware of the most important risks. The second approach is the risk-averse, where no investments are made in order to reduce the probability of occurrence of risk. The last one is the risk-seeker where the organization is prepared to face all risks and is often called gambler. In the long term, the risk-seeking companies can get a lower profitability compared to risk-natural firms. This is because of the large investments and losses when repeating the risk management processes over and over again to ensure all risks have been managed before the risks actually occurs (Winch, 2002).

2.4.4 Limits of risk management

The level of risk is always related to the project complexity (Darnall and Preston, 2010). The fact that there are so many risks which can be identified in the construction industry, can be explained by the projects' size and their complexity. The bigger the project is, the larger the number of potential risks that may be faced. Several factors can stimulate risk occurrence. Those most often mentioned in the literature are financial, environmental (the project's surrounding, location and overall regulations), time, design and quality. Other influences on the occurrence of risk are the level of technology used and the organization's risks (Gould and Joyce, 2002).

Cleden (2009) claims that complexity is a factor that can limit a project; the bigger and more complex a project is, the more resources are required to complete it. Moreover, when all potential risks have been identified, the project team must remember that there might be more threats. Therefore, the project team should not solely focus on management of those identified risks but also be alert for any new potential risks which might arise. RM should be used as a tool to discover the majority of risks and a project manager should be also prepared for managing uncertainties not included in a RM plan (Cleden, 2009).

2.4.5 Risks in construction projects

Due to the nature of the construction sector, RM is a very important process here. It is most widely used in those projects which include high level of uncertainty. These types of risk investments are characterized by more formal planning, monitor and control processes. The easiest way to identify risk is to analyze and draw a conclusion from projects which failed in the past. To make sure that the project objectives are met, the portfolio of risks associated with all actors across the project life cycle (PLC) should be considered (Cleland and Gareis, 2006). In the early stages of the project where planning and contracting of work, together with the preliminary capital budget are being drawn, risk management procedures should be initiated. In later stages, RM applied systemically, helps to control those critical elements which can negatively impact project performance. In other words, to keep track of previously identified threats, will result in early warnings to the project manager if any of the objectives, time, cost or quality, are not being met (Tummala and Burchett, 1999).

There are a number of risks which can be identified in the construction industry and which can be faced in each construction project regardless of its size and scope. Changes in design and scope along with time frames for project completion are the most common risks for the construction sector. The further in the process, changes in scope or design are implemented, the more additional resources, time and cost, those changes require. Project completion ahead of time may be as troublesome as delays in a schedule. Too quick completion may be a result of insufficient planning or design problems which in fact shorten the completion time but on the other hand lead to a low quality of final product and increased overall cost. Being behind schedule generates greater costs for both investors and contractors due to non-compliance with contracted works (Gould and Joyce, 2002). And thus it is important to keep a balance in the concept of time-cost-quality tradeoff, which more widely is becoming an important issue for the construction sector (Zhang and Xing, 2010). Depending on the project scope, types of risks may differ among investments. Thus, a more detailed risk identification analysis for the construction sector will be a subject of one of the next chapters (2.5.1) in this paper.

2.5 The risk management process

As mentioned above, an RMP described by Smith *et al.* (2006) has been chosen for the purpose of this paper. This section will further explain the RMP, its four stages and how it can be used in managing risks.

2.5.1 Risk identification

Winch (2002) claims that the first step in the RMP is usually informal and can be performed in various ways, depending on the organization and the project team. It means that the identification of risks relies mostly on past experience that should be used in upcoming projects. In order to find the potential risks, an allocation needs to be done. This can be decided and arranged by the organization. In this case, no method is better than another, since the only purpose is to establish the possible risks in a project.

Risks and other threats can be hard to eliminate, but when they have been identified, it is easier to take actions and have control over them. If the causes of the risks have been identified and allocated before any problems occur, the risk management will be more effective (PMI, 2004). RM is not only solving problems in advance, but also being prepared for potential problems that can occur unexpectedly. Handling potential threats is not only a way to minimize losses within the project, but also a way to transfer risks into opportunities, which can lead to economical profitability, environmental and other advantages (Winch, 2002).

The purpose of identifying risks is to obtain a list with potential risks to be managed in a project (PMI, 2004). In order to find all potential risks which might impact a specific project, different techniques can be applied. It is important to use a method that the project team is most familiar with and the project will benefit from. The aim is to highlight the potential problems, in order for the project team to be aware of them. Authors describe many creative alternative methods. To systematize this process, all the methods which can be found in the literature have been put together in Table 3. (Smith *et al.* 2006; Lester, 2007; PMI, 2004)

 Table 3 Risk identification techniques

Information gathering methods	Workshops Brainstorming
	Interviews
	Questionnaires
	Benchmarking

	Consulting experts	
	Past experience	
	Delphi technique	
	Risk breakdown structure	
	Visit locations	
Documentation	Databases, historical data from similar projects	
	Templates	
	Checklists	
	Study project documentation (plan, files etc.)	
	Study specialist literature	
Research	Stakeholder analysis	
	Research assumptions	
	Research interfaces	

Lists with potential problems are created on different bases and are tailored for a certain project individually. In the literature, examples of risks can be found which can be used in creating those compilations. Possible risks which can be found in the literature are combined in Table 4. (Smith *et al.* 2006; Potts, 2008; Lester, 2007; Bing, et al, 2005; Webb, 2003; Darnall and Preston, 2010; Edwards, 1995; Jeynes, 2002)

Risk categories		
Groups:	Risks:	
	Financial	
Monetary	Economical	
	Investment	
Political	Legal	
	Political	
Environment	Environmental	
Environment	Natural, physical	
Technical	Technical	
Project	Contractual, client	

	Project objectives
	Planning, scheduling
	Construction
	Design
	Quality
	Operational
	Organizational
Human	Labor, stakeholder
	Human factors
	Cultural
Market	Market
	Safety
Safety	Security, crime
Materials	Resources
	Logistics

2.5.2 Assessment/analysis

Risk analysis is the second stage in the RMP where collected data about the potential risk are analyzed. Risk analysis can be described as short listing risks with the highest impact on the project, out of all threats mentioned in the identification phase (Cooper *et al.* 2005). Although some researchers distinguish between terms risk assessment and risk analysis and describe them as two separate processes, for the purpose of this paper, this part of RMP will be consistent with the model provided by Smith *et al.* (2006) and described as one process.

In the analysis of the identified risk, two categories of methods – qualitative and quantitative – have been developed. The qualitative methods are most applicable when risks can be placed somewhere on a descriptive scale from high to low level. The quantitative methods are used to determine the probability and impact of the risks identified and are based on numeric estimations (Winch, 2002). Companies tend to use a qualitative approach since it is more convenient to describe the risks than to quantify them (Lichtenstein, 1996). In addition, there is also one approach called semi-quantitative analysis, which combines numerical values from quantitative analysis and description of risk factors, the qualitative method (Cooper *et al.* 2005). However, this approach will not be further addressed in this paper.

Within the quantitative and qualitative categories, a number of methods which use different assumptions can be found, and it may be problematic to choose an appropriate risk assessment model for a specific project. The methods should be chosen depending on the type of risk, project scope as well as on the specific method's requirements and criteria. Regardless of the

method chosen, the desired outcome of such assessment should be reliable (Lichtenstein, 1996). Perry (1986) mentions that the selection of the right technique often depends on past experience, expertise, and nowadays it also depends on the available computer software.

Lichtenstein (1996) explains a number of factors that can influence the selection of the most appropriate methods in the risk assessment for the right purpose. It is up to each organization to decide which of these factors are the most critical for them and develop the assessment accordingly. In a survey conducted by Lichtenstein (1996), many factors were discovered, and the most important ones are listed below.

- Cost of using the method, both the employment cost and the method itself
- Adaptability, the need of adapting to the organization's requirement
- Complexity, how limited and simple the method is
- Completeness, the method needs to be feasible
- Usability, the method should be understandable to use
- Validity, the results should be valid
- Credibility

Below is a brief description of various risk analysis methods. All of these methods are used in the construction industry (Azari, 2010).

