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Risk Management in the Norwegian Public Road Administration - a case study

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

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CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2012
Master Thesis 2012:42

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ABSTRACT

Working with Risk Management is not a new invention. The concept is regarded as an acknowledged process to improve performance and control costs. However, it is not until recently that many organizations have realized the benefits of integrating a Risk Management Process that works with risk and opportunities in a more strategic way. Traditionally Risk Management has been handled by managers in projects; this trend gradually fades as projects managers encourages their entire staff to participate in the process. This case study is performed through interviews and elucidates how the Risk Management Process is handled within an infrastructure project managed by The Norwegian Public Road Administration. Findings from the interviews will be compared and analyzed to acknowledged Risk Management theory.

Key words:

Risk Management, Risk Management Process, Risk, Uncertainty, Opportunity, Risk Identification, Risk Assessment, Risk Response, Norwegian Public Road Administration, Infrastructure

Contents

Preface

In the present study a Norwegian infrastructure company named The Norwegian Public Road Administration (StatensVegvesen) was investigated. A case study of the early phases of their infrastructure project gave this thesis its standpoint. The initial stage of the investigation began late 2011, and the actual case study was conducted between January and May 2012, with meetings, workshops and interviews. The final presentation of the study was given the 30th of May 2012.

The project was investigated with focus on Risk Management. The Norwegian Public Road Administration's existing model was examined and focus was put on the comparison between the company's models, and already published acknowledged theories within the Risk Management field.

The research was supervised by Martine Buser at Chalmers University of Technology whose reflections and recommendations were much appreciated. A special thanks to Øyvind Moshagen, Nina Kanne Stenumgård, and Lars Kristian Dahl at the Norwegian Public Road Administration for their kindness and support during our visits.

Notations

NPRA	**Norwegian Public Road Administration**
RM	**Risk Management**
RMP	**Risk Management Process**
PUS	**Practical uncertainty management in a project owner's perspective**
KS2	**External Quality Assurance**
PMI	**Project Management Institute**

1 Introduction

The Norwegian Public Road Administration (NPRA) is undertaking a huge infrastructure project in the eastern region of Norway. The setting of this part in Norway involves complicated conditions such as geotechnical difficulties and limitations in available space to build. The current road has a high death rate and is one of Norway's most important roads in logistical terms, when it comes to transporting material and food from the northern and eastern parts of Norway. The initiative of the new project is driven at a state level. To optimize the use of resources, and to account for unexpected events, the Norwegian Public Road Administration uses the Risk Management Process (RMP).

This chapter has for intention to give a short introduction to Risk Management (RM) and its background followed by an introduction of the case investigated in this report. The purpose is to introduce unfamiliar readers with the concepts of RM.

1.1 Risk Management

Working in projects is not a new invention, especially in connection to the construction industry. It was not until the 1950s when more general methods were developed. This development of planning processes and the use of numerical methods for measuring uncertainties was performed in connection to military project in the US (Maylor, 2010). It was this work that during the 1960's and 70's resulted in the development and foundation of the Project Management Institute (PMI), International Project Management Association (IPMA), and Association of Project Management (APM).

According to Project Management Institutes body of knowledge (Project Management Institute, 2008) RM is one of the nine most important parts a Project Manager has to undertake in his role. This is supported by both Potts (2008) and Winch (2010) who view RM as one of the more difficult tasks a Project Manager will deal with in connection to the project management profession. Max Abraham, a famous construction lawyer, once said that Risk Management is

> *"the most delicate and dangerous subject I could find"*(Potts , 2008).

Risk has always been handled by managers in one way or another within a project. However, it is not until recently that many organizations have realized the benefits of working with risk in a more strategic way. Winch (2010) states that effective routines in dealing with uncertainties and risks can help a Project Manager achieve better control and will therefor benefit the overall project objectivities. Cooper at el. (2005) refers to RM as

> *"the culture, processes and structures that are directed towards the effective management of potential opportunities and reverse effects".*

Despite this, RM is not particularly common in the construction industry.

In order for an organization to work with uncertainties and risk in an effective way it is important to work with a systematic approach (Smith , et al., 2006). This means that an organization needs to work in a formal way with the Risk Management Process. A common way to divide the process is into identification, assessment, response, monitoring and control.

1.2 Initiative and background to project

NPRA is the responsible organ for the planning, constructing and operational parts of the Norwegian road network and infrastructure. They are also responsible for the national vehicle inspection as well as for the driving training and licensing within the country. Their main objectives and vision stated on their web page are to develop the society into a better one, and to improve and maintain a safe, eco-friendly and capable transport system. They also do that by interacting with different stakeholders, such as politicians, users and other interested parties (Vegvesen, 2012).

The organization of NPRA is divided into five regional offices. A project in the eastern region is investigated in this report. One of the main tasks for the eastern region is to develop the European Highway 6 (E6) which is the main link between northern and southern parts of Norway and is an important part in the connection between the northwestern part with the central east part of the country. Furthermore, the road is important for the adjacent towns and communities in terms of business connections. The road serves as a transportation lane for tourists, locals and for heavy traffic in the region; about 15 - 20 percent of the total traffic accounts of heavy vehicles (Vegvesen, 2012).

The investigated project emerged when The Norwegian Public Road Administration decided that the current situation between the town of Biri and Otta was not satisfactory when it came to road safety, accessibility and the environmental aspects. Between the years from 2001 to 2010, 48 persons died, 91 were seriously injured and 549 other accidents had been reported from the section between Biri – Otta. This section of road is 140 kilometers long and is divided into seven different infrastructural projects and is illustrated in figure 1.

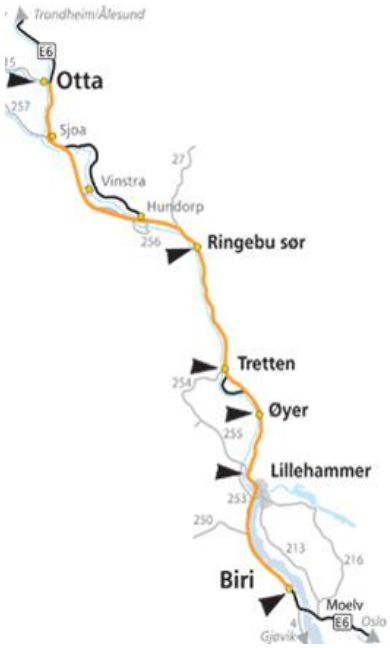

Figure 1: Illustration showing the section between Biri – Otta (Vegvesen, 2012).

The studied cases that has been used for this report is the project between Frya – Sjoa which is one of the two parts of the bigger project between southern part of Ringebu and Otta. This is illustrated in figure 2.

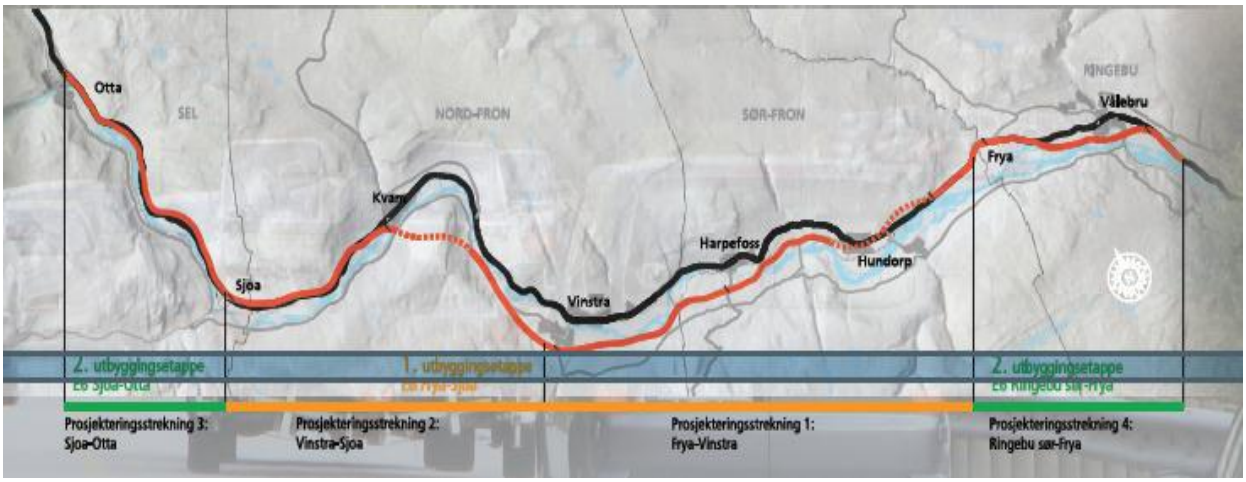

Figure 2: Illustration of Ringebu – Otta divided into its different development steps.

(Vegvesen, 2012)

The old section of E6, which is illustrated by the black line in figure 2 is currently going through several small communities and has an average daily traffic of approximately 7000 vehicles in Ringebue, and 5700 vehicles in Otta. The average daily traffic has its peak in July with 65-70 percent over the current designed capacity of the road. Since the road runs through several smaller communities many parts of it have reduced speed limits. To overcome these obstacles the goal is to develop a new part of E6, which is illustrated by the red line in figure 2.

The Frya – Sjoa project is a section of approximately 34 kilometers and it will be constructed as a two lane road with center barriers and section wise overtaking fields. There will be two tunnels, the Hundorp tunnel which will be 4.5 kilometers, and the Teigkamp tunnel which will be 3 kilometers long. In addition to this, there will be totally 35 new constructions such as bridges, 3 crossings with the already existing railroad, 5 new road crossings, 18 kilometers of new produced local roads, and 5 kilometers new pedestrian and bicycle roads.

The project is in currently in the planning phase and the first part of the section between Frya – Vinstra is planned to have its construction start during the summer of 2012 and the second part between Vinstra – Sjoa is planned to start spring 2013. The entire section should be finished by autumn 2016.

The project organization in focus is stationed in Lillehammer where the main office of the region east also is situated. The project organization currently employs less than 25 employees, but the organization will be expended to roughly 60 when the project planning and initial stages are completed.

1.3 Purpose and goals of case study

The focus of this report is the RM methods, management and the implementation of the RM processes in The Norwegian Public Road Administration (NPRA) region east. The project is currently in a late planning stage and several Risk identifications and assessments have already been conducted. The NPRA has a RM system that is used throughout the whole organization. This report is the result of a case study in how the project office of the earlier mentioned part of the E6 handles the risk. Their models and tools will be described later in the report.

The purpose of this report is to elucidate the questions and discussions presented below and to compare them with the relevant theories described in the chapter of the theoretical frame of reference. The framework will present a theoretical view and background by ways of which a comparison and analysis of the current ways of risk management will be performed.

The current way of working with risk implies such questions as how the risk management process and models are used within the NPRA as well as how the employees are evaluating, managing and handling the risks in their projects. Furthermore, the report has for the intention to locate areas where theory and practice differ. This will hopefully indicate areas for change or improvement for the company.

In collaboration with the project managers of NPRA Region East, the important issues concerning risk, that they considered interesting to elucidate, were pointed out. These thoughts and questions are central to the report. The areas of interest to NPRA Regions East were:

- How the leaders could inspire employees to work with risk
- How to achieve a better risk awareness within the organization
- How to identify and evaluate risks
- The assessment of risk costs
- Accountability and monitoring of risk
- How to create a better and more suitable risk meeting structure

1.3.1 Research question

To elucidate how RM methods and tools are implanted, managed and communicated within an infrastructure project in The Norwegian Public Road Administration region east.

1.3.2 Limitations

The present report and research are founded on a theoretical framework based on RM literature. The study was performed in collaboration with NPRA and little attention was given to other stakeholders, and no interviews were conducted with companies other than the NPRA. The project was in the planning phase, thus limiting the authors to consider the early phases of the project. The authors of the report are non-native English speakers.

2 Methodology

This chapter describes how the study was conducted, which methods were used and how they were used. This section will also concisely explain some of the main tools that were considered and used in this report.

2.1 A qualitative Approach

The data collection for the thesis is based on means to get a qualitative approach. The data gathering started with studies of already published articles, research and literature. The techniques that were used during the later phases of the process were: interviewing NPRA's employees and observing at the project main office to make sure the results and hypothesis were not off focus.

The main challenge in the formulation of the theoretical framework was to make sure the right scope was chosen. Given the wrong theoretical framework the report and scope would shift and give emphasis to non-important issues in the area of the project.

The authors adapted an iterative approach to the writing process as their knowledge in the area increased they re-wrote the framework to better suit the issue.

2.2 Data Gathering

During the data gathering phase the issue of data assembly was not concerning finding information in the field but rather choosing proper sources and acknowledging their origin. It was obvious that the qualitative approach had to be taken where the focus was on acknowledged sources and authors with rather well-known names within the field.

2.2.1 Literature study & theoretical framework

The literature study takes form as a critical in depth assessment of research that has been done previously. It was important to stay true and avoid bias in the choice of the information and previous research. This is hard though without much academic experience, that is why academic library search engines were used to get a rather selective search results. The fact that the credibility of such search engines is relatively high to start with is a good set off point. The most frequently used academic search engine used in this project was the Chalmers Library search engines which accesses many databases around the globe. Other accessed sources were institutions such as: Project Management Institute, CONCEPT, PUS, NTNU research department. Usually the academic reports referred to RM books that also had to be considered in order to get the full picture.

2.3 Applied Tools & Strategy

This section will describe the different tools used in the research and how they were interpreted. Further it will describe the strategy of the report and how it aims to give relevant results by using the tools and strategies.

2.3.1 Case Study

The qualitative approach through the case study was chosen since the research aims to give a broad explanation to the research question and to use a variety of sources. According to Yin (Yin, 2003) the case study approach can be used in different cases, such as:

- when the focus on the research, is to answer "how" and "why"
- when one wants to cover contextual conditions because one thinks that they are relevant to the study
- the boundaries are not clear between the phenomenon and context

This means that the case study should be used when the context of where the research is done is of essence to the study. In this case the whole picture of the organization has to be accounted for, it could not be considered without its context.

2.3.2 Qualitative Method

The qualitative method approach was chosen since the desired result of the report is to get a description and experience of how things work within the organization rather than getting the entire and absolute picture. Compared to the quantitative method which bases its results on statistics the qualitative approach needs to be carefully developed. If, for instance, the wrong selections of interviewees are chosen, the results will be uninteresting and deceptive for supplementary studies. Noor (2008) acknowledges that even though the case study approach with the qualitative method approach could be criticized due to its lack of clear scientific firmness and lack of general appliance it is very appropriate in situations where complex processes and real life situations take place.

2.3.3 Interviews

Following the initial stages of the report the next step was to extend the knowledge even further by making interviews with the company. The qualitative approach was chosen with a semi-structured interview. This form of interview is useful when the researcher wants to obtain relevant information and get openly expressed answers (Cohen & Crabtree, 2006). A semi- structured interview is conducted by engaging in a formal interview with the interviewee where the interviewer uses an interview guide that consists of a list of questions. This list of questions is used as a guide to the interviewer that should be followed during the interview; these questions are normally followed in a specific sequence but if the interviewer finds a specific answer interesting he could stray away from the initial question and develop the question further. If conducted correctly, with well-developed questions, the semi-structured interview will give reliable and comparable qualitative data (Cohen & Crabtree, 2006). The development of questions is usually performed by undertaking the analysis of the situation where observation and questioning people with knowledge in the area to get the understanding of the topic. The technique of giving open ended questions provide a broad view of the interviewee's standpoints as well as give in-depth

viewpoints and provide interesting facts, since the interviewees have the opportunity to express themselves in their own terms.

The interviews were conducted with seven employees of different genders from the project organization. The interviewees' length of employment within NPRA varied from 2 years to approximately 35 years and their level of education varied significantly. All interviews varied in duration between 30 to 45 minutes and the interview questions were adjusted in accordance with the interviewees' position in the organization. This was done to get a more holistic picture on how the organization functions and relates to risks. There was an intentional overrepresentation of employees with a management role in the interviews; this was done in order to understand how managers think issues concerning risk should be communicated within the organization.

2.3.4 Meetings

In order to get a good understanding of how the project and the organization handle risk, several meetings were carried out in the project office in Norway. These meetings were attended in order to get the necessary information and input from the organization. Participants from the project organization were amongst other project leaders and managers with different responsibilities. Three meetings were attended and are described below.

- **Introduction meeting**
  The introduction meeting was held during the entire day at the office where the main goal was to get an understanding of the outlines of the entire project, as well as to get a better view of how the organization worked. There were several employees present to explain their role in the project as well as to give a picture of how they worked with risk and how they interpreted it. Their current risk model was explained, followed by the description of how they currently worked in risk meetings, as well as how they communicated the importance of it.

- **Monthly Project meeting**
  The project meeting took place approximately five weeks after the introduction meeting. The entire project organization was participating and the project manager informed the organization of the current project status.

- **Risk assessment meeting**
  Shortly after the project meeting a chance of participating in a risk assessment meeting was provided. The risk assessment meeting provided a good opportunity to observe how the organization works with risk assessment in practice.

All of these meetings helped to get a better understanding of the context of the company and also what kind of situation they are working in. All of the methods used in their risk model as well as their internal information system and hierarchy were described. The meetings proved to be vital for the understanding and conclusion of the report. Although the meetings provided an insight in how the organization works with risk related issues these meeting were insufficient to get the whole holistic picture of the company.

3 Theoretical frame of reference

In the present chapter the theories of RM and their adjacent areas of interest are introduced. In the following sub chapters the fundamental information about issues that are of importance for the understanding of the thesis' results and how the conclusion and comparisons are made. The theoretical frame of reference includes descriptions and explanations to terms such as "risk", "opportunity", "wicked problems" and other terms of significance. It also includes explanations to areas concerning organizations working with the project structure. Furthermore it will embrace the most common risk tools and the explanation of RM and its utilization. The goal of this chapter is to orientate the reader in the vast jungle of RM theory and make an attempt to describe the important aspects of the present thesis and its implementation.

3.1 Uncertainty

The practice of Project Risk Management is commonly known and often used within companies as an attempt and method to handle risk. The practice of Uncertainty management is less known, and even less so accepted (Perminova, et al., 2007). In the project risk management literature it is hard to find a uniform definition of what uncertainty actually means. Since all projects include, to some extent, complexity and uniqueness they will naturally also include a level of uncertainty which can turn out to be positive or negative. Uncertainty can be thought of in several ways where Atkinson (2006) describes it as a potential variability in relation to performance measures. This aspect of uncertainty describes that the variability cannot be known and is therefore very hard to measure and manage. Uncertainty includes a variety of sources where Atkinson (2006) defines key areas, amongst them:

- Uncertainty associated with Estimating
- Uncertainty associated with Project parties
- Uncertainty associated with Stages of the project life cycle

The aspect of uncertainty in estimating has a wide range of reasons where Buehler, et al. (2002) and Armor & Taylor (2002) argue that some of the main attributes to consider are:

- Lack of clear specifications of what is required
- Lack of experience in particular activity
- Emerging factors that are unknowable at the beginning of the project
- Bias and opportunism in projects

Furthermore, Buehler, et al. (2002) argues that uncertainty related to project parties is a very important issue. They claim that many projects focus on mere technological uncertainties when they really should be focusing on the uncertainties introduced by having multiple parties interacting in a project. According to them, the most important factors associated with uncertainty in project parties:

- Uncertainty with the objectives and motivation of each party
- Uncertainty of the reliability and the quality of the preformed work
- Uncertainty of the parties' performance
- Uncertainty of the parties' abilities

One important aspect of the uncertainty definition is to separate it from the common risk description. The risk is usually explained to be an uncertain event that either has a positive or negative impact (Project Management Institute, 2008). Most projects have restriction in time, resources, cost and scope. These variables are hard to predict and even harder to quantify to get a realistic view of the outcome. A skilled project manager should be able to measure possible options when deciding what action to plan and to pick the optimal choice in each of the alternative actions. The real problem a project manager encounters would be that of making optimal choices amongst many possible actions and how to be able to predict the outcomes (Andersen, 1996).

So what separates risk from uncertainty? According to Frank (1999) uncertainty is either aleatory or eptimistic. The aleatory uncertainty origins from the Latin word "alea" meaning dice; this implies that uncertainty has to do with chance. Eptimistic uncertainty arises from the lack of knowledge; meaning that it could have been foreseen if more information were provided. However this definition does not separate the terms risk and uncertainty, it is a mere attempt to describe the nature of the term. Using the definition of eptimistic and aleatory uncertainty Hillson (2004) tries to separate the terms by the following two statements:

- **Risk is measurable uncertainty**
- **Uncertainty is immeasurable risk**

Given this definition it implies that all the eptimistic uncertainties could be transferred into risks by adding the adequate information. However it is important to remember that the definition of risk implies that risk can produce both positive and negative consequences on a project (Project Management Institute, 2008). With this definition, the uncertainty will also be able to take shape of positive or negative uncertainty since the uncertainty is an immeasurable risk. A positive uncertainty could also be called an opportunity. In other words, an opportunity is a positive effect of uncertainty that can be party managed throughout the project life cycle (Olsson, 2007).

In early project management literature it was said that every project was unique, but the current trend amongst literature and research argues that projects are only unique to some extent. This trend encourages the project managers to use some sort of strategic tools when planning since the project is only unique to some extent implying that some of the event in the project will be repeatedly occurring in projects alike. According to Davies et al. (2006) project managers can employ experience gained from earlier projects to the next in form of standardized processes and procedures.

Even if risk emerges from uncertainty it has been viewed as mostly technical risks in projects leaving out many aspects of risk to be examined and taken into account when formulating the existing project risks for a complete project. The technical risk approaches are usually easily identified because they are relatively simple to quantify and to find possible means to "treat" the risk. Olsson (2007) argues that risks can be identified with the definition of its complexity and solution strategy. He describes, amongst others, two types of problems that shape the project risks and opportunities:

1. Tame problems
2. Wicked problems

1. The tame problems are problems that have a rather trivial solution such as mechanical problems that give somewhat linear optimal solutions to be considered. The tame problems could be seen as dynamic and have a structured complexity that could be treated and solved with an analytical or algorithmic solution. This implies that if tame problems are broken down into sub categories and the adequate information and methods are added to eliminate the uncertainties related to the tame problem it can, by definition, become a known and measurable risk. This suggests that the method could also be regarded to treat opportunities, since opportunity is a positive uncertainty.

   According to Olsson (2007), typical examples of tame problems could be problems that arise during the bid phase of the project. For example, the availability of customers, the accessible technology required compared to the needed, the degree to which the company is able to satisfy stakeholders expectations, and more traditionally business risks. The more traditional risks could be such ones as knowledge of product, knowledge of similar projects and knowledge of the project owners' finance. All of these parts are considered to be tame according to Olsson (2007). This implies that they are possible to identify, quantify and manage through RM procedures.

2. Wicked problems arise from a much higher complexity and dynamic situation. The dynamic complexity of interdependency and human behavior is examples of wicked problems. The wicked problems have no clear solution and every attempt to solve them will count significantly, resulting in an impact on the organization. The complexity of the wicked problems indicates that they are ever changing and impossible to categorize with sufficient information to solve. According to Ritell & Webber (1973) there are certain key factors that identify and explain wicked problems:

- All wicked problem are essentially unique
- There is no definitive formulation of a wicked problem, thus defining a wicked problem is a wicked problem in itself.
- There is no best solution to a wicked problem and solution to them cannot be true or false, rather better or worse.
- There will only be one attempt to solve the problem and no chance for trial and error, thus every attempt counts significantly
- The manager or planner has no right to be wrong when dealing with wicked problems; they are still accountable for the outcome.

Given the above stated list this implies that the wicked problems cannot be solved. Although Olsson (2007) argues that they can be contained if they are accepted by the organization to be wicked problems. Holt (2004) finds that there has to be a much broader focus on resolution between available potential solutions to be able to cope with wicked problems.

Even though wicked problems are hard to identify, and even trickier to solve, it is important for the organization not to discard them because of the complexity of their nature. The uncertainties that involve only trivial problems will be more assessed due to the fact that they are easier to manage with simpler means. The organization could with an inappropriate attitude and training simply focus on the risks and uncertainties

that can be easily quantified and assessed. High complexity risks and problems usually involve human aspects and relationships between factors such as the impossibility to actually know if the stakeholders speak what's on their mind when they are negotiating or informing. The employees of the organization will not always have the proper skills or knowledge for a task but might have certain reasons to argue that he or she has. Such aspects could be identified as wicked problems that, of course, serve as a nontrivial role in the organization. In some organizations it can be considered as a subject that is out of bounds to put as a risk simply because it would put the company in bad light and perhaps question employees competence. These areas of taboo are risks in its own and should be treated as such.

3.2 Risk

The former Minister of defense in USA, Donald Rumsfeld, said;

> *"As we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the one's we do not know we do not know."*

In a sense this expression is very humoristic, but if you view it out of a risk perspective it can be very useful to explain what risks are. According to Winch (2010), there are risks that we think we know. These risks are categorized as "known knowns". They are risks that have been identified and assessed with a probability. Risks in this category can usually be detected by careful planning in the early phase of the project and handled accordingly.

For "known unknowns", "unknown knowns", and, "unknown unknowns", Winch (2010) considers them as cognitive conditions of uncertainties and they are illustrated in figure 3.

The difference between "known unknowns" and "known knowns" is that in both cases a risk source has been identified. However, for the "known unknowns" a risk probability cannot be given for the risk event. In the case of "unknowns knowns" someone knows about the risk and the probability connected to this certain risk event but they are withholding the information and does not inform the organization about the emerging risk.

Risks associated with "unknown unknowns" are risk sources that has not been identified and are in most cases risks that appear to develop from nowhere and can have a severe impact on the project. Risks in the category "unknown unknowns" are in risk theory called the black swan theory, developed by NassimTaleb (2007).