2.5.2.1 Quantitative methods

Quantitative methods need a lot of work for the analysis to be performed. The effort should be weighed against the benefits and outcomes from the chosen method, for example smaller projects may sometimes require only identification and taking action on the identified risks, while larger projects require more in depth analysis. The quantitative methods estimate the impact of a risk in a project (PMI, 2009). They are more suitable for medium and large projects due to the number of required resources such as complex software and skilled personnel (Heldman, 2005).

Scenario technique - Monte Carlo simulation

The Monte Carlo method is based on statistics which are used in a simulation to assess the risks. The simulation is used for forecasting, estimations and risk analysis by generating different scenarios (Mun, 2006). Information collected for the simulation is, for instance, historical data from previous projects. The data represent variables of schedule and costs for each small activity in a project, and may contain pessimistic, most likely and optimistic scenarios (Heldman, 2005). The simulation can be presented as a basket with golf balls, as Mun (2006) explains the process. Data (the golf balls) are mixed and one of them is picked each time the simulation is done. The chosen unit is an outcome which is recorded and the ball will be put back into the basket. The simulation is then redone a number of times and all outcomes are recorded. After completing the simulations required number of times, the average is drawn from all of the outcomes, which will constitute the forecast for the risk (Mun, 2006). The result from this method is a probability of a risk to occur, often expressed in a percentage (Darnall and Preston, 2010).

The most common way of performing the Monte Carlo simulation is to use the program Risk Simulator software, where more efficient simulations can be performed. This analysis can be also done in Microsoft Excel where a special function is used to pick the data randomly, but the results can be very limited (Mun, 2006).

Modeling technique - Sensitivity analysis

The purpose of a sensitivity analysis is to establish the risk events which have the greatest impact or value. Those events are later weighed against the objectives of the project. The higher the level of uncertainty a specific risk has, the more sensitive it is concerning the objectives. In other words, the risk events which are the most critical to the project are the most sensitive and appropriate action needs to be taken. (Heldman, 2005)

The result from the analysis can be presented in a spider diagram, Figure 4, that shows the areas in the project which are the most critical and sensitive. Moreover, one disadvantage with this analysis is that the variables are considered separately, which means that there is no connection between them (Perry, 1986 and Smith *et al.* 2006).

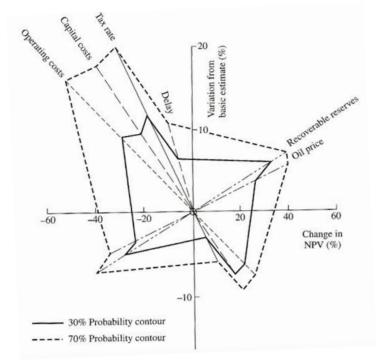


Figure 4 This figure shows how a sensitivity analysis can look like. (Smith et al. 2006)

The method requires a model of project in order to be analyzed with computer software. According to Smith *et al.* (2006), the project will benefit if the method is carried out in the project's initial phases in order to focus on critical areas during the project.

Diagramming technique

Decision tree analyses are commonly used when certain risks have an exceptionally high impact on the two main project objectives: time and cost (Heldman, 2005). There are two types of decisions trees; called Fault tree analysis (FTA) and Event tree analysis (ETA).

The FTA method of analysis is used to determine the probability of the risk and is used to identify risks that can contribute or cause a failure of one event (Cooper *et al.* 2005). The purpose is to find the underlying causes to this event. It is usually drawn up as a sketch of a tree. The branches are the causes to the problem, and the starting point of the tree is the problem itself. Each branch has its own sequence of events and possible outcomes. The problem could depend on some causes that are interrelated with each other, or simply random

causes (Cooper *et al.* 2005). By having many branches, the tree provides an opportunity to choose which branch to follow and base decisions on, see Figure 5 (Heldman, 2005).

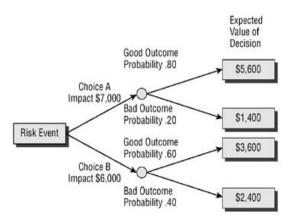


Figure 5 An example of a decision tree (Heldman, 2005)

Fault tree analysis (FTA) and a similar analysis called event tree analysis (ETA), are simple methods which can be used as a structured model to identify causes and effects of a single event, but present different approaches (White, 1995).

As explained, ETA is very similar to the FTA, but what differentiates the methods is the outcome. ETA is also drawn as a tree but in an opposite approach than the FTA. According to White (1995), failure generally does not has its roots in a single cause. It is rather described as a chain of causes and consequences in a sequence which can end up in major damage for the project. The tree consists of branches which represent the consequences that can be followed by that main event that this method is analyzing. Every branch has its own focus on a specific type of causes, which is why the importance is so great to create a risk assessment. (White, 1995)

In both FTA and ETA, cause-effect skills are required including the possibility to understand how failure could occur and see which failure modes can arise from the situation respectively. Therefore it is preferable to have an analyst within the field of risk management in the project team (White, 1995).

2.5.2.2 Qualitative methods

Qualitative methods for risk assessment are based on descriptive scales, and are used for describing the likelihood and impact of a risk. These relatively simple techniques apply when quick assessment is required (Cooper *et al.* 2005) in small and medium size projects (Heldman, 2005). Moreover, this method is often used in case of inadequate, limited or unavailable numerical data as well as limited resources of time and money (Radu, 2009). The main aim is to prioritize potential threats in order to identify those of greatest impact on the project (Cooper *et al.* 2005), and by focusing on those threats, improve the project's overall performance (PMI, 2004). The complexity of scales (Cooper *et al.* 2005) and definitions (PMI, 2004) used in this examination reflect the project's size and its objectives. During the phases of the PLC, risks may change, and thus continuous risk assessment helps to establish actual risk status (Cooper *et al.* 2005).

Limitations of qualitative methods lie in the accuracy of the data needed to provide credible analysis. In order for the risk analysis to be of use for the project team, the accuracy, quality, reliability, and integrity of the information as well as understanding the risk is essential. Qualitative methods are related to the quantitative methods, and in some cases constitute its foundations (PMI, 2004).

PMI (2004) identifies four qualitative methods for risk assessment: Risk probability and impact assessment, Probability/impact risk rating matrix, Risk Categorization and Risk Urgency Assessment. These methods are briefly discussed below.

Risk probability and impact assessment

By applying the method called risk probability and impact assessment, the likelihood of a specific risk to occur is evaluated. Furthermore, risk impact on a project's objectives is assessed regarding its positive effects for opportunities, as well as negative effects which result from threats. For the purpose of this assessment, probability and impact should be defined and tailored to a particular project (PMI, 2004). This means that clear definitions of scale should be drawn up and its scope depends on the project's nature, criteria and objectives (Cooper *et al.* 2005). PMI (2004) identifies exemplary range of probability from 'very unlikely' to 'almost certain', however, corresponding numerical assessment is admissible. The impact scale varies from 'very low' to 'very high'. Moreover, as shown in Figure 6, assessing impact of project factors like time, cost or quality requires further definitions of each degree in scale to be drawn up. Each risk listed under the identification phase is assessed in terms of the probability and the impact of its occurrence (PMI, 2004).

	Relative or numerical scales are shown				
Project Objective	Very low /.05	Low /.10	Moderate /.20	High /.40	Very high /.80
Cost	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost lincrease
Time	Insignificant time increase	<5% time increase	5-10% time increase	10-20% time ilncrease	>20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end iten is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

Figure 6 Definition of Impact Scales for Four Project Objectives (PMI, 2004)

Risk impact assessment investigates the potential effect on a project objective such as time, cost, scope, or quality. Risk probability assessment investigates the likelihood of each specific risk to occur. The level of probability for each risk and its impact on each objective is evaluated during an interview or meeting. Explanatory detail, including assumptions justifying the levels assigned, are also recorded. Risk probabilities and impacts are rated according to the definitions given in the risk management plan. Sometimes, risks with obviously low ratings of probability and impact will not be rated, but will be included on a watch-list for future monitoring (Ritter, 2008).