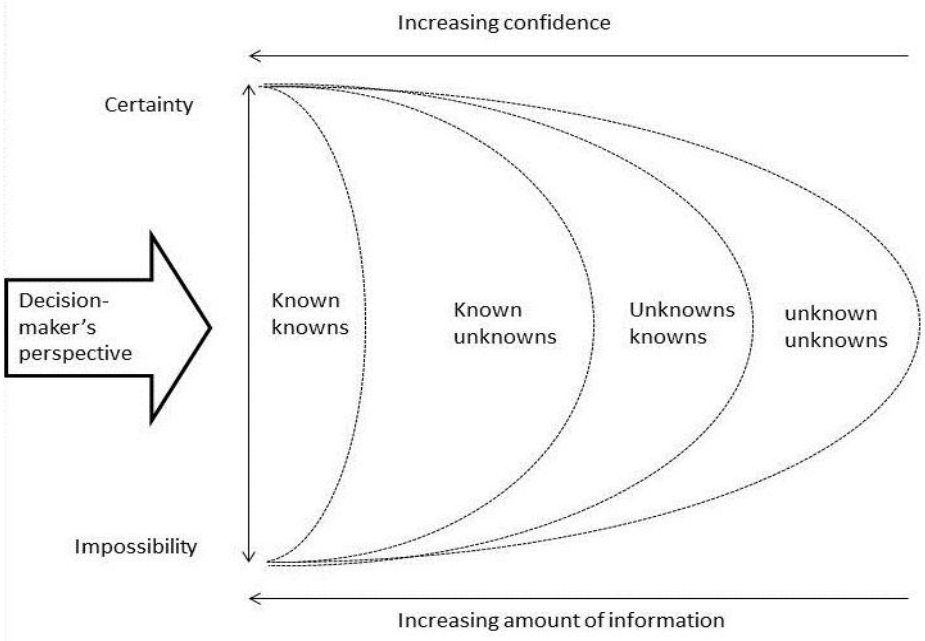

Figure 3: Risk perception according to Winch (2010).

There are numerous definitions of what risks in projects are (Perry & Hayes, 1985). Chapman & Ward (2003) view risks as:

> *"the exposure to the possibility of economic or financial loss or gain, physical damage or injury, or delay, as a consequence of the uncertainty associated with pursuing a particular course of action"*

Hertz & Thomas (1994) view risk as:

> *"a barrier to success"*

Baloi & Price (2003) view risk as:

> *"the likelihood of a detrimental event occurring to the project"*

The above mentioned definitions view risks as something negative without considering that risks can have both a negative or positive impact on a project. One definition that takes both sides into account is the definition given by PMI. In the fourth edition of the PMBOK, project risk is defined as

> *"an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives"*(Project Management Institute, 2008).

This definition of risk is in some senses very broad and open for interpretation, but in contradiction to the earlier definitions it views risks as something that can be either positive or negative for the project. It helps organizations view risk as something that can bring an opportunity to the project instead of just being something that will affect the project in a negative way.

Even if there are many varieties in how risks are defined most of them show some common characteristics. The common characteristics that can be found between them are according to Chia (2006);

- A risk is a future event that may or may not occur.
- A risk must also be an uncertain event or condition that, if it occurs, has an effect on, at least, one of the project objectives, such as scope, schedule, cost or quality.
- The probability of the future event occurring must be greater than 0% but less than 100%. Future events that have 0% or 100% chance of occurrence are not risks.
- The impact or consequence of the future event must be unexpected or unplanned for.

3.3 Opportunity

The most common way of seeing risk is indisputably in a negative manner. The main reason for most companies to introduce RM is to take measures against events that can cause negative consequences to the project (Olsson, 2007). Nevertheless, a rather different point of viewing risk as not only involving negative consequences but also to involve positive outcomes has arisen. Olsson (2007) states that an opportunity derives from uncertainty where the opportunity is considered to be the positive perception of uncertainty.

However, Hillson (2004) argues that the use of a proper risk management process will be adequate to handle and manage the opportunities in a project. He also argues that there are some additions to the traditional risk model that are needed in order to manage opportunities within a risk model, hence the negative outcomes usually gets the greatest attention compared to the positive.

Limitations for the risk models not suiting opportunity management could be that it is; not appropriate for the specific industry, not to reflect upon opportunities and to focus only on single project approaches (Pender, 2001), (Shen, 1997). There are many different approaches how to define risk and opportunity, regardless of these the aim of focusing on opportunities must be to get the positive effects of uncertainty and risk assessed on the project objectives.

However, as Olsson (2007) points out, "*talk is cheap*", meaning that companies rather talk about opportunities than actually manage and do anything about them. Olsson finds the phase of tendering and pre-project to be those involving most identification of opportunities in projects. He finds that the opportunities that are managed later in the project are not managed initially due to the risk management process but rather other circumstances call for it.

Furthermore, Olsson (2007) considers that if the project employees share a holistic view of the project when it comes to project limitations, scope, goals and stakeholders they find it much less difficult to identify and reflect on opportunity. To get this holistic view Olsson introduces three major internal factors considered important to succeed; team spirit, competence and internal communication. When considering competence within an organization the most important is the competence of the project manager, who should inherit the aspects of encouraging co-workers and taking

part in open discussions as well as communicating project objectives and organizational requirements.

The level of complexity related to the opportunities will also influence the way of handling them. As described earlier wicked and tame problems include a certain level of complexity, the same applies to opportunities. In the case of opportunities that include little complexity the way of handling them usually reveals itself quite straight forward. When handling opportunities involving high levels of complexity Olsson (2007) argues that the best way to handle such wicked and complex opportunities is to encourage communication within the project organization as well as to spread the importance of the holistic view of the project and costumer expectations. Holt (2004) argues that a different approach must be taken when dealing with issues that are "wicked", this involves the emphasis on comparing different solutions to try and optimize the outcome. However, "wicked problems" imply that there might not be a best solution to the problem but rather not any solution at all. This is why it is harder to evaluate the managing of complex opportunities compared to straight forward "tame" opportunities.

3.4 Risk and Opportunity management

In the perfect world there would be ideal engineers, great designs, and the force of nature would be predictable. All the uncertainties in a project would be gone and there would not be any need for RM (Smith , et al., 2006). As we all know this is not the case. A project constantly faces uncertainties, especially in the early phases.

> *"The first step in the risk management process is to acknowledge the reality of risk. Denial is a common tactic that substitutes deliberate ignorance for thoughtful planning."*
>
> *- Charles Tremper*

In all projects uncertainties will become reality, either as risks or opportunities. In order to deal with these a serious project organization will need some sort of RMP. There are numerous different ways on how RM should be viewed, but the one supported by many scientists is that it should be a continuous process that is integrated with other PM processes (Jaffari, 1999). Maylor (2010) defines RM as the process of how to deal with uncertainty and risks in both the earlier phases in a project as well as an ongoing process during the project development.

Many Project Managers use RM processes to focus on the negative sides of an uncertainty and forget to put focus on eventual opportunities a project can benefit from. Maylor (2010) claims that many great ideas are lost in the project organization; the main reason for this is that there are no clear ways for them to be explored.

If a project views the RMP as both Risk Management and Opportunity Management this will probably develop the organization and more opportunities can be harvested by the organization (Winch , 2010). Other benefits that can be derived if the organization views uncertainties as both risks and opportunities are that the organization still can benefit from the probabilistic meaning of risks, and shift the traditional way to view RM problems into a more strategic way to deal with risks and opportunities.

If the organization desires to be successful in their work with RM it is important to involve people that are working within the organization. Smith et al. (2006) brings up some key factors that are important if the organization is going to work in a proactive way with risk and opportunity. The key factors are:

- Management support
- Openness
- Motivation
- Training and involvement of key personnel

If these factors are combined with a RMP that puts focus on participation, ownership and responsibility the organization will get a solid ground to become successful in their undertaken tasks.

According to Project Management Institute, project risk management is the process that concerns conducting RM planning, identification, analysis, responses, monitoring and control on a project (Project Management Institute, 2008). The Project Management Institute process's for RM is not the only method available. During the last couple of years there has been a number of different processes developed. Some of the most important and popular are: PRAM (Chapman, 1997), RAMP (Institute of Civil Engineers, 2002) RMS (Institute of risk Management, 2002). Even though there is a couple of different process they all show similarities in their framework with differences in the established step in order to get risk control. Effective RM involves a four-phase process, and they consist of a combination of qualitative and quantitative approaches on how to deal with risks (Nieto-Morote & Ruz-Vila, 2010). The RMP that is used in this paper is shown below in figure 4. The circularity of the model is important since the process involves a learning process over time and the Project Manager needs to work with the model in a continuous iterative principle (Winch , 2010).

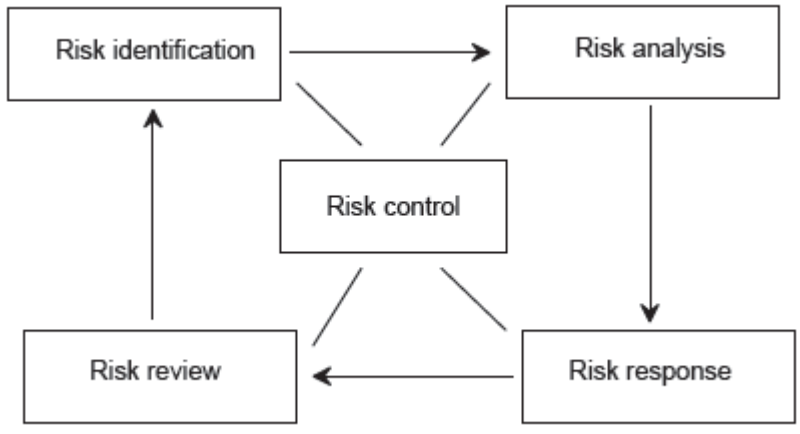

Figure 4: The RMP model according to Smith et al. (2006).

The first step in the process is the risk identification; in this step risks are identified and determined in which way they are going to affect the project and the characteristic of the risk is documented. This step is usually not so scientific but the parties that are

involved in risk identification are more or less relying on the participants experience in the specific project field (Winch , 2010).

The second step of the process is the risk assessment; this can be done in a qualitative, semi-qualitative, or quantitative process and the goal is to prioritize and assess the risks that have been identified for further analysis.

The third step of the process is the risk response; by this step options and actions are developed to enhance opportunities and to reduce threats to the projects objectivities. There is a number of ways to respond to the risks that have been identified and assessed (Winch , 2010).

The fourth and the last step in the RMS concerns reviewing risks and monitoring them.

3.5 Communication

Most literature concerning RM considers communication important, however, in most cases it generally concerns how the risk manager should communicate with a communication plan (Heldman, 2005). This is of course important, not only for spreading how the progress in the risk process is developing but also for the ability to be able to backtrack in the risk process if it is necessary.

Heldman (2005) brings up lack of communication as one of the main reasons for a project failure. If this is so, then communication is of great importance when it comes to RM. Not only for communicating the most critical risks that the project is facing but also for communicating eventual opportunities that are arising. This is supported by Olsson (2007), who states that internal communication in an organization is one of the key factors for a project to be successful.

If the project manager or the person responsible for the risk process has a good plan or routine when it comes to communicating the risks and opportunities the project is facing within the organization, the interest for RM will increase amongst employees not actively involved in the process. Heldman (2005) supports this by arguing that communication concerning the risk process should be held as a continuous point on project meetings.

3.6 Project Phases

According to Maylor (2010) the definition of a project is that it has a certain time limit and limit in resources. If the whole project is taken into account the term life cycle approach can be used where the entire project and all its phases are taken into account. The phases of a project can be divided into certain areas of interest where different industries are categorizing their phases differently. In construction projects Bennet (2003) argues that there are four main phases that are typical for a construction project.

- Pre-project phase
- Planning and design phase
- Execution phase
- Closure phase

The first step of Bennett's structure is the pre-project phase followed by the planning and design phase. When the pre-project and design phase are completed the contracting and procurement phase begins when contractors for the project are selected. This phase is followed by the project mobilization, project operational phase, project close out and project termination phase. Due to the variety of phases they must all have an individual approach and management process to be handled.

The phases of interest in this report are the initial phases; in this case it is the pre-project phase and the planning phase including the design phase.

Pre-project phase

The pre-project phase includes all of the necessary stages to conclude if the project is worthwhile to undertake and put into the planning and design stage. In this stage all the stakeholders and concerned parties should be involved and give their input to decide how and if to proceed. Bennett (2003) describes the pre-project phase to be a project idea that includes the initial problem description and outline. The pre-project phase also demister how the project owner interacts with the construction organization and the design organization.

Planning and design phase

According to Bennett (2003) the Planning and design phase is divided into steps to make the process of explanation easier:

- **Formulation of project organization**
  The major actors within the projects are gathered and their individual tasks and responsibilities are defined, thus forming the project team. The project team develops a project brief that contains the extent and function of the project. This step also involves the making of a stakeholder analysis of some degree where the risks associated with the current idea and functions of the project are identified.

- **Analysis stage**
  When the stage of formulating the project organization and selecting the best possible option with the existing data, the phase of analyzing begins. In this stage the analysis of how the proposed structure will be able to alter the project time plan, risks or safety aspects.

- **Early calculations and estimates**
  When the analysis of the project is complete and all of the parameters are identified a preliminary budget of the project is made. This is the first calculation that helps the project owners to decide how they should proceed.

- **Contract document**
  The final stage of the planning and design phase is the development of the contract form. The document that is constructed contains detail drawings, specifications, drawing and requirements for the future contractors.

3.7 Risk tools

In this chapter the aim is to go through the RMP and discuss which methods and tools are used in different phases. To do so the RMP described by Smith et al. (2006) will be used. As mentioned earlier in the chapter about RM, Smith et al. (2006) RMP consists of a four-phased process. The four phases are risk identification, risk assessment, risk response, monitoring and reviewing risks; they are illustrated in figure 4.

3.7.1 Risk Identification

The first step in the RMP is the risk identification; in this step the goal is to determine which risk that may have an effect on the project and to document their characteristics (Project Management Institute, 2008). The identification is of a qualitative approach and studies have shown that the more effort that is put in the identification process in the initial stages of the project the more positive impact it will have on the project in the later phases. The identification process will form the basewhere risks, uncertainties, constraints, policies and strategies for the control and allocation of risk are established (Potts , 2008). There are numerous techniques and tools that can be used to identify risks. According to Cooper et al. (2005) some of the more common are:

- Brainstorming
- Checklists
- Questioners and surveys
- Work Breakdown Structure analysis
- Interviews and focus group discussions
- Examination of similar projects and activities made locally or oversea, this includes studying post-projects reports and documentations.

The above stated techniques are the most common and are used when it comes to identifying risks but there are some techniques that can be used in special circumstances (Cooper, et al., 2005). These techniques are Decisions Trees and can be divided in to two main types of trees, which are:

- Fault tree analyses – A systematic method for representing the logical combinations of the system state and possible causes that can contribute to a specific event.
- Event tree analysis – An event tree describes the possible range and sequence of outcomes that may arise from the initiating event.

When identifying the risks it is important to develop a risk register (Project Management Institute, 2008). The risk register should contain the outputs from the risk identification, starting with the risk with the highest impact on the project. The risk register should give each of the risks a number and document the possible impact the risk can or will have on the project, this can be done in a risk description work sheet. Cooper et al. (2005) suggests that the documentation should consist of the following;

- The main assumptions and mechanisms to the risk arising
- The criteria likely to be affected
- In which phase of the project the risk is most likely to occur
- What consequence the risk will have
- The accountable risk owner

3.7.2 Risk Assessments Tools

The second phase of the RMP is the risk assessment. The overall goal with the risk assessment is to conduct analysis and evaluation of the risks that have been identified in the identification phase.

In the assessment phase the project will be able to sort out and prioritize the risk according to their probability or impact on the project. This is often done to get a good view of which risks that are most important to address in an early stage. Cooper et al. (2005) divides the risk assessment in to qualitative, semi-qualitative, and quantified risk assessment. The semi-qualitative approach will only be described briefly in this thesis.

Chapman and Ward (2003) argues that to achieve an effective risk assessment process in the project, there is a need to have the qualitative as well as the quantified approach to risk assessment. In early phases of the project it is common to have a qualitative identification and structuring process followed by a more quantitative choosing and evaluation process later on.

Qualitative- and Semi Qualitative Risk Assessment

In the qualitative risk assessment the basic idea is to evaluate the probability of a risk event occurring and the possible impact it will have on the project (Heldman, 2005). Furthermore, Cooper et al. (2005) argues that risk assessment consists of both risk analysis and risk evaluation, and its purpose is to develop agreed priorities for the identified risk. However, this report will not distinguish between the analysis and the evaluation. Furthermore, Cooper et al. (2005), addresses qualitative risk assessment as a possibility to make descriptive scales that are likely to occur in the project. This is commonly done by receiving opinions of experts, employees with long experience and key stakeholders. The general benefit with qualitative approaches to risk assessment is that it is simple, easy to use and sufficient for many purposes in most kind of projects. The difference between qualitative and semi-qualitative risk assessment is that the semi-qualitative process extends the qualitative process in such a way that by allocating numerical values to the descriptive scales which have been developed during the qualitative assessment (Cooper, et al., 2005).

According to Project Management Institute (2008), some of the most useful methods to use for a qualitative risk analysis are:

- Risk Probability and Impact Assessment
- Probability and Impact Matrix

Furthermore, if a qualitative risk analysis is performed in a professional manner it will turn into a rapid and cost-effective tool to establish priorities for the planning of risk

response and also become a fine foundation for the quantitative risk analysis, if required (Project Management Institute, 2008).

Risk Probability and Impact Assessment

In the risk probability and impact assessment the likelihood of each specific risk occurring is investigated (Project Management Institute, 2008). This method is two approaches merged into one. One approach is the risk probability assessment which investigates the probability or likelihood that each specific risk will occur and the other approach is the impact assessment. The impact assessment is evaluating the effect the investigated risk will have on project objectives, such as cost, time, quality or performance.

The model is not only about the impacts the risk will have on the project in a negative manner but is also considering which eventual positive opportunities the risk could have (Project Management Institute, 2008).

According to Heldman (2005) assigning probability and impacts to risks can be a very subjective matter, therefore it is important for the organization to develop or adjust existing probability and impact scales for every new project. This will help to eliminate some of the subjectivity involved in using this model.

According to Maylor (2010) scales can be expressed as low – medium – high on a 1-3, 1-5 or 1-10 scale. The Project Management Institute (2008) describes their scale of probability in five steps from ‘very unlikely’ to ‘almost uncertain’. Furthermore, they are translating their descriptive scale into a numerical scale between 0-1.00. The impact scale is divided into five steps from ‘very low’ to ‘very high’.

As shown in figure 5 it is not sufficient with a single scale for all the objectives that are assessed in the figure. In this case it is necessary to develop a more descriptive scale for all the objectivities that are assessed and how their impact will affect the project in terms of impact scale.

Defined Conditions for Impact Scales of a Risk on Major Project Objectives
(Examples are shown for negative impacts only)

Project Objective	Relative or numerical scales are shown				
	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 increase
Time	Insignificant time increase	<5% time increase	5-10% time increase	10-20% time increase	>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 item 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

This table presents examples of risk impact definitions for four different project objectives. They should be tailored in the Risk Management Planning process to the individual project and to the organization's risk thresholds. Impact definitions can be developed for opportunities in a similar way.

Figure 5: Example of risk probability scales and impact their impacts on project objectivities according to PMI (2008)

The proper way of working with risk probability and impact assessment in terms of probability for each risk, and impact on its objectivity, is by evaluation during a risk assessment meeting or during interviews (Project Management Institute, 2008). Clarifying details, including assumptions that will justify the levels assigned should be documented. Furthermore, risk probabilities and impacts should be rated according to the definition given in the RM plan, and risks with low probability ratings and impacts should not be dismissed but rather put on a watch list for future monitoring (Project Management Institute, 2008).

Probability/ Impact risk rating matrix

If there is a need for further analysis of the risks and impacts that was developed during the risk probability and impact assessment a common tool used is the probability/ impact risk rating matrix. This method is a mixture of qualitative and semi-qualitative approach. If the probability and impact scale that have been used during the risk probability and impact assessment are numerical values between 0-1.00, the probability/ impact value can be calculated as: (probability x impact). The value that is received can be plotted in the probability/impact matrix. An example of the probability and impact matrix is illustrated below in figure 6: the figure visualizes impact as both threats and opportunities.

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

Figure 6: Example of risk probability and impact matrix according to PMI (2008)

As illustrated in figure 6, an organization can rate a risk separately for each objective that has been chosen in the risk probability and impact assessment. The objectivities can be cost, time, quality or scope, for instance. The figure also illustrates how the use of different color schemes can be used to highlight which risks, both threats and opportunities that should be assessed for further prioritizing and response. The risks that are in the dark grey area are the risks that have the biggest impact on the objectivity if it occurs; this is the risk that needs to be addressed in a priority action and aggressive response plan (Project Management Institute, 2008).

Quantified Risk Assessment

The quantitative risk analysis is methods that are used to identify and asses risks when data is uncertain or unavailable (Smith , et al., 2006). In the quantitative analyses the purpose is to use the numerical ratio scales for probability and consequence instead of the descriptive scales that are used in the qualitative analysis. According to Maylor (2010), the quantitative risk analysis is an attempt to provide a mathematical model of a scenario in an attempt to allow the brain to comprehend the effect of a large number of variables on the outcome, the main goal is to estimate the impact of risk on project objectivities (Project Management Institute, 2008).

In contrast to qualitative risk analysis, quantitative risk analyses could be complicated and time consuming. In most small to medium sized projects it is usually enough to perform a qualitative analysis only. The quantitative approaches to risk analysis are in most large scale projects a necessity to do because of the high complexity. Heldman (2005) argues that quantitative risk analyses are more suitable in medium to large projects. This is mainly because of the methods that are used need highly skilled employees and demands a high number of resources such as complex software programs.

As in the qualitative risk analysis there are numerous different tools that can be used when it comes to the quantitative analysis. Some of the most common that are used in the construction industry are:

- Diagramming techniques - decision trees
- Modeling techniques - sensitivity analysis
- Scenario techniques - Monte Carlo simulations

Decision trees – Diagramming techniques

Decision trees can be very useful if the scenario is complex. One of the main benefits with decisions trees is that they contain a diagramming technique which can be useful in situation when you need to assess probabilities of particular events that are reliant on previous events (Potts , 2008). Decision trees can be used in the identification process as a simple qualitative method, however, if a decision tree is used with detailed consideration and probabilities/ distributions to each of its events it becomes a powerful quantitative tool. Decision trees are most commonly used for risks impacting either time or cost, and can be used to calculate the expected value as well as to evaluate different alternatives before choosing (Heldman, 2005),(Potts , 2008), (Kendrick, 2009). A simple decision tree is shown in figure 7

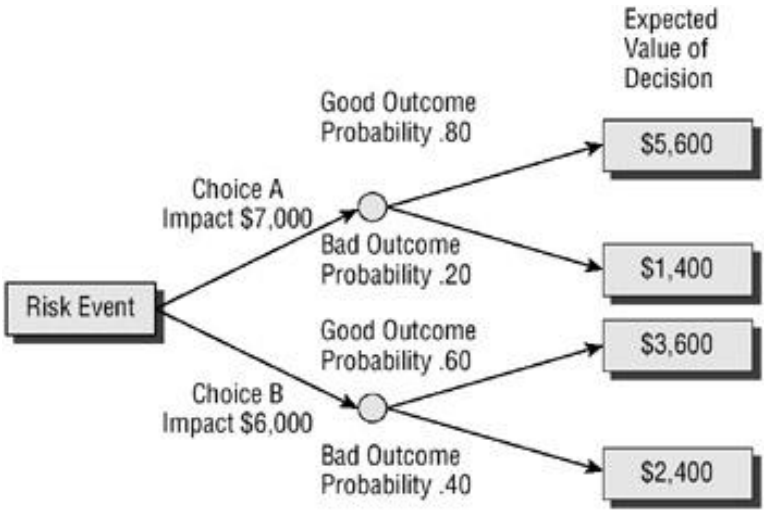

Figure 7: An example of a decision tree (Potts , 2008).

Modeling techniques - sensitivity analysis

Sensitivity analyzes can be a non-probabilistic or probability-based modeling technique that can be used to establish which risk event that have the greatest impact on a specific project objectivity such as the cost. The main purpose of the sensitivity analysis technique is to answer "what if" questions about isolated key variables and what the impact will be if the variables are changed in an incremental way (Smith , et al., 2006).

According to Smith et al. (2006) the basic idea of a non-probabilistic sensitivity analysis is that it is carried out by identifying the project variable that should be analyzed and given upper and lower boundaries which the variable are allowed to vary within. The technique allows the variables to vary in small steps so that they can be calculated and analyzed with the economical parameters in mind. The calculated data is usually shown in a spider diagram. Figure 8 below illustrates an example of the sensitivity analysis plotted into a spider diagram.

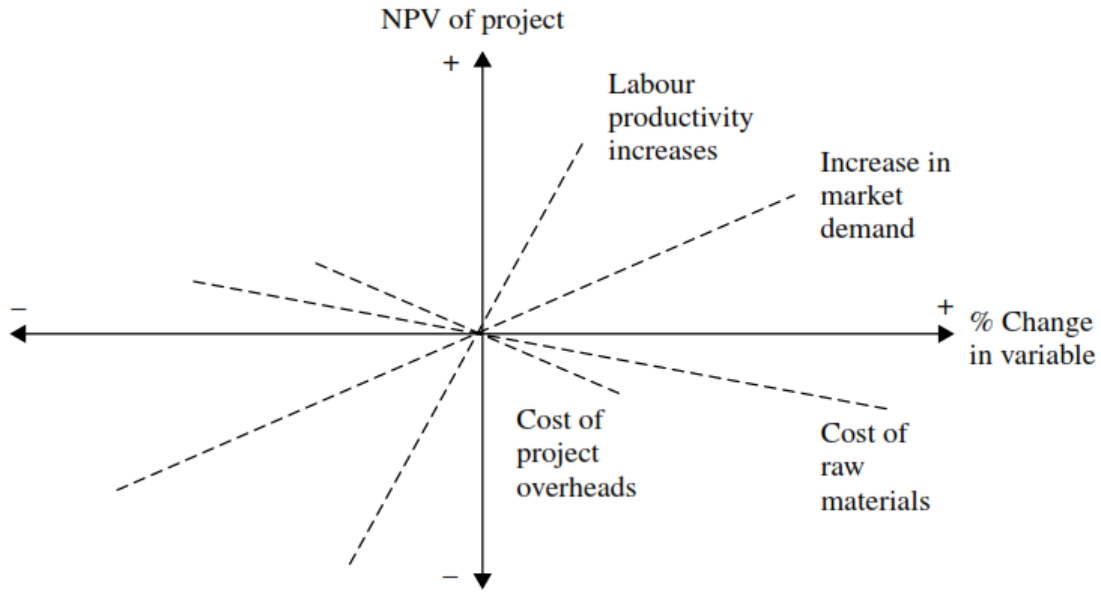

Figure 8: An example of a non-probabilistic sensitivity analyses (Smith , et al., 2006).