Probability/impact risk rating matrix

Probability and impact, which were assessed in the previous step, are used as basis for quantitative analysis and risk response which will be explained further in the paper. For this reason findings from the assessment are prioritized by using various methods of calculation which can be found in the literature (PMI, 2004). Westland (2006) computes the priority score as the average of the probability and impact. The range of priority score, the rating and color are assigned to indicate the importance of each risk (Westland, 2006). In order to set priorities, impact is multiplied by probability. The compiled results are shown in the matrix in Figure 7(PMI, 2004). Such combination of factors indicates which risks are of low, moderate or high priority. Regardless of the calculation method chosen, such a combination of data shows priority of previously identified risks by use of i.e. corresponding colors or numerical system and helps to assign appropriate risk response. For instance, threats with high impact and likelihood are identified as high-risk and may require immediate response, while low priority score threats can be monitored with action being taken only if, or when, needed (PMI, 2004).

Probability and Impact Matrix											
Probability	Threats					Opportunities					
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05	
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04	
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03	
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02	
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01	
	0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05	
threshold	Impact (ratio scale) on an objective (e.g., cost, time, scope or quality) Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.										

Figure 7 Probability and Impact Matrix (PMI, 2004)

Risk categorization, and Risk Urgency Assessment

Two methods mentioned by PMI (2004) are not as commonly used as probability and impact. Risk categorization is a way of systematizing project threats according to e.g. their sources, in order to identify areas of the project that are most exposed to those risks. Tools which can be used in this method are work break down structure (WBS) or risk breakdown structure (RBS), and their role is to develop effective risk response (PMI, 2004). WBS breaks down large activities into small, manageable units and creates linked, hierarchical series of independent activities (Maylor, 2005). RBS categorizes risks and shows their dependencies (Dallas, 2006). The role of the second method, Risk Urgency Assessment, is to prioritize risks according to how quick response they require.

Lists with risks prioritized by applying qualitative methods, can be used to bring attention to significant problems to the project. Problems that are classified as a medium level risks can be a subject of a quantitative analysis to have better control over them. The threats that are assessed as low impact can be placed on a watch list and monitored. It will allow the project

team to focus on more important issues. Risk categorization helps reveal the weak links in the project organization where more attention should be directed (PMI, 2004).

2.5.3 Risk response

This third step of the RMP indicates what action should be taken towards the identified risks and threats. The response strategy and approach chosen depend on the kind of risks concerned (Winch, 2002). Other requirements are that the risk needs to have a supervisor to monitor the development of the response, which will be agreed by the actors involved in this risk management process. (PMI, 2004)

Winch (2002) claims that the lower impact the risk has, the better it can be managed. Most common strategies for risk response are: avoidance, reduction, transfer and retention (Potts, 2008). Beyond those types of responses, Winch (2002) describes that sometimes it is difficult to take a decision based on too little information. This may be avoided by waiting until the appropriate information is available in order to deal with the risk. This way of acting is called 'Delay the decision' but this approach is not appropriate in all situations, especially when handling critical risks. Those need to be managed earlier in the process.

2.5.3.1 Avoidance/prevention

If the risk is classified as bringing negative consequences to the whole project, it is of importance to review the project's aim. In other words, if the risk has significant impact on the project, the best solution is to avoid it by changing the scope of the project or, worst scenario, cancel it. There are many potential risks that a project can be exposed to, and which can impact its success (Potts, 2008). This is why risk management is required in the early stages of a project instead of dealing with the damage after the occurrence of the risk (PMI, 2004).

The avoidance means that by looking at alternatives in the project, many risks can be eliminated. If major changes are required in the project in order to avoid risks, Darnall and Preston (2010) suggest applying known and well developed strategies instead of new ones, even if the new ones may appear to be more cost efficient. In this way, the risks can be avoided and work can proceed smoothly because strategy is less stressful to the users.

Cooper et al. (2005) list some activities that can help to avoid potential risk:

- More detailed planning
- Alternative approaches
- Protection and safety systems
- Operation reviews
- Regular inspections
- Training and skills enhancement
- Permits to work
- Procedural changes
- Preventive maintenance

2.5.3.2 Reduction/mitigation

By having an overview over the whole project it is easy to identify problems which are causing damage. In order to reduce the level of risk, the exposed areas should be changed (Potts, 2008). This is a way of minimizing the potential risks by mitigating their likelihood (Thomas, 2009). One way to reduce risks in a project is to add expenditures that can provide benefits in the long term. Some projects invest in guarantees or hire experts to manage high-risk activities. Those experts may find solutions that the project team has not considered (Darnall and Preston, 2010).

Mitigation strategies can, according to Cooper et al. (2005), include:

- Contingency planning
- Quality assurance
- Separation or relocation of activities and resources
- Contract terms and conditions
- Crisis management and disaster recovery plans

Those risks which should be reduced can also be shared with parties that have more appropriate resources and knowledge about the consequences (Thomas, 2009). Sharing can also be an alternative, by cooperating with other parties. In this way, one project team can take advantage of another's resources and experience. It is a way to share responsibilities concerning risks in the project (Darnall and Preston, 2010).

2.5.3.3 Transfer

If a risk can be managed by another actor who has a greater capability or capacity, the best option is to transfer it. Potts (2008) states that the risk should be transferred to those who know how to manage it. The actors that the risks can be transferred to are, for example, the client, contractor, subcontractor, designer etc, depending on the risk's character. As a result this could lead to higher costs and additional work, usually called risk premium (Potts, 2008). It must be recognized that the risk is not eliminated, it is only transferred to the party that is best able to manage it (PMI, 2004). Shifting risks and the negative impacts they bring is also an option when the risks are outside the project management's control, for example political issues or labor strikes (Darnall and Preston, 2010). The situation may also consist of catastrophes that are rare and unpredictable in a certain environment. (Winch, 2002) Such risks that are beyond the management's control should be transferred through insurance policies.

2.5.3.4 Retention

When a risk cannot be transferred or avoided, the best solution is to retain the risk. In this case the risk must be controlled, in order to minimize the impact of its occurrence (Potts, 2008). Retention can also be an option when other solutions are uneconomical (Thomas, 2009).

2.5.4 Monitoring

This final step of RMP is vital since all information about the identified risks is collected and monitored (Winch, 2002). The continuous supervision over the RMP helps to discover new risks, keep track of identified risks and eliminate past risks from the risk assessment and

project (PMI, 2004). PMI (2004) also states that the assumptions for monitoring and controlling are to supervise the status of the risks and take corrective actions if needed.

Tools and techniques used to risk monitor and control may be (PMI, 2004):

- Risk reassessment identification of new potential risks. This is a constantly repeated process throughout the whole project.
- Monitoring of the overall project status are there any changes in the project that can effect and cause new possible risks?
- Status meetings discussions with risk's owner, share experience and helping managing the risks.
- Risk register updates

By managing the whole RMP, the process can be evaluated. This is a method of creating a risk register where all risks and their management can be allocated in order to facilitate future projects (PMI, 2004). This is also a way to improve the project work, since the advantages and disadvantages will be brought up.

3 Method and materials

A research process consists of a number of sequential steps. It begins with finding the research area and formulating research questions. Further, the investigation method should be chosen along with research design and data collection techniques. Finally, the collected data is analyzed and interpreted what leads to drawing conclusions. (Bryman and Bell, 2003)

The research method is a technique for collecting data which can involve specific instruments such as self-completion questionnaires or structured interview. For the purpose of this master thesis a qualitative research method has been chosen to provide a description of how people experience the application of RM in the complex project organization. According to Morgan and Smircich (1980) the choice of the method should be made based on the nature of the research problem. Qualitative methods are based on the facts which are socially constructed rather than objectively and are based on peoples' experience (Noor, 2008). Qualitative research is an inductive approach where theories are generated out of collected data (Bryman and Bell, 2003). Thus this method is most appropriate for this thesis since it uses people's experience.

In order to understand and examine the application of RM in a project organization, the case was chosen study as a research design. Case study is one form of research design (Bryman and Bell, 2003) and is not intended as a study of the entire organization. Its purpose is to focus on a particular issue, feature or unit of analysis (Noor, 2008) and consists of direct observation of the study (Yin, 2009). The case study in this thesis is a construction project of a school. The school burned down to the ground in 2009 and needed to be rebuilt. The project was intended to last for 3 years. Due to the limited time for the research in this study, our observations were made only for the project's initial stage. Many actors with various backgrounds were involved in the project and it thus was interesting to see how RM can be applied in such a complex organization.