The difference between the non-probabilistic and probabilistic sensitivity analyses is that the latter involves assigning subjective probabilities to the alternative outcome (Smith , et al., 2006). If this technique is to be used in the proper way there is a need to have great knowledge of the project in detail, if this is not the case the model will have a deceptive impact on the result (Smith , et al., 2006). Figure 9 below illustrates a spider diagram plotted from the probabilistic sensitivity analysis.

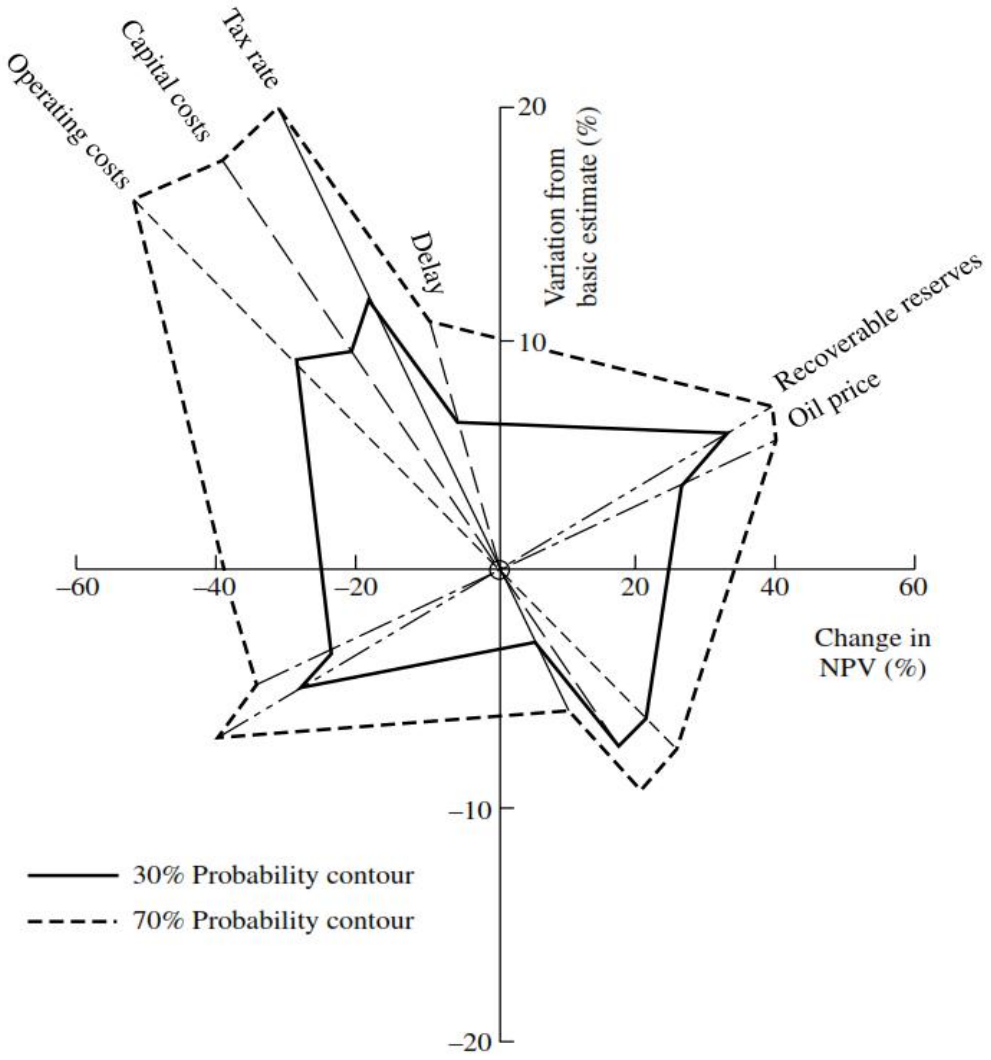

Figure 9: An example of a probabilistic sensitivity analyses (Smith , et al., 2006).

Furthermore, Smith et al. (2006) brings up a number of issues they view as limitations to sensitivity analysis. The main limitation, as they see it, is when one variable is changed the model assumes "*cetris paribus".* This means that when one variable is changed the rest of the variables remain the same. However, in reality this is not likely the case (Smith , et al., 2006). The method does not consider the probability of events that are connected with both the variable and the project outcome. This technique requires that the project has been computer modeled before any analysis can be performed. This can lead to the situation where the project requires someone with skills in simulating project models.

Scenario techniques - Monte Carlo simulations

When it comes to modeling techniques for schedule and cost one of the most used is the Monte Carlo analyze. The Monte Carlo analyzes is a powerful tool, consisting of a random number generator producing thousands of samples. These can be used to simulate different scenarios in order to assess the risk associated with the project as a whole (Mun, 2006), (Heldman, 2005). The method is very proficient for

forecasting/prediction, risk analysis and sensitivity analysis (Heldman, 2005). Mun (2006) describes Monte Carlo simulation in its simplest form by picking golf balls out a basket. The golf balls that are bouncing around in the basket represent the data in the simulation. Each time one golf ball is picked the ball will represent an outcome and is noted, after the notation the ball is returned in the basket. This operation iterates for as long as the simulation proceeds. When the simulation is over the average is calculated from the entire recorded outcome. The average will constitute the calculated risk probability for the simulated event.

In order to create accurate Monte Carlo analysis the project must provide the model with data. Most simulations use existing data from earlier projects with risks that are similar to the one that needs to be analyzed. This means that it is important for a company to build up a database over time with data that can be used in risk analyzes.

3.7.3 Risk Response

The main purpose of risk response is to develop options and actions to maximize opportunities and minimize threats to the project objectives. Furthermore, during the planning of the risk response the chosen action must be appropriate to the risk as well as in terms of cost effectiveness and realism to the project context. The risk response that has been chosen must have an agreement between all involved parties and owned by the responsible owner (Project Management Institute, 2008).

There are four common strategies of responding to risks. Potts (2008) defines these four different risk strategies as:

- Avoidance/prevention,
- Reduction/mitigation,
- Transferring
- Retention (accepting)

Besides these four general strategies, Winch (2010) and Cooper et al. (2010) bring up insurance as a possible strategy for risk response. In addition to these five methods Winch (2010) argues that in some cases it is difficult to make decision if there is not enough information available. In these cases he argues that it can be more suitable to delay the decision making until more information is available. He considers this an effective management strategy if the risks have high-impacts on the project.

Heldman (2005) makes an important remark that a project manager should consider the financial cost for implementing each risk response. If the cost is higher for the implementation than it is for the consequence for the actual risk, it is more economically profitable for the project to accept the risk. The same implies in the situation where the time and effort to develop the risk plan is greater than the outcome.

Besides the strategies described above for dealing with risk, Project Management Institute (2008) brings up four strategies that can be used to deal with positive risk or opportunities. The strategies are: exploit, share, enhance and accept. The fourth one, accept, can also be used as a strategy for risks with a negative impact on a project (Project Management Institute, 2008).

Avoidance/prevention

The safest way to deal with a risk is to avoid it completely (Cretu, et al., 2011). If risks that have been identified and analyzed have possible negative impacts in such a way that the entire project is endangered the best approach to deal with the risk is to change the projects scope, or in the most radical case, cancel the entire project (Potts , 2008). Cooper at al. (2005) sees risk avoidance as an alternative way of risk reduction, where undesired events can be avoided by taking a different course of actions.

In most projects, avoidance is the best way of dealing with risks. This is because one of the purposes of avoidance as a strategy is that it will obliterate the risks (Kendrick, 2009). This can be done by considering alternatives for the project during the design and planning stages and make changes if major risks are detected. This is why involving RM in early phases of a project is a preventive method to detect risks before it shows impacts on the project (Winch , 2010).

Cooper at al. (2005) and Kendrick (2009) give good examples of how risk prevention can be used to avoid possible risks. The difference between them is that Cooper at al. (2005) views risk prevention connected to the project as a whole. Kendrick (2009) has divided risk prevention into different categories. The categories he provides are: avoiding risk on the project scope, schedule risks and consequences, and risks connected to resources. Some of the risk preventions that are brought up are:

- More detailed planning:
  - Reduce the number of critical paths
  - Less dependencies between activities
  - Schedule the highest uncertainty activities as early as possible
  - Avoid, if possible, to have same staff members working on more than one successive or concurrent critical (or near critical) activities
  - If possible, break down long-lasting activities as much as possible and reschedule work for more flexibility
- Training and skill enhancement of project team members:
  - Educate team members in more efficient methods in the commencement of the project
  - Reduce the work load on fully loaded or over committed resources
  - Limit commitment of project staff to other projects
  - Use the most skilled personal for critical activities
  - Minimize dependency on single individuals
- Avoid “not invented here thinking”; willingness to leverage others work

Reduction/Mitigation

By using risk mitigation as a strategy for dealing with risks the project are trying to reduce the probability of a risk event and its impact down to an acceptable level (Heldman, 2005). This strategy against risks is in most cases more economical advantage in the beginning of a project life cycle, since the cost for the risk mitigation will be higher later in the project life cycle (Cretu, et al., 2011).

One of the downsides if risk mitigation planning is used in an incautious way is that it can introduce new risks to the project (Heldman, 2005). This brings up the importance

for communication in RM. One of the cheapest and most effective ways to mitigate risk within a project is effective communication by the project manager. The bigger understanding and visibility there is for risk within the organization the more likely it is that people working with risk will do their best to prevent it to happen (Kendrick, 2009).

Cooper et al. (2005) brings up some key issues that mitigation strategies can include:

- Contingency planning
- Quality assurance
- Crisis management and disaster recovery planning
- Contract terms and conditions

Transfer

If an identified risk can be better managed by a third party, either because they have more information about the risk or better capacity to manage it, it should be transferred (Winch , 2010). Commonly used transferring techniques involves; insurance, warranties, guaranties, performance bonds, or contracting (Cretu, et al., 2011), and it is most effective when dealing with financial risks (Project Management Institute, 2008). Depending on the risk characterization the actors that the risk can be transferred to are: client, contractor, subcontractor or designer (Potts , 2008). One of the downsides with transferring a risk to a third party is that it could lead to additional work and consequently higher costs for the project (Potts , 2008).

Retention

If the risk cannot be avoided or transferred, or if the cost of doing so is higher than the impact cost for the risk the best solution in these cases is to retain the risk within the organization for further monitoring and control (Cooper, et al., 2005).

Insurance

For risks that have a low probability but high impact risks, which have been left over after other risk treatment actions, for instance a fire, a good strategy to address these risks is by insurance (Winch , 2010). One type of insurance that can be used is liquidation damages clauses in contracts. A benefit with liquidation damages clauses in contracts is that it can be a good incentive for the contractor or suppliers to actively work with their own organizations RMP.

3.7.4 Opportunity response

All of the above mentioned strategies for responding to risk are supposed to reduce the negative impact a risk can have on the project. Stated below there are some response strategies that can be implemented if the project or risk manager deals with opportunities. According to Project Management Institute (2008) there are four ways opportunities can be dealt with, these four are: exploit, share, enhance, or accept.

Exploit

If a risk with positive impact has been identified, the organization can exploit the risk to be sure to realize the opportunity. The exploitation strategy tries to minimize the uncertainty connected with the opportunity. This is done to ensure that the opportunity actually occurs and is not overseen by the organization. It can be done by assigning the right resources within the project to reduce the time of completion or to provide lower costs than it was planned for from the beginning (Project Management Institute, 2008).

Share

Sharing an opportunity with a third party involves allocating some or all of the ownership to the parties that are most suitable to handle the opportunity for the projects benefit. This can be done through: risk-sharing partnerships, joint ventures, special purpose companies, or teams. The main idea is that all the involved parties should benefit from the shared opportunity (Project Management Institute, 2008).

Enhance

By enhancing an opportunity, the RM team attempts to increase the probability and/or the positive impact of the opportunity. This can be done by identifying and maximizing key drivers connected to the opportunity so the probability attached to it will increase. One way of enhancing an opportunity is to allocate more resources to an activity for an earlier finish than originally planned (Project Management Institute, 2008).

Accept

By accepting an opportunity the risk manager is willing to yield any advantages if they come along, not actively pursuing it (Project Management Institute, 2008).

3.7.5 Monitoring and Control

The last and final step of the RMP is monitoring and control of the risks. In this stage all the information about the identified, assessed and analyzed risks are collected and monitored (Winch , 2010). According to PMI (2008), in the stage of monitoring and control it is appropriate to develop a risk response plan, keep track of identified risks, identify possible new risks, and keep track of potential remaining risks (Project Management Institute, 2008). Furthermore, in this step of the project there is a chance of evaluating the efficiency, both positive and negative, of the RMP throughout the entire project life cycle and keep a supervising eye on already identified risks if more information becomes available (Project Management Institute, 2008), (Winch , 2010).

Monitoring and control of risks and opportunities should be done on a regular basis. Cooper et al. (2005) suggests that this should be done as a standing point in project meetings where you run through the most critical risks on the risk register. One of the major tools and in some cases the most important one in this stage is the risk register (Cooper, et al., 2005), in addition PMI (2008) discusses some tools and techniques that can be used as a complement to the risk register.

Some of the recommended tools and techniques according to PMI (2008) are:

- Risk reassessment on already assessed risks on the risk register. During this process new risks are commonly identified and can be assessed.

- The main idea with Risk audits is to examine and document how effective previous risk responses have been for the project. It is up to the Project Manager to decide how frequently these audits should be performed. It can be a part of the normal project review meeting or it can be performed as individual or external audits.

- A very popular way of doing Variance and trend analysis is by earned value analysis (EVA). Through the EVA the project can predict how they are in accordance to the project performance. If there is any deviations from the projects baseline plan the organization can use this information to predict eventual uncertainties, risks or opportunities for the project.

- Status meetings should be held on a regular basis so that the risk owners can discuss the risk and share their experience with others in the group. PMI (2008) also stated that the more regular these meetings are the more effective the organization will become in identifying risks and opportunities.

The output from these techniques will help to update the risk register so that the project always has the newest information when they are working with the risks. Other benefits and outputs that can be derived from it are according to PMI (2008), updates of project management plans and documents. The update of the project management plan is only necessary if the risk and control process have identified some changes that have to be done to minimize or terminate risks that will change the original plans.

4 Handling of Risk in NPRA a case description

The following chapter explains the existing risk handling process within NPRA. It includes an explanation of the general guidelines that are published within the entire organization and its development. Furthermore, it introduces the given definitions of expressions such as uncertainty and risk and how the guidelines within NPRA view them. Later in the chapter there is a description of how an organization is supposed to implement the guidelines in separate projects and what tools are available and how they should be used.

The purpose of this chapter is to provide a description of how the organization is supposed to work with RM. This will be compared to the results on how actually work later in the discussion.

4.1 Background to Risk Management in the Norwegian Public Road Administration

With the support of the Norwegian Centre for Project Management (NSP) and the research program "Concept", the Public Roads Administration was invited to participate in the research project "Practical management of risk in the project owner's perspective" (PUS) in 2006. This was done in collaboration with Statoil, Telenor, the Armed Forces, Statsbygg and Jernbaneverket. This collaboration project was formally completed in November 2010. The project intended to lead to an increased focus on RM in the companies.

Concept's research program has produced a report named "Management of public investments" in which 12 of the Norwegian Public Road Administrations KS2 projects from year 2000 and until 2010 have been analyzed in relation to corporate governance, planning and costs, effectiveness, project management, contract management and risk management. KS2 is an external audit performed in projects exceeding 500 million NKR. The grading of KS2 consists of three levels where the green is a positive valuation, yellow implies some serious remarks while red means significant objection from the researchers undertaking the study. According to the study, 9 of 12 projects investigated had a yellow or red mark.

The KS2 project intended to align all the public companies and to create a common understanding among them to avoid misunderstandings and mistakes (Finansdepartimentet, 2008). The definitions and information in their guiding documents is developed in the year 2000 in cooperation between the Ministry of Finance and companies covered by the Norwegian standard agreements (rammeavtalen). Together they developed guidelines for quality assurance of cost estimates, including risk analysis for larger governmental investments. The document was originally drawn up in spring of 2001 and has since then laid out the foundation of work with the external quality assurance (KS2). The guidelines are meant to be recommendations for the structure of each individual project and how it is managed instead of being a strict model which they are bound to work from.

Concepts report shows that road construction projects are lacking a proper RM system. In some of the projects an inadequate understanding of the phenomenon of RM was identified. One of the report's conclusions is that, some project managers can manage uncertainty well with intuitive methods, but it is very dependent on the individuals.

PUS work within the Public Roads Administration lead to three main targets formulated:

- Develop and implement new analytical tools for uncertainty in different phases
- Develop procedures for risk and uncertainty in investment projects
- Ensure that the uncertainties are identified, processed and documented in the intranet database

In the investigated project of the Norwegian Public Road Administrations the uncertainty strategy assumes that all projects are carried out in accordance with Handbook 151 of The Norwegian Public Road Administrations. This handbook includes Management of progress and economy as well as a section on uncertainty management.

4.2 Accountabilities of Project Managers in the Norwegian Public Road Administration

According to Handbook 151 the client is responsible for preparing the plan for RM. Furthermore, all parties involved in the project have a duty to report on matters that should be considered and incorporated into the plan.

In accordance with the RM plan all project managers are responsible for ensuring that risks that are identified will be disclosed so that they can be managed and monitored in the project's RM system. The project manager is responsible for assessing the uncertainties on the focus list and to make sure to report these further within the project.

According to plan for RM, the Planning Manager, Project Manager and Construction Managers are responsible for assessing the probability and consequences of registered uncertainty. They are also responsible for submitting suggestions to the ones responsible for the uncertainty and try to reduce the uncertainty over time.

4.2.1 The interpretation of Uncertainty and Risk

Within the NPRA the definition and interpretation of risk and uncertainty is given in the Guidance for Risk Management in NPRA. The handbook states that, one always has to live with uncertainty in all projects. This means that they consider it to be unavoidable and something that should be managed instead of ignored and avoided. Furthermore, it states that uncertainty can have both an upside and a downside and they find it important to focus on the opportunities in both directions. The handbook states that uncertainty can be either a risk or an opportunity. According to them; uncertainty is the lack of complete security, that is, there exists more than one possible outcome.

One important aspect that is given in the handbook is that it recommends that the uncertainty management is preferably done by involving the entire organization and that everyone needs to be aware of the importance of the system. The handbook also acknowledges that it is important to emphasize that uncertainties can arise at any time and that they should be handled and reported straight away.

The guideline consider it important that the focus on the risks does not take all the attention, but that they also put emphasis on looking for opportunities that can be exploited to the project's advantage. Their RM is therefore not intended to unilaterally reduce the uncertainty, rather to control it so that the risks are not excessive. By doing so they intend to control the risk that is identified and meanwhile to make the best of the opportunities that arise. The uncertainty plan will therefore become a living document that follows the development of the project.

The handbook states that the goal of all uncertainty management is to:

- prevent the occurrence of adverse circumstances or at least reducing the effects of these

- make the best of the positive opportunities offered at any time of the project

The purpose of the RM plan for projects within the company is that they can ensure that the uncertainty associated with the execution of the project will be handled in an optimal manner. This means that all work in the Public Roads Administration, conducted by their own employees or contractors, should be done in a way that does not impose unnecessary inconvenience or danger to the participants in the project or for the environment. In addition, the risk plan exists to ensure that the project is carried out cost-wise optimal, that risk is minimized and that the positive opportunities that might occur will be exploited and used for the project best.

4.3 Roles in risk management

To be successful in RM the Guidance for Risk Management recommends that there are clear roles, so that everybody involved in the Risk Management process knows who is responsible for specific tasks.

The project owner’s responsibility in this process is to develop demands on how the project should be conducted and how risks should be handled. The project owner is responsible for making sure there is a proper RM plan, risk assessment and a response plan during the planning phase. During this phase the project owner is also accountable for acquiring continuous reports on how risk, time and cost estimates are developing in the project. Furthermore, it is the project owner’s responsibility to make sure that RMP is managed in an effective manner when it comes to developing the process, collecting experiences from the project, and making sure that there are systems for developing the knowledge of the personnel. In the final report the project owner is accountable for making sure that the report contains an assessment on how the project have been able to meet the reality when it comes to risk analyses, if the risk process has worked properly and if there are any advice on how to develop the risk process even further.

The Project Manager has the overall responsibility for the development of the risk plan, follow-up and reporting from the RMP. In less complex projects it is up to the Project Managers to delegate the entire responsibility or parts of it to employees within the project organization. In larger projects the NPRA guide recommends the Project Managers to appoint one risk coordinator. It is recommended that the appointed person has sufficient power and influence in the project organization. The

coordinator has the responsibility to lead the risk process during the project and to make sure that the risk plan, register, and reporting is done.

When it comes to the responsibility of risk owners in the risk register, it is recommended that the owner should be responsible for the part of the project that the risk is most likely to happen in.

4.4 General Risk Management process in NPRA

The general process in how RM should be conducted within NPRA is presented in the document Guidance for Risk Management within NPRA (Veileder for usikkerhetsstyrning I StatensVegvesen). In most cases, RM is connected to the overall cost plan that has been developed for the project. The main process is illustrated in figure 10.

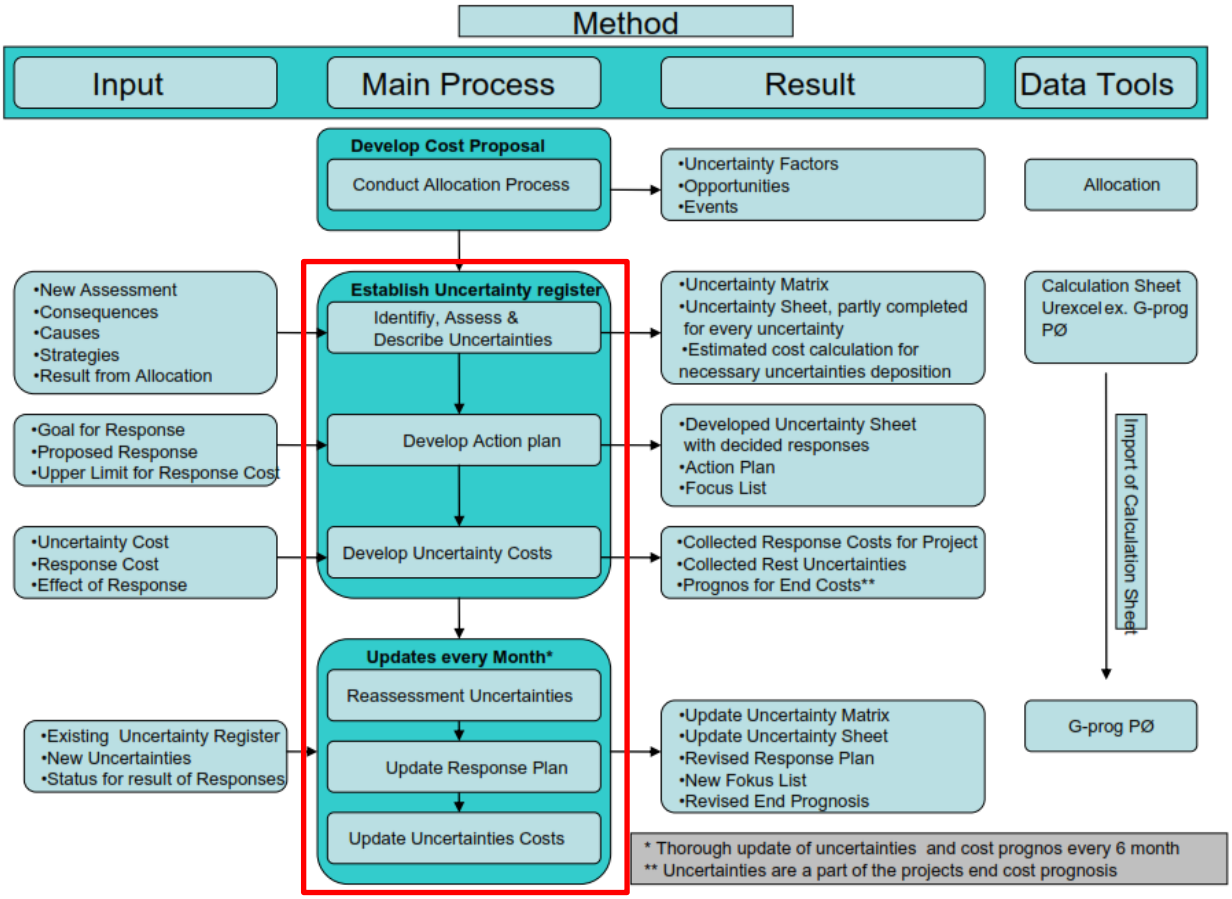

Figure 10: General process for RM in NPRA, marking shows the area of specific interest (Vegvesen, 2012).

If the project in question develops a RM plan, this should be done in the pre-project phase. For all projects undertaking the KS2 revision, the RM plan should be developed before the work with the quality assurance has started.

As can be seen in figure 11, the first step following the general cost estimate is to establish the projects risk plan, followed by the risk register. After the risk register is established the process goes into a cyclic process.