Further to collect data, semi- structured interviews were chosen in order to obtain most accurate answers based on the interviewees' opinion and experience, and to facilitate further analysis. The interview is an insightful tool which focuses directly on the studied topics but also includes bias and can be manipulative. Interviewing is one of the most common sources for collecting qualitative data (Yin, 2009). There are a number of different types of interviews and some of them are more applicable to one method then to the other. For instance the most common types, structured or semi-structured interview, are most often used in qualitative research. In the semi-structured form, the interviewer prepares a number of questions that are in the general form of an interview schedule. It is standardized in order to minimize differences between interviews within one project. Moreover, the sequence of questions may vary and the follow up questions can be asked in response to some significant replies (Brymann and Bell, 2003).

3.1 Data collection

In order to collect appropriate data for the study, different sources have been used. For the theoretical background, a literature study has been conducted, using both scientific articles written by professionals in the field as well as books in the area of project and risk management.

3.2 Case study and interviews

To determine how RM theories are used in practice, a construction project of a school was used as a case study. Next, to get an overview of RM practices used by different professionals, all parties participating in the project were asked to take part in the research. An inquiry was sent by e-mail to all 27 parties and answers/acceptance to an interview were received from seven recipients out of the total 27. The respondents were engineer, architect, client, final users and project managers. As a result, seven semi-structured interviews were conducted with people who had an active role in the project, Each interview took approximately 40 minutes. The interviews were held in Swedish in order to obtain as much information as possible and avoid misinterpretation that could occur had the interview been held in English. The whole interviews were also recorded so that the correct information would be available for use in this research, as well as provide the possibility to go back to analyze in detail what the respondents really said. The respondents were asked if they would like the interview to be recorded, and all interviewees agreed to this.

Questions were formulated in a way to determine how RM is used in practice and how familiar the actors in the project are with this concept. It was important to establish during the interview in which phase of the PLC the actors were taking an active part in, and their role in the project. This information was necessary in order to ensure that representatives of each project phase would be interviewed to get the picture of risk in the whole project. Based on this information, all respondents were, among other things, asked to identify the greatest risks in each phase they operate in and type of response taken against it. The actual questions used in the interview are listed in Appendix 1.

As a follow up to the interview, an on-line questionnaire was sent out to each respondent, and the answers were used to demonstrate how one of the RM methods can be used in practice. For this purpose, one of the qualitative RM methods, probability and impact assessment, was chosen. The respondents were asked to answer four questions with pre-defined answers regarding each risk they identified in the main interview. The number of identified risks had varied among respondents and thus sent out questionnaires consisted number of questions. Firstly, respondents were asked to evaluate the probability of risk occurrence. In three other questions impact on time, cost and quality was evaluated separately. The scale used for assessing probability was from 0.1 (low probability) to 0.9 (high probability) and the possible choices were 0.1, 0.3, 0.5, 0.7, and 0.9. Whereas impact was evaluated in a range from 0.05 (low impact) to 0.8 (high impact) and the possible choices were 0.05, 0.10, 0.20, 0.40, and 0.80. The same scale was used to evaluate impact on all three project objectives. The results were later combined in a matrix and used for further analysis.

3.3 Limitations

The project used in the case study was in its initial stage. Thus, the collected information does not give the holistic overview of risk in the project, even though some of the respondents were going to be present under the whole project duration.

4 Results

The results are the findings from the case study. The description of the project is followed by the results from the conducted interviews.

4.1 Project description

The project used in this case study is a school located in the Gothenburg area. At the time of investigation, the investment was in its initial stage where plans, layouts and documentation were being prepared. The project duration was estimated to be approximately 2.5 years, and started in the end of 2010. The temporary organization formed for the purpose of the school construction involved a number of professionals from the municipality as well as from the construction industry. The actual project structure is presented in Figure 8.

The vision for the project was to deliver it with '0 errors'. It was believed that if the team could decrease the number of errors in the initial phases, then the operational phases should proceed without any major problems. Setting such a vision was supposed to help to deliver the project on time, budget and to the right quality. The project team did not work with RM, but were interested in learning more about the concept. Due to the advancement of the project at the time of research, it is not possible to say if the "0 errors" vision had been eventually achieved.

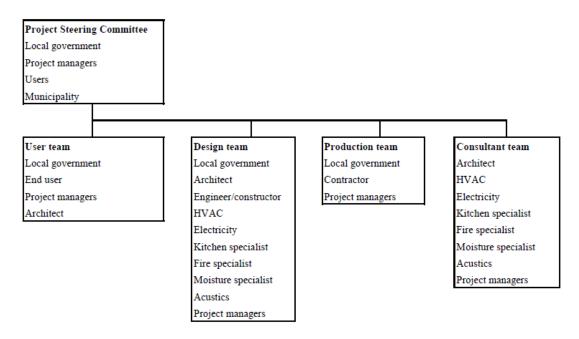


Figure 8 Organization chart over the case study

4.2 The PLC

The PLC used in the project was adapted from the model presented by Bennett (2003), which divides the PLC into six phases. The chosen PLC was a typical model used for construction projects. The actual time plan of the school project was combined together with the theoretical PLC in a graphic way in order to show the project duration in a systematic way (see Figure 9). Such combination was also necessary to make sure that people from different phases of PLC had been interviewed in the case study. The fact that actual project schedule fit the PLC, is

close to Smith *et al.* (2006) theory where the combination of the PLC depends on the project type.

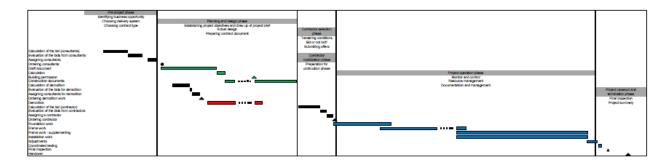


Figure 9 PLC in the top vs the actual project time schedule, where the colors represent different activities in the project.

The conducted interviews revealed how RM is used in practice and how actors in the project are familiar with this concept. This part presents results obtained from the research and relations between risk practices applied by the engineer, architect, client, users and project managers in the project environment. The respondents represented each phase of the PLC and their roles varied from active to passive, depending on the project stage. Most of the interviewed professionals were active only in the two first phases, the pre-project phase and the planning and design phase, and more passive during rest of the project. In this case, being passive means to provide support or supervision in order to monitor and control the project progress. Figure 10 presents graphically how those roles change over PLC.

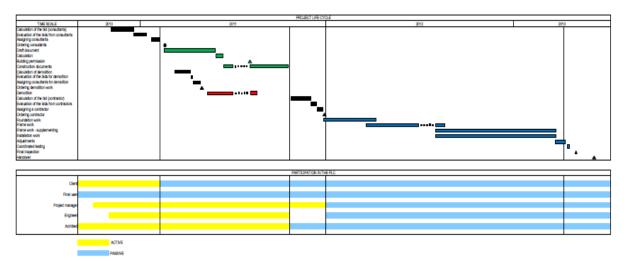


Figure 10 The PLC of the case study combined with the roles of the interviewees. The yellow bars represent a active role and the blue bars, a passive role.

4.3 Risk definition

Within the construction industry, RM is a concept which is very rarely used in the structured form as mentioned in the literature. Actors within the studied project perceived risk and RMP

in various ways. While asking what a risk meant to them, the word was defined as a difficulty, uncertainty, threat, unpredictable event or danger, but also more descriptive as challenging the project success, obstacles on the way to achieve the set goal or not meeting the project objectives. An interesting observation was that everyone perceived risk as something negative which should be avoided.

4.4 The RMP

Figure 11, provides a summary of the literature research, in order to facilitate the use of the RMP. All four steps are included and are placed on the left hand side. On the right, the follow up procedures are listed to clarify some of the techniques used to manage the risks in the most effective way. By following the arrows on the graph, all the necessary steps of RM will be performed. This process should be continuously performed throughout the whole project in order to keep track of all potential risks.

Further, the knowledge of RMP was examined in the interviews. Only few respondents were familiar with this concept and knew some of its elements. The others described similar but not such systematized processes used in their everyday life or work situations. In other words, risk management was not described as the structured form of identification, analysis, response and monitor, but rather as a process of managing risk. It could be assumed that everybody was using RM but not always was aware of it.