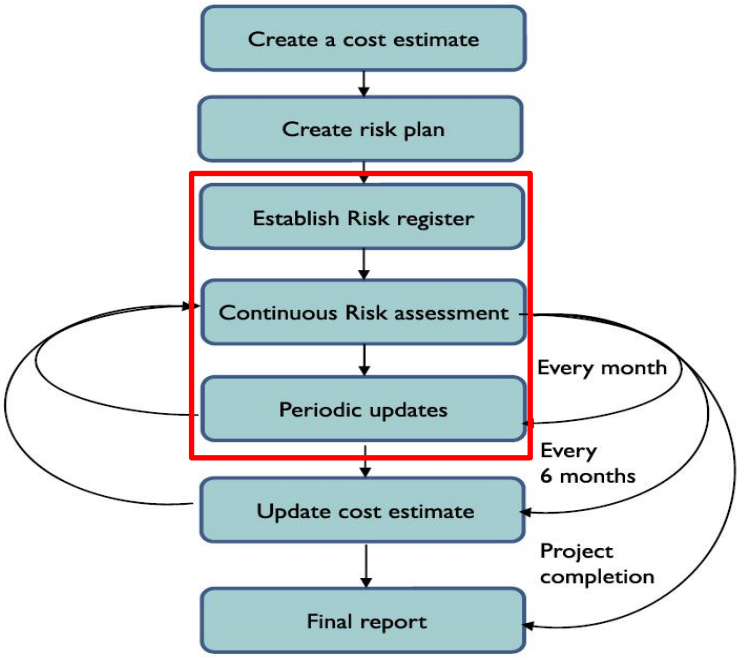

Figure 11: Steps in the RMP used in NPRA, marking shows the area of specific interest (Vegvesen, 2012).

The main reason for the process to be cyclic is that the Guidance for Risk Management in NPRA recommends project organizations to work with RM as a continues process. It is recommended that the Project Manager should consistently work with predicting and identifying risks and uncertainties and other activities that fall naturally into the daily work of RM. According to the model it is recommended to have periodical update meetings every month. During these meetings people involved in working with risks should have a run through the entire risk register. This is done for the register to be always updated with the latest description and valuation of the monitored risks. Furthermore, the result of the updated risk register which shall contain time and cost prognoses should be reported to the project owner. These meetings can be a part of project, or building meetings, as a regular part of the work.

Every sixth month the cost plan should be updated in the cost control program called "G-Prog Project Economy" or "Anslag". If any new information concerning risk is discovered during the update of the cost it should be reported back to the risk register for further analysis.

After the completion of the project an end report shall be conducted in the database, "Kostnadsbanken" in accordance with the proper procedures. In this database, the Project Manager shares his or hers experiences about the risk and uncertainties that have been managed throughout the project, the impact of the risks and how they were dealt with. This is done so that NPRA could build up a solid base for eventual improvements in issues concerning, analyzes, routines, governance and management.

4.5 Risk Management Plan

The main purpose of the risk and uncertainty management plan for projects within NPRA is to ensure that the uncertainty associated with a project will be handled in an as optimal manner as possible. The plan should consist of a brief description of the project and should be connected to the governing documents that will be used in the

project. Moreover, the risk and the uncertainty management plan are there to inform the project owner about how the project is addressing risks.

The risk and uncertainty management plan should consist of the project goal and which strategy that will be used to achieve it. This means that the project manager should describe why RM is important in this project and why the project should aim to fulfill the strategy when it comes to reducing risks/uncertainties and exploiting opportunities and choosing which tools that are going to be used. If several different tools are being used there must be a description of which tools are used when and the boundary between them.

4.5.1 Routines Concerning Continuous Risk Work

The routines described earlier concerns the development of the risk/uncertainty register in the initial stages of a project. If an organization wants to work continuously with risk it is important that the project organization develops routines concerning how this should be done. Once again the Guidance for Risk Management in NPRA suggests that it is beneficiary to divide the work into sub chapters and develop routines for each of these chapters. It also states that each chapter should describe and answer the following:

- **What** shall be done
- **Who** has the responsibility and **who** is involved
- **Why** shall it be done
- **When** shall it be done

When it comes to identification of risks the guidance recommends that it should not be done by brainstorming sessions or other group related process, for instance in workshops. Instead, if the project works with continuously identifying risks it will identify potential risks along the development of the project. Further benefits with working with continuous identification of risk are that the identified risk can be documented and put in the risk register as soon as they are identified.

The guidance for Risk Management in NPRA recommends that the sooner the identified risk is assessed and valued in meaning of probability and impact and put up on the risk register the more beneficial it is for the project. In the continuous work it is up to the project and its managers to develop routines in reassessment of the identified risk. This can be necessary if something happens in the project or its environment that changes the character or probability of the risk. A reassessment of the already assessed risks should normally be performed in periodic follow up meetings.

When it comes to selecting response and implementation the guidelines states that it is important for the project to develop routines. This issue is important both when it comes to newly identified responses as well as old revised responses.

Furthermore, the guidelines states that it is important for the organization to develop routines concerning how and what that should be reported both internally as well as externally within the organization. These routines should cover how newly identified risks should be reported within the organization.

4.5.2 Follow-up meetings Routines

According to the guidance of Risk Management within NPRA it is central for the organization to have follow-up meetings for risks on a regular basis. These meetings should be conducted each month. To supplement these meetings it is recommended to have meetings every sixth month concerning cost estimate in the project.

To have an effective process during these meetings is important for the organization to develop routines connected to the meeting procedures. These routines should concern such questions as how to work with the RMP and whom to report to.

4.6 Risk Register

Concerning the use of the risk register, the Guidance for Risk Management within NPRA recommends that one person should be responsible for the maintenance of the register. The register should also contain the tools that are going to be used in the risk process, for instance G-Prog Prosjekt Økonomi, NPRA excel spreadsheet for risk register or paper based version of the same sheet. The location where the register is stored is dependent of which tools that are used.

Furthermore, Guidance for Risk Management in NPRA brings up the importance of building routines on how the register should be stored. It also mentions that it is very useful to keep stored copies of the register so that it will be possible to back track in the register to see what has been done before.

4.6.1 Routines concerning development of risk/uncertainty register

To maximize the impact of the risk register it is important for the project to develop routines that should be used during the work with the risk register. The Guidance for Risk Management in NPRA suggests that during the development of the register it can be useful to divide the work into sub chapters and develop routines for each chapter. It also states that each chapter should describe and answer the following four questions:

- **What** shall be achieved and **What** shall be done
- **Who** is responsible and **Who** shall be a part of the group
- **How** shall it be executed or **How** was it executed
- **When** was it executed or **When** shall it be executed

These documents should contain information on how the project should work with RMP and which routines that should be used. It is important to describe what the project already concluded and how the project will precede with the RMP process.

4.7 Risk register and risk sheet used in NPRA

All projects in NPRA use the same risk sheet as a tool in RM. This sheet has been developed as a result from the research project PUS. The risk sheet is the base for the risk register and if properly used the risk sheet will automatically generates information lists that can be used in the evaluation of the risk. The risk sheet generates the following lists: risk matrixes, risk list, action list, focus list and calculation sheet for the risks. An example of the risk sheet and its contents is shown in Appendix A.

One part of the generated lists is the risk matrix. As mentioned above the risk sheet has been developed as a result from PUS, this means that the sheet is developed to be used in a variety of different projects. The Guidance for Risk Management within NPRA states that it is important to calibrate the classification of the consequence classes for risk and opportunity connected to the risk matrix. This calibration should be done so that it suits the specific project. The consequence classes which are notated by a K for risk and M for opportunities are divided into four different steps. For risks it goes from K5 which are catastrophically down to small, K2. The same approach is used for opportunities: M5 is very big and M2 small. An example of the risk matrix is shown in figure 12. Furthermore, examples of how consequence classes could be calibrated along with other information lists that can be generated from the risk sheet are displayed in Appendix A & B.

PK matrise	Consequence							
	Risk				Opportunity			
Probability	Catastrophic	Critical	Severe	Low	Low	Middle	Big	Very big
>50%	20	15	10	5	-5	-10	-15	-20
25-50%	16	12	8	4	-4	-8	-12	-16
5-25%	12	9	6	3	-3	-6	-9	-12
1-5%	8	6	4	2	-2	-4	-6	-8
<1%	4	3	2	1	-1	-2	-3	-4

Figure 12: The risk matrix used within NPRA (Vegvesen, 2012).

5 Results

The result chapter is divided into three main part:;

- *The first part of the result elaborates how the RMP is conducted according to the RM plan in the project.*

- *This is followed by results from meetings where the authors participated. There were a total of three meetings attended. The first meeting was an introduction meeting. The second meeting was an official project meeting where the whole project staff was present. The third one was a risk assessment meeting.*

- *The last part of the results concerns the findings from the conducted interviews.*

5.1 Risk Managed in the Case Project

In accordance with the guideline for risk management in NPRA the Project Manager has developed a general plan on how to deal with risks and opportunities for the Biri – Otta project as a whole. In this document it is stated that in support to RM the project should strategically focus on Quality, External environment, Finance and Cost and project progress to reduce uncertainties and unplanned events. It is also stated that the project should be focused both on risks as well as opportunities continuously throughout the entire project lifecycle.

According to this document, the governance structure for the project when it comes to RM is that all employees have a responsibility for identification of uncertainties and that these should be reported and stored in the risk management system. The Project Manager, Planning Manager and Construction Manager are the employees that should be responsible for assessment of identified risks when it comes to probability and impact. Furthermore, these employees are responsible for making suggestions, on who is the most suitable person to handle the risk and which response that should be preferred. The employee that has been chosen to handle the risk is also the one that owns the responsibility of making the right measure to reduce the risk. The Project Managers responsibility is to assess the risks on the focus list and to make sure to report these further in the organization.

For the entire project of Biri – Otta, the risk sheet is used as the main tool for registration and follow – up. The risk sheet is stored in e – room, which is a web hotel that is used for all documentations within the project.

In the continuous work with risk, the risk document brings up how the Biri – Otta project should work with identification, valuation of identified risks, response, documentation and report structure. This document provides guidance on how the project should work with periodic follow – up. Hence, this document is overall very much aligned with the recommended ways of working with RM stated in the guidance for Risk Management within NPRA.

This RM plan is incorporated into a central governing document for the Frya – Sjoa project, which is developed from a general document for the entire east division of NPRA called “Styrningssystem for Prosjektavdelningøst”. This governing document brings up issues concerning the projects fundamental base, general frames and goals, and strategies for different parts of the project.

The strategy for the Frya – Sjoa project is the same as for the Biri – Otta project. According to the governing document the focus should be upon Quality, External environment, Finance and Cost and project progress to reduce uncertainties and unplanned events. For each of the different focus points, a list with more detailed description on how they should fulfill the strategy has been developed.

Every second week during the planning phase the organization have been holding preliminary construction plan meetings and construction plan meetings. During the preliminary meetings, uncertainties that have been identified are discussed by the Project Manager, Construction Manager, Quality Manager, and other key personal in the organization. If the discussed uncertainties are valuated to be critical or if they are assessed to be of high risks to project economy or progress they are brought forward to specific RM meetings that are held once a month. These uncertainties that are handled during these RM meetings become the foundation for the risk focus list.

In contrast to the preliminary construction meetings, employees attending the ordinary constructions meetings should according to the governing document be, besides the project management team, consultants. During these meetings uncertainties in connection to consultants' details and deliveries is discussed and assessed.

Every month the project undertakes an RM meeting and report meetings. During the RM meeting the main issue is to address all the critical uncertainties that have been identified during the preliminary construction meeting or construction meeting and to revise already exciting risks on the risk focus list. In this meeting the project manager, assistant project manager, construction manager, quality manager, and other key personal are attending. They are responsible for assessing the risk when it comes to probability and impact.

In the beginning of the Frya – Sjoa project an economic calculation has been done for uncertainties in connection to the project implementation. The five most critical uncertainties found in this investigation are: construction execution (23.8%), market situation (23,4%), project organization (9.1%), conformance in connection to details (8.4%), and ground condition/ geology (4.9%). The once that are concentrated most on are the project uncertainties that have a bigger percentage than 5 %.

5.1.1 Introduction Meeting

It came to our attention that there was a variety of interpretations on how to use the risk model and how to assess risks within the organization. Furthermore, the project manager showed concerns in how to communicate the importance of the risk handling to all parts of the project organization.

The main issues that were discussed during the introduction meeting were:

- The assessment of risk costs
  In the risk assessment meetings the project managers found it very hard to interpret how to put a cost on identified risks. Concerning the risk sheet the organization had several areas of uncertainty on how to work with it in a proper manner. This included in what areas the risk had implementations such as cost, quality, progress, judgment, and safety. In this matter the organization was perceived to have difficulties when it came to defining risks as other than costs in the risk sheet. Furthermore the interpretation was that the risk list only

was used in order to acknowledge the risk rather than handling it. Regarding the risk cost, it was perceived that the participants did not have an aligned view in the topic.

- How to identify and evaluate risks
  The view of how they identified risk changed during the meeting. In the beginning of the project one brainstorming activity took place where the entire organization participated. During this brainstorming, risks connected to the project as well as to the environment were identified. The interpretation was that following the initial meeting the organization only identified risks during the monthly risk assessment meetings. During these meetings the participants consisted only of persons in leading roles in the organization. The evaluation of risk was done in a qualitative approached were the organization relied on the participants in the monthly meetings experience.