Only one of the interviewees was familiar with RMP in the structured way as presented in the literature, because it was used in one of the previously performed project the interviewee had taken part in. The reason for not using the RMP, according to all interviewees, was the lack of knowledge in this field. A remark from one of the respondents was "I think it is more common to use RM within infrastructure projects rather than residential". The reason was that there are more funds designated for infrastructure projects since they are characterized by the high level of complexity and a number of risks associated with them.

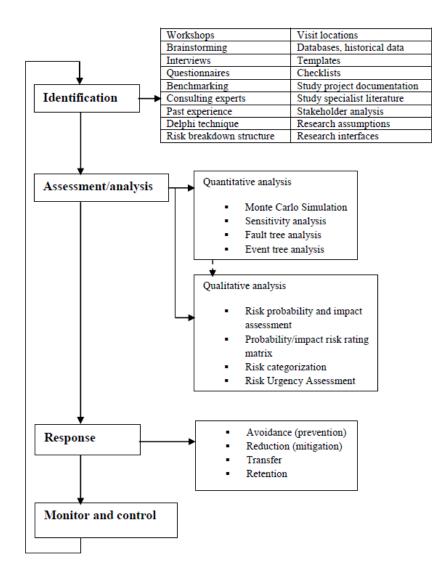


Figure 11 A coherent picture of how to manage risks

4.4.1 Risk identification

Experience was the most frequent answer to questions about risk identification methods. Previous projects were considered by respondents to be a great source of potential risks. Another way of discovering possible risks was to analyze future consequences already in early stages of the project or as this interviewee expressed it: "imagine how it is going to be in reality". This respondent wanted to deal with problems before it would be too late. Therefore it was important to raise awareness in early stages where actions are still possible to change.

While identifying risks within the actors' organizations, more structural techniques were mentioned. Checklists and manuals were commonly used documented forms of risk identification on the organizational level. Discussions and experience were commonly used as information gathering methods while observations and learning were identified as additional forms of identification.

One respondent mentioned that his organization was certified according to ISO standardization, which indicates that quality is ensured in the performed project. It was explained as "there is for example risk evaluation for the bidding process" in this standardization, which indicates that RM is included to a small extent, and can be used as a checklist in projects, and function as a risk tool.

The techniques used for identifying risks in this specific project varied among the respondents. Since the project was relatively large with several actors engaged in it, the majority of work depended on cooperation between them. Therefore, discussions were the most widely used tools used to identify risks in the project. Another tool was a self control which was constantly performed. Further experience was mentioned as a main source of potential risks which could occur in the current project. One of the interviewees explained that "by experience you will get more knowledge" and knowledge is vital in future projects. Checklists and manuals were applied by those who provided technical services in the project, while the practitioners used more detailed precision in their work. Observation was one more technique that was brought up, as another tool to identify risks.

As a follow up to risk identification techniques, all respondents were asked to identify the biggest risks in each phase of the project they were operating in. The results are presented in Table 5 which can be found under 'risk response' paragraph below.

4.4.2 Risk assessment

To manage and analyze the potential risks, the most widely used tool was discussion. The risks were primarily managed within the actor's organization concerning only the scope of worked assigned, then later managed and consulted with the other members of the project team. Within the project, there had been few meetings organized where risk issues were raised. The purpose was to consult the problems with experts from the field in which the problem was identified. Systemizing and mapping were those only techniques of handling risk used at those meetings.

Furthermore, interviews revealed that respondents were using a variety of methods to prioritize already identified risks. The most common way was to set criteria in order to rank the most critical risks. The type of criteria used depended on the profession of the actor. Based on the created pattern, all potential risks were then listed and put in order. An example of the order obtained from prioritizing risks was the economy related problems which were ranked higher in the hierarchy than the time related problems. One respondent identified resources, economy and technical aspects as the set of criteria used in all projects undertaken by his organization. Another example of hierarchy used in this process was needs of the end users over needs of secondary ones. In this particular case, the first group was represented by students who would be attending the school while the other group was their parents and school staff. The respondent who used such a hierarchy also thought that the economy related problems are extremely important regardless of the project type. Moreover the economy related category was mentioned by all respondents as the most important factor to prioritize risks in the project.

The other way to prioritize risks within the project was a discussion which involves more than two actors. Most respondents declared that they use experience from previous projects to facilitate discussions. Moreover, such discourse was used as a tool to alert other participants about potential risks and by discussing prioritize these which had the biggest impact on the project.

Only one of the respondents was familiar with the structured RM methods, but had knowledge only about one of them. The other interviewed actors were not aware that such methods

existed and that they could be used for the evaluation of risks. Nevertheless, all of the respondents agreed that they had never tried to learn any of the RM techniques. For many years, risks have been managed in other ways within their organizations, and any supportive methods seemed not to be needed.

In addition, the respondents declared that they could start implementing methods, if only they had more information about methods in general and a guide for how to use them. All interviewed professionals were willing to learn more about RMP although they needed to be sure that the effort spent on applying it would pay off. The most expected incentive was to improve the overall performance of the project. In addition, the respondents would like to see methods as a tool to have control over the situation. In other words, the methods should facilitate improvements and help to avoid surprises. In brief, all respondents believed in better results and project performance as a result of implementing structured methods. Furthermore one respondent mentioned some other techniques used to analyze risks, which are used to evaluate and follow up the area of problems. Although those techniques are not the same as the ones used within the construction industry.

4.4.3 Risk response

As emerged from the interviews, dealing with risks was performed in rather unstructured ways. Whereas some organizations had procedures or used checklists to minimize risks, others felt more comfortable with transferring it to experts in the relevant area. Moreover, a discussion had again been mentioned as yet another tool used to mitigate the problem.

Further on, for each problem identified during the interview, respondents were asked to propose an action which should be taken in order to respond to the risk. The results are gathered in Table 5.

Table 5 Risk identification and response from the interviews

DL O					RESPONSE
PLC		PHASE NO TYPE OF RISK		TYPE OF RESPONSE	DESCRIPTION
lase	Identifying business		misunderstand the client	mitigate	Frequent discussions with the client.
	opportunity		Miscalculation [1]	mitigate	Detailed discussions with the client
Pre-project phase	Choosing delivery system	1	Miscalculation [2]	mitigate	checklists
Pre	Choosing contract type		choosing not the right consultants [1]	mitigate	check up on the companies
	Choosing contract type		choosing not the right consultants [2]	retain	biding process is regulated by law and they have no impact on it
	Establishing project objectives and draw up		lack of cooperation between actors in the project	mitigate	facilitate cooperation by organizing project team meetings
	of project brief		Shortage in resources	mitigate	making adjustments in a number of resources used in order to fit in the schedule
gn phase		2	cheap, not efficient solutions which can be more expensive over time	mitigate	By being active in the project and questioning unclear issues
Planning and design phase	Actual design		problems with design	transfer	Transferring risk by involving experts in the process
Planning			users do not take decisions necessary for work progress	mitigate	make a pressure for decisions being make on time
	Preparing contract documents		not achieve a good final result	mitigate	highlight all potential risks or problems on the workshop or a meeting
			gap of knowledge	mitigate	Being active in the process and take an action when any problem occurs
ion phase	Setting tender conditions by the owner		Not finding the right contractor [1]	avoid	make sure that the contractor has enough knowledge and resources to perform the project
Contractor selection phase	Contractors decisions whether to bid or not Submitting offers		Not finding the right contractor [2]	mitigate	check up on the companies
Contractor mobilisatio n phase	Preparation for construction phase		Not finding the right contractor [3]	mitigate	well prepared bidding requirements
	Monitor and control	-	contractor has not enough knowledge or experience	avoid	well prepared procurement
phase			moisture	mitigate	involve specialists from the field
Project operation phase	Resource management		loosing control over the project	mitigate	using quality systems and self control
Project	Documentation and		Delays in construction schedule	mitigate	Being active in the process and take an action when any problem occurs
	management		Delays in construction schedule	transfer	transfer risk to the project team
Project cbseout and termination phase	Final inspections	- 5			
Project and teri ph:	Project summary 5				

4.5 Risks handled in the project

The respondents shared different opinions of how risks were managed within the project. Although everyone agreed that no structured way of working with risk was established. It was the responsibility of the individual organization to manage their own risks identified in the project. However, this did not mean that risk was ignored. An activity which gave a chance to exchange experience and raise potential problems was a project kick-off, an introduction to the project involving all participants. At that meeting, all actors involved in the initial stage of the project were discussing issues related to the project. Furthermore, some actors worked with specific checklists and manuals which are considered to be RM tools.

A more specific way of handling risk is modeling in 3D. This tool was used in the school project by those actors who worked with the technical aspects, i.e. architects, engineers, client etc. It helped to avoid problems with design and let the final product be seen in an early project stage. In addition, any potential problems which emerge in the design process with help of 3D modeling could be handled in advance.

4.6 The vision of "0 errors" in the project

All respondents complied with the '0 errors' vision but at the same time they believed that delivering absolute '0 errors' project in the construction sector was not possible. Thus, everyone made their own definition of it. Thus, the aim for most respondents was to avoid any bigger defects in the project.

To avoid the larger errors, all actors found communication to be the key to the success. It could be achieved by closer cooperation in the project team and helping each other. Moreover, awareness of potential risks and being active helped to deliver a project with a number of errors close to zero.

4.7 Application of the probability and impact method

As mentioned in the Method section, an online questionnaire was sent out as a follow up to the interviews. The main goal was to focus on the previously identified risks, in order to put in a probability and impact matrix and show an example of an RMP method. The respondents were asked to evaluate the probability of the risk's occurrence as well as the impact on time, cost and quality. The scale used for this assessment was adapted from the PMI (2004) book and is presented in Table 6 and Table 7 for probability and impact respectively.

Table	6	Probability
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PROBABILITY	Very low	Low	Moderate	High	Very high
RISK A	0.1	0.3	0.5	0.7	0.9

IDENTIFIED RISK	PROJECT OBJECTIVE	Very low (0.05)	Low (0.10)	Moderate (0.20)	High (0.40)	Very high (0.80)
	COST	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost increase
RISK A	TIME	Insignificant time increase	<5% time increase	5-10% time increase	10-20% time increase	>20% time increase
	QUALITY	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

Table 7 Impact on time cost and quality

Depending on the type of probability, a rate between 0 and 1 is assigned to the risk. This number is multiplied together with the rate of impact in order to get a result. This is done in Table 8 which also shows the level of the risk. Risks marked in the right upper corner are the risks with the greatest negative impact on the project performance. On the other hand, risks marked in the left bottom corner are categorized with low influence on the project. The remaining risks in the middle of the matrix are classified as a moderate level where the risks should be concerned, but not as extreme as the most negative risks. From this matrix, it is easy to reflect over which action to take against an evaluated risk. All risks will be ranked which facilitates to alert the most critical ones.

0,80	0,080	0,240	0,400	0,560	0,720
0,40	0,040	0,120	0,200	0,280	0,360
0,20	0,020	0,060	0,100	0,140	0,180
0,10	0,010	0,030	0,050	0,070	0,090
0,05	0,005	0,015	0,025	0,035	0,045
IMPACT↑ PROBABILITY→	0,1	0,3	0,5	0,7	0,9

Table 8 Matrix

Finally, the results were combined in a table (Table 9) based on a matrix above. Risks marked with red color, see Table 8 (right upper corner of the table) are those with the biggest negative impact on the project performance. To systemize the most critical risks regarding time, cost and quality the results are shown on three separate graphs. Figure 12 shows the most critical risks which impact time, while Figure 13 and Figure 14 present the same results for cost and quality respectively. Risks located in the upper right corner of each graph are those most critical ones, while those located in the left lower corner were identified as having minor impact.

The numbers in brackets are used when more than one respondent gave the same answer.

Table 9 Evaluation results

IDENTIFIED RISK	PROJECT OBJECTIVE	PROBABILITY	IMPACT	MATRIX
	COST		0,10	0,030
M isunderstand the client	TIME	0,3	0,10	0,030
	QUALITY	T T	0,20	0,060
	COST		0,20	0,140
Lack of cooperation between	TIME	0,7	0,20	0,140
actors in the project	QUALITY	† ′ †	0,05	0,035
	COST		0,10	0,030
Not finding the right	TIME	0,3	0,10	0,030
contractor [1]	QUALITY	0,5	,	0,120
			0,05	,
Contractor has not enough	COST	+ . +	0,10	0,010
knowledge or experience	TIME	0,1	0,40	0,040
	QUALITY		0,05	0,005
	COST	ļ	0,40	0,120
Miscalculation [1]	TIME	0,3	0,20	0,060
	QUALITY		0,05	0,015
	COST		0,20	0,100
Shortage in resources	TIME	0,5	0,20	0,100
	QUALITY	t f	0,05	0,025
	COST		0,80	0,400
Delays in construction	TIME	0,5	0,80	0,400
schedule [1]	QUALITY	+ ^{0,0} +	0,00	0,400
	COST			, ,
Cheap, not efficient	1		0,80	0,720
solutions which can be more expensive over time	TIME	0,9	0,80	0,720
expensive over time	QUALITY		0,40	0,360
Delays in construction	COST	↓ ↓	0,05	0,025
schedule [2]	TIME	0,5	0,40	0,200
	QUALITY		0,20	0,100
	COST		0,10	0,050
Gap of knowledge	TIME	0,5	0,10	0,050
	QUALITY		0,05	0,025
	COST		0,20	0,100
Miscalculation [2]	TIME	0,5	0,80	0,400
	QUALITY		0,10	0,050
	COST	0,3	0,10	0,050
Problems with design	TIME			
FIODICIIS WILL design			0,10	0,050
	QUALITY		0,05	0,025
Choosing not the right	COST	0,5	0,40	0,200
consultants [1]	TIME		0,40	0,200
	QUALITY		0,80	0,400
Users do not take	COST		0,20	0,100
decisions necessary for	TIME	0,5	0,80	0,400
work progress	QUALITY		0,80	0,400
	COST		0,40	0,200
Not finding the right	TIME	0,7	0,80	0,400
contractor [2]	QUALITY	t †	0,80	0,400
	COST		0,80	0,400
Moisture	TIME	0,5	0,00	0,200
	QUALITY	0,0	0,40	0,200
Choosing not the right	COST	+	0,20	0,100
consultants [2]	TIME	0,3	0,10	0,050
	QUALITY		0,20	0,100
Not achieve a good final	COST		0,20	0,100
result	TIME	0,3	0,10	0,050
	QUALITY		0,20	0,100
	COST		0,20	0,100
		0,1	0,10	0,050
Not finding the right	TIME	0,1		
Not finding the right contractor [3]		0,1		0.050
	QUALITY	0,1	0,10	0,050
		0,1		0,050 0,025 0,025

TIME MATRIX

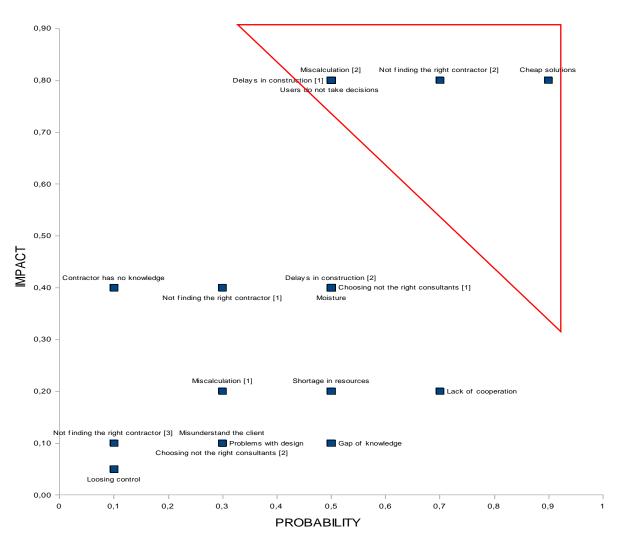


Figure 12 Time matrix

Regarding the risks which were identified in the interviews, some were more critical than others according to the interviewees' evaluation. In this case, miscalculation in the bidding process for the consultants and not finding the right contractor have been evaluated as the high risk problems that might occur and could cause delays in the time schedule. As soon as they are under control, the time delays can be prevented. This is one major benefit while doing such a risk assessment, it shows where to put focus on in order to keep the project running without interrupting and to have control. COST MATRIX

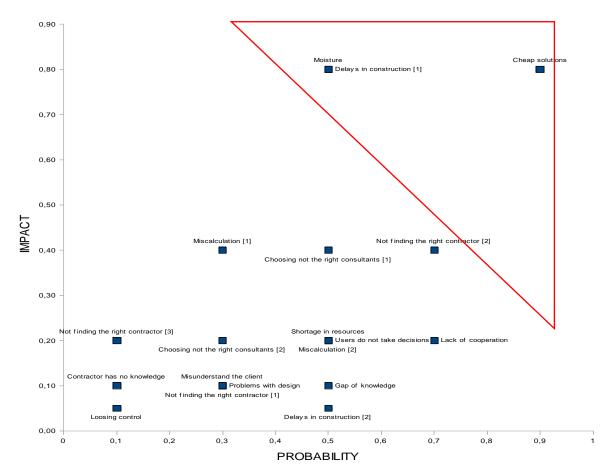


Figure 13 Cost matrix

Critical risks that affect the cost aspect are, for example, moisture and cheap solutions. If there is no attention paid to these risks means that they could result in additional costs for the project.

QUALITY MATRIX

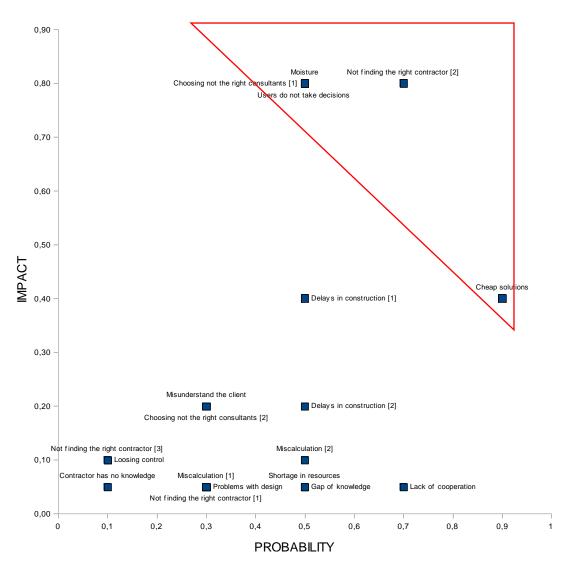


Figure 14 Quality matrix

The risks that can challenge the quality of the project are, in this example, moisture and not finding the right contractor. The mentioned risks are large risks that can affect the project to a large extent. For example, if the right and appropriate contractor is not found, then the quality can be affected in a negative way, which can result in the client not handing over a project according to the requirements and expectations. Therefore, it is important to deal with the risks when they are still manageable in order to deliver what the client wants and within the project objectives. It is the reason for why the three objectives – cost, time and quality – have been inspected and evaluated in this case study. Of course, there are many other risks that can occur in this project, but due to the limited research, only these risks in the matrixes have been brought up. The ideal scenario would be that all major and potential risks are evaluated to facilitate the way to success for the project.

5 Discussion

In this chapter of the thesis, the research questions will be answered based on the case study with comparison to the theory.

5.1 How are risks and risk management perceived in a construction project?

RM is explained as a structured way of managing risks and other threats in daily work. This is of great importance in the construction industry where projects are often exposed to uncertainties and risks. According to the theory, following all steps of the RMP facilitates achieving success with a project. For everyone who has been studying construction management, RM is recognized as a widely used concept and is emphasized in many courses. But when investigating the concept in practice, there are not many who understand the meaning and content of RM. Surprisingly, actors operating in the construction industry are not even familiar with the expression 'risk'. Findings from the interviews showed that the term risk was more understood as an undesired event, problem or threat that makes it difficult to achieve project objectives. The same result was obtained by Klemetti (2006) who reports that respondents considered risk as a negative concept. However as implied by Webb (2003), risk can be both positive and negative in its effect, which contradicts our respondents' opinion that risk can have only negative consequences.

In fact, many companies in the construction industry tend to adapt RM to only some extent. As was mentioned in the theory, organizations can have different approaches regarding how and to what extent risks are handled. Those main concepts were risk-averse, risk-natural and risk-seeker. Again, organizations within the construction industry do not work with RM in such a structured way, which means that there are some other ways of managing risks when it occurs. This shows that the industry is risk-natural, and corresponds with the research done by Lyons and Skitmore (2004), who also found this approach to be the most common within the sector.

Another point is that most respondents were not familiar neither with the concept of RM nor any methods within the RMP. Similar results were obtained by Klemetti (2006) who found that for many of the interviewees, risk processes and theoretical models were totally unknown. However, some of the respondents in our study were using techniques from the area of RM. Referring to some everyday practices explained by the interviewees, actions taken against potential problems could be classified as RM methods, even though the actors were not aware of it. For example, one of the actors talked about evaluating risks from the economical perspective, in order to choose the right path. This is the same as the Decision tree analysis where several risks are analyzed to ensure that the right way of working has been selected.

Another example used was the way of handling risks within one of the respondent's organizations. In that situation, critical risks were selected and handled immediately; this helped to eliminate smaller risks and focus on the most threatening ones. This is a typical way of analyzing risks according to the qualitative method called Risk Urgency Analysis. Those examples prove that actors in the industry handle risks in their everyday operation, but are not aware that it actually is the RM framework. In addition, all respondents declared that they could start implementing methods, if only they had more information about them and a guide how to use them. This finding is consistent with research done by Lyons and Skitmore (2004)

who found lack of information as the second biggest obstacle preventing implementation of risk management. In mentioned research the biggest problem identified was lack of time which was also mentioned by one respondent in this research.

Yet another finding from the interviews shows a differentiation between how risks are managed by individuals and in a team. Individuals and their organizations most often use checklists and other manuals while groups use discussion as the most common technique to identify risks and problems. This statement is partially supported by Klemetti (2006) who found group meetings and discussions as the most relevant way to identify and manage risks.

5.2 How is the risk management process used in practice?

To show how the RMP is used in practice, it is helpful to divide the process into the different main parts such as identification, assessment and response.

5.2.1 Identification

Among respondents, past experience and discussions were the most commonly used techniques to identify potential risks. This finding corresponds with the research by Lyons and Skitmore (2004) that showed brainstorming and case based approach as the most popular risk identification tools. In fact, no time in the project was reserved for RM and respondents declared that potential risks were handled at the time of their occurrence. In order words, the members of the project team were not identifying risk in a structured way as described in the literature. They believed that their time was used more efficiently when they worked on the actual project instead of searching for problems. Only to a small extent were risks in the project identified by experience. Moreover, a number of risks which are characteristic for a construction project can be gathered in the form of a checklist and be used in future projects.

The other finding from the interviews was that the most common way of risk identification was discussion. This tool, along with brainstorming and using previous experience, was used by the project team at the kick-off meeting, where one of the activities was to identify potential threats to the project. At the meeting, all actors taking part in the initial stage of the project were present. Even though RM was not used in the investigated project, such a meeting could be classified as a part of RMP. By organizing such meetings, parties were given a chance to discuss and identify potential problems. This is consistent with Westland's (2006) theory that all the stakeholders should contribute in drawing up risk plan to make sure that every potential risk has been identified. The meeting organized at the beginning of the planning phase is also consistent with Lyons and Skitmore (2004) research results that planning and execution are those two phases where RM is most widely used.

Yet another finding from the interviews shows a differentiation between how risks are managed by individuals and in a team. Individuals and their organizations most often use checklists and other manuals while groups use discussion as the most common technique to identify risks and problems. This statement is partially supported by Klemetti (2006) who found group meetings and discussions as the most relevant way to identify and manage risks.

5.2.1 Assessment

In this part of the RMP, the greatest differences can be discovered between the theory and how the industry actually works. As previously stated, the respondents were not familiar with any method used to analyze potential risks. Overall not many practitioners in the construction industry who work with residential projects use these structured methods. Lyons and Skitmore (2004) found that intuition, judgment and experience are the tools most often used in risk analysis while structured methods like Monte Carlo or risk impact assessment are used only to some small extent.

One of the reasons for not using structured methods according to respondents was limited budget. One interviewee explained that most residential projects have limited profit margins; this prevents major changes or implementations of new solutions. Moreover, the general lack of knowledge within the area of RM can result from limited resources such as time or money. This statement corresponds with previously quoted research done by Lyons and Skitmore (2004) which indicates lack of time as the factor which prevents organizations from implementing risk management. Furthermore, the industry is not willing to change. Only some of the companies are willing to implement RMP in their operation if only a tangible outcome will be granted.

As indicated by Lyons and Skitmore (2004), the qualitative approach is the most common type of technique to analyze risks. At the same time, it is the easiest tool to assess the risks, since it only includes the probability and impact assessment. There is no need of doing complicated calculations which require i.e. computer software. The quantitative methods are much more resource consuming and require skilled personnel and technical equipment. That is why it is only medium and large companies which can afford to allocate more resources for these methods (Lyons and Skitmore, 2004).

Since none of the respondents had knowledge about RM methods, a probability and impact method was chosen and performed in the form of an online survey in order to see how risk assessment works in practice. As a result of the follow up questionnaire, risks with the biggest impact on project objectives were identified. Cheap solutions were the threat which was found to have the biggest impact on time. Again, cheap solutions and not finding the right contractor were those risks with the biggest impact on cost and quality respectively. In contrast, different results were obtained in research done by Zou et al. (2006) who found tight project scheduled as the risk with the greatest impact on all three project objectives. Such a discrepancy can be due to different research methods. In this current research, respondents were ask to identify potential risks themselves while Zou et al. (2006) provided respondents with a list of 88 potential risks in a construction project. Further, data were processed in the same way by using probability and impact matrixes. The results are biased also by type of professions held by respondents. Regardless the type of risks which were identified as the most hazardous ones, risks which scored the most and had the highest probability of occurrence, were those to which a response should be applied in order to minimize its negative impact on project objective. (PMI, 2004)

5.2.3 Response

In the theory, four of the most common actions to be taken against potential identified risks were explained. As concluded from the interview, actors have no knowledge about any type of response. Only few respondents gave answers which could be interpreted as transferring risks and by this, mitigating the problem. However, discussion and checklists were the main tools to support the actions. It is clear that there is also lack of knowledge within this area.

In addition, based on the results from the case study where risks were identified by the actors, mitigation was the action chosen most often. Many of the respondents agreed that all risks are

manageable and therefore reduction is the best alternative. In the Lyons and Skitmore (2004) research, risk reduction was also the type of action most often chosen against risks.

5.3 How do risks change during a project life cycle?

The findings from the interviews show that actors and their roles change depending on the phase of the PLC. This is consistent with the theory by Smith *et al.* (2006), that parties involved change as the phases change. In the case of the investigated project, some actors were present under the whole PLC while the others took part only in some part of it. Most of the respondents held an active role in first two phases and a passive role in the others. Therefore, a number of risks identified in those initial parts of the PLC are higher than in the later ones.

The nature of risks identified by respondents differed depending on the project phase. Initially, risks were rather broad, such as the risk of misunderstanding client's requirements, not choosing the right consultants or not achieving a good final result. The further in the PLC, the more specific the range of the risk became, as a result of more detailed planning and design process. Therefore in the next phase, planning and design, respondents identified shortage in resources, problems with design or cheap solutions as those main risks. Looking further on the longest phase, project operation, only very characteristic risks such as delays in the construction schedule or moisture were identified. This pattern complies with assumptions made by Smith *et al.* (2006) who suggest that the nature of risks changes with the project progress, from a broad to a narrower range of issues. Furthermore, the author implies that the type of risk is closely associated with the type of activity undertaken in a certain phase. This statement has also been proven in the research, since type of risks identified differs significantly over the various stages of the PLC. Problems closely related, for instance to design process, were not identified as a potential threats in any other phases.

6 Conclusion

- Risk is perceived as a negative term, even though in theory it can have two dimensions.
- Professionals in the construction industry are using techniques described in the literature concerning RM, but are not aware of it. Risks are being managed every day in the industry, but not in such a structured way as the literature describes. As also other researchers confirmed, the knowledge of RM and RMP is close to zero, even though the concept of risk management is becoming more popular in the construction sector.
- There is a willingness among respondents to start using RMP, but it has to bring profits to the organization.
- By applying a simple method, it is possible to identify potential risks in an easy way. Moreover it gives possibility to detect which of the identified risks has the biggest impact on time, cost and quality. Those risks should be eliminated or mitigated by taking an appropriate action. The research showed that the most common action was risk mitigation. Moreover it was proven that the results from probability and impact method may differ among projects due to the fact that each project and its scope are unique.
- It was important to establish during the interview which phase of the PLC the respondents were taking part in and what their role in the project was. Based on that, we could systematize the answers and see types of risks identified in various phases of the PLC. The conclusion was that there are risks which are characteristic for each project stage.
- As the research showed, unstructured form of RM is to some extent used in the construction sector. Thus application of actual RM into companies should not be difficult. As proved by the research, knowledge is the factor which is missing for organizations to implement RM. Thus, this aspect of application of RM could be further investigated in terms of how to facilitate use of RM in a construction sector. Moreover a simple RM manual could be developed including basic theoretical information as well as ready-to use guidance for one of the RM methods.

7 Reflection

RM is becoming a very popular topic nowadays. When searching through job adverts, it becomes obvious that a lot of companies from various sectors are looking for certified risk managers. Thus we found it interesting to do research in this area, and study this concept in more detail. A lot of information is available in the literature regarding RM in the form of books, articles or other publications. However information provided in those sources is rather messy. For the purpose of the master thesis research, a number of positions had to be read to find appropriate information. Some theories provided by RM literature are not at all applicable to construction industry, so we had to be very careful with choosing the right data. Moreover we wanted to see how RM works in practice. Even though not many of the actors participating in the project agreed for an interview, we managed to collect enough data to complete the study. The results which we obtained were very surprising with the extent to which RM is used by professionals. The knowledge we gained while working on the thesis could be successfully used in our future professional careers. Each project manager should have a basic knowledge about risks associated to a project and how to handle them. Thus we think that the research done for this master thesis was not a waste of time, but actually gave us a strong basis of RM.

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APPENDIX A – INTERVIEW QUESTIONS

Introduction:

- 1. Which role do you have in the project?
- 2. Which phase of the project do you take part in?
- 3. How would you define a risk? (risk, problem, threat etc)
- 4. Are you familiar with the concept of risk management and the Risk Management Process?

The questions will follow the Risk Management Process (identification, assessment/analyze and response). Today, each organization to some extent uses risk management concept, even if it is not officially classified as the typical risk management. Therefore, the questions are being formulated in a way, so that all of you can answer them.

Identification:

- 5. How do you identify risks/threats in the project...
 - a. as an individual?
 - b. in the organization?
 - c. in this project?
- 6. Regarding the phase you take part in and role you have in the project, which are the main risks (threats) are associated to your function (max. 3)? (If you take part in several phases, please identify risks in each phase.)
- 7. What effects can those identified risks have on time, cost and quality, in the project?

Risk assessment:

- 8. How are you working with risks? How is it handled within the project (procedures etc)?
- 9. Assuming that you have identified a number of risks in the project, how would you prioritize them (Q no. 6)? Would it differ from other projects you work/have worked on?
- 10. Do you use any methods to analyze risks? (for example Fault Tree Analysis, HAZOP, What If)
 - a. If yes, what methods?
 - b. If no, what are the reasons of not using any methods? (do you know any methods, have you heard about any?) What would make you start using methods? (incentives)
- 11. If you use/will use methods, what do you think is the most desired outcome, what do you expect?
- 12. Do you believe that applying structured methods will improve overall project performance?

Risk response:

- 13. What action do you usually take against risks? (As individual, organization and project?)
- 14. What action would you take to the identified risks in the project (Q no.6)?

Handling risk in organization:

15. How is risk handled within this project organization - Use examples from experience, from this project and how do you think risk management should be organized in a project?

How do you imagine the project and the vision "o errors"?