- Accountability and monitoring of risk
  During the first meeting the organization presented the risk list which consisted of less than fifteen identified risks. These risks were handled out for monitoring and control to a relatively small group of employees within the project. Some of these risks were given to employees with little connection to the identified risk. Moreover, during this first meeting discussions were held concerning the size of some of the identified risks. The essence of the discussion related to the sheer size of some identified risks, implementing that they were hard to handle and monitor by a single person. Furthermore the project leaders realized that some of the big risks also could involve opportunities for the project but they were not assessed during the monthly meetings.

- Achieving better risk awareness within the organization
  During the meeting the project leaders discussed how they would like to achieve a better understanding and awareness of risk within the organization and how they found the level of awareness rather insufficient at the time. The general impression was that the organization had not received any formal training or education in RM when current risk model was introduced within NPRA.

- How the leaders should inspire employees to work with risk
  The Project Manager expressed his beliefs that a risk and opportunity aware organization will perform better to the project goals. However, he found it difficult to know how to inspire and spread the importance of working with risk in an effective and proper way. Discussions were held on how to make sure that the organization worked in such a way with risk and how to keep it up during the project phases. He wanted to encourage the employees to not only see the negative side when it comes to risks but also embrace the opportunities that could arise from it.

- How to create a better and more suiting risk meeting structure
  The participants discussed how the organization should become more effective during the risk assessment meeting. Ideas concerning who and how many should participate during the meetings, and also how frequent the risk assessment meetings should take place came to the intention.

5.1.2 Project & Follow up Meeting

The meeting was held to inform the organization about the external KS2 revision that took place a week earlier. As an effect of the external revision and this thesis, they had put much effort into the risk process since the first visit. The organization had received positive feedback from the external companies that conducted the revision on how they handled the project including risks.

During the afternoon there was a follow up meeting where the managers explained that the risk list had been developed from approximately ten risks and opportunities to more than fifty. Furthermore, the project had done a calibration of the risk sheet so it would fit the project better.

5.1.3 Risk Assessment Meeting

During the last day of visiting the project office the authors had an opportunity to participate in a risk assessment meeting. The attending staff consisted of: the assistant project manager, the risk coordinator and the construction manager. During this meeting it was observed that the participants showed an increased interest in the risk assessment process. However, the risk sheet used in the assessment meetings proved some flaws when it came to user friendliness and efficiency. Moreover, during this meeting it was unclear for the participants how to evaluate and calculate the expected impacts of risks. Furthermore, the employees proved difficulties separating risk costs connected to the society from costs connected to the project. The authors' experience from the meeting was that the meeting participants did not share an aligned view when it came to estimating risk costs.

5.2 Findings from Interviews

This chapter contains an interpretation of uncertainty, risk and opportunity that was given during the interviews. Furthermore, the findings of the interviews are divided into the four steps of the RMP and an additional part containing findings related to communication.

5.2.1 Interpretation of uncertainty, risk and opportunity

According to the findings there was a broad variety on how the interviewees defined uncertainty, risk, and opportunity. When it came to their definitions most the interviewees did not share the same definition as given in this report. The interviewed gave their definitions and thoughts which are presented below:

- Uncertainty

  When asked what uncertainty meant to them they gave a variety of explanations such as uncertainty becomes a risk when it becomes a real threat; other founds uncertainty as mostly containing opportunities. One of the interviewed said that in earlier projects uncertainties have been seen as costs for the project, but in this project uncertainties are interpreted more like opportunities. Others could not give a clear definition of uncertainty, however they argued that they had the "uncertainty thinking" in the back of their minds. Two of the interviewees gave a definition of uncertainty that was closer to the definition given in this report. Their view on uncertainty was that when an uncertainty can be quantified, concretized and handled with a list of actions it will become a risk. Although many of the interviewees gave some sort of answer, they all shared one common opinion, that the phrase uncertainty and risk was hard to separate and concretize.

- Risk

  None of the interviewed saw themselves to be risk averse. However, they all felt that there is more focus on risk within the organization now than it was before and the work has now become systematic. Even though risk has got more focus the view in this matter was diverse. Thoughts and questions that were brought up during the interviewees including matters such as: is it a risk if the threat is out of control for the project? During the interviews the interviewees gave no clear line between risk and uncertainty, as mentioned before all of them felt that uncertainty and risk is used in a very "fuzzy" way. Nevertheless, amongst all different interpretation of risk one interviewee had a clear thought on how to see risk. That definition was very close to the definition used in this thesis. The explanation of risk was: a risk develops when an uncertainty becomes a real threat.

- Opportunities

  The thoughts about opportunity amongst the interviewed was relatively aligned, all considered opportunities as something the project would benefit from when it came to the project objectives. For example unnecessary constructions that could be avoided with the right measures and tactics. This unified way of looking on opportunity was strengthened by the perceived felling that the organization was very positive and opportunistic in their way of working.

5.2.2 Risk identification

The only organized risk identification meeting was held in the initial phases of the project. This was conducted as a brainstorming meeting involving bigger parts of the organization. The meeting included identification of both inner and outer uncertainties that could affect the project. Furthermore, in the initial phases of the project, SWOT-analyze were also conducted to identify risk and opportunities in connection to the project cost proposal. During the interviews it was found that the way the organization work with identification was done by discussion and experience within the organization. Most of the interviewees did not share a common understanding of what risk identification involved. Most of them thought that they had a logical way of thinking about risk in the back of their minds and that this was enough to identify the risks concerning their work. None of them used or knew about any formal tools besides brainstorming that they could use to identify risks. However, the desire for a strategic and proactive risk process showed with comments such as:

> *"Everyone should be involved in the risk identification process and the process should be easy to follow."*

Nevertheless, a few of the interviewees found that they had a common way of identifying risks that simply included a certain level of communication within the project office. This way of identifying risk was found insufficient due to the fact that everybody actively involved in the risk process was on the management level. This was considered not to be in line with the thoughts of the risk identification; that it should be easy to follow the process and that everybody should be involved. Their ways of sharing the identified risks were done either by direct communication with the person responsible for the risk process or during the monthly risk assessment meetings.

5.2.3 Assessment and analyses

Assessment of all the identified risks was done in the risk meetings by discussion. In these discussions the weight was on expertise and experience. The primary tool that was used during the monthly risk assessment was the risk sheet and the meeting included employees with a management role in the project organization. Some of the interviewees thought that the leaders and managers in the organization took too much responsibility for the assessment of the risks. They thought that it would be good to involve all levels of the organization to some extent in the risk assessment process. This standpoint was shared by some of the managers:

> *"It is only the managers of the organization that shares a bigger understanding of the risk process; it is vague in other levels of the organization. This is something we need to improve."*

The general perception on the risk sheet was that it was a good tool for the organization and that much useful information and lists can be derived from it. But it

was mentioned that the model was too academic and difficult to interpret the proper way of working with it.

> *"The tool is too complicated to be used effectively; it needs to be improved for a more practical use."*

There were discussions that the model needed to be more adoptable to a variety of needs. Furthermore, the organization had major difficulties on how to assess risks and opportunities in their risk sheet when it came to categorizing and calculating the impact costs.

5.2.4 Risk response

The available responses to risks according to the risk sheet are: to accept the risk, handle the risk or to transfer/share the risk with a third party. This understanding to the different alternatives was relatively common amongst the interviewees. Accepting risks was considered to be done within the organization simply by confirming that the impact of the considered risk was taken into account and evaluated. To handle a risk was considered a response when the impacts of the risks were too severe or unacceptable for the project objectives. However, there were discussions about the importance of assessing and controlling the risks before they were transferred into contract documents, this is done in order to evaluate and to transfer the risk in a way that is favorable to the project objectives. This was, according to the interviewee, a strategic aspect to transfer the risks that were best handled by a third party.

5.2.5 Monitoring and Control

In the area of monitoring and controlling the opinions were many and somewhat aligned. As mentioned before the risk list was developed from roughly ten identified risks to about fifty. This was considered a very bold step amongst many of the interviewees who found that it would be hard to monitor and control so many identified risks. There were several who thought that it would be insufficient to have only one meeting a month, although, some mentioned that having too many meetings would be problematic concerning the already tight schedule. Nevertheless, most of the interviewees shared the same thoughts when it came to the organizations need to change their way of working with the risk list. One of the interviewees found that some of the identified risks and opportunities on the list could be further divided into several more subjects.

> *"We need to have a one – to – one relationship in the risk list."*

By dividing the risk list into several smaller subjects they found that there was a possibility that the focus and initial intention with the risk list could be lost.

> *"The risk list should not become an activity list."*

Further discussions that were held during the interviews involved the responsibility for updating and handling the risk list has developed to a major time consuming task for the responsible person. Several of the interviewees thought that it would be more efficient for the organization if the risk owner of the risk has the responsibility for the control and updating of the risk list.

5.2.6 Organization and Communication

When asking questions regarding how the organization was perceived, the general picture from the interviewees was that the organization was open minded when it came to sharing personal opinions and thoughts. The organization saw the leaders to be appropriate in their position and to encourage people involved in the risk process to work further with risks. Nevertheless, it was expressed during the interviews that the organization, during the implementation of the risk model, lacked support from higher levels of NPRA. In the initial phase the risk model was faced by skepticism to be just another process without a real need for it in the organization. When the interviewees where faced with the question about NPRA's guideline of how to deal with risk, few knew about it and even less had read it.

> *"The goal is to get everybody involved in the work with risk, but I'm not sure if the guideline is the right way to communicate the importance of it".*

Some felt that it was important to work proactive with questions concerning risks and to let it take its time to spread and get a strong foundation within the organization. They thought that control and steering is necessary and that it is important to spread the knowledge to all levels within the organization.

During the interviewees there was an observation that risk awareness and interest of the risk process has increased significantly. The organization felt like they had good knowledge to handle risks, however, this is due to experience rather than education concerning RM. It was told that the only internal course that brings up risk within NPRA is a course in traffic safety and handling. In this course the concept of handling risk was presented but it was more related to the traffic safety.

The means of communicating risk within the organization are mostly done by interpersonal discussions in the project office. On the other hand, the interviewees felt like the project organization had no clear path for the employees to communicate risk.

> *"Communicating risk and opportunity within the project will develop a better understanding and consciousness in the organization."*

6 Discussion

This chapter will answer the research question and reflect upon and compare the case study to the theory and the guideline of RM in NPRA.

RM is not a new term to NPRA, however there was no common and shared way to work with RM before. Earlier experiences of large cost overruns have increased the focus on projects and its management. This increased focus has resulted in various actions in NPRA; one of the main focuses has been on RM and RMP. This is shown in a rather recent research program Concept and PUS performed in collaboration with NTNU and the main public actors in Norway.

The organization works with RM in a controlled and structured way in accordance to NPRA's model and shows big interest in the RMP. This is in coherence with Jaffari (1999) and Maylor (2010), who both regard RM to be a structured and continuous process throughout the whole project lifecycle. However, the organization finds their RM model to be very academic and hard to interpret, this is possibly the result of the Concept research program which left all organizations to work with the same model. This model has not been specifically adapted to fit NPRA's needs. Nevertheless, with the external revision conducted with KS2 the models scales have been slightly adjusted in favor to the project.

The managers of the organization are very enthusiastic when it comes to RM, they see the RMP as a strategic tool to control cost overruns and the implementation of the time plan. However, when the current Project Manager took charge in the project, there were discussions on how the model should be used and how the organization should interpret uncertainty, risk and opportunity. The project managers' goal was to align the organization and to acquire a common understanding on how the project should commence working with RM. This is shown in the organization where the common interpretation has shifted from regarding risk as something solely negative to also have an upside. This is aligned with PMI (2008) definition of risk:

> *"an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives."*

Nevertheless, during the interviews it came to the author's attention that the view of risk was not shared throughout the organization. The employees showed difficulties defining what a risk actually meant. This could be a consequence of a rather large variety in risk awareness among the employees. If the organization would have a common definition of a risk the risk awareness would increase in the organization (Maylor, 2010). Despite the absence of a common understanding of RM, the organization showed great initiative to work with risk issues. However, the organization was rather unaware of the specific RM tools that could be used in different project phases besides the ones stated in NPRA's guidelines for RM. Some of the employees used expressions such as working with risk in the "back of their minds". The techniques described were relatively close to academic tools such as using simple decision tree analysis to identify risks. Furthermore brainstorming activities were common when identifying risks in the initial stages of projects. Some risks that were identified were considered to be "out of their control" by the

organization and therefore not assessed. This relates to wicked problems where Olsson (2007) argues that problems with a high level of complexity are problems that have no clear solution and will essentially be unique to its nature. Even though these problems are hard to solve they could be devastating to the project if not given the correct attention. With the wrong attitude and training the organization will simply focus on uncertainties and risks that are easily quantified and assessed instead of paying attention to more complex problems. Wicked problems that we consider important to NPRA involves for example: human behavior, risk competence and averseness, and organizational communication related to the RMP. In some cases these can be areas of taboo and therefor become a risk in itself.

The definition and explanation of uncertainty and risk in the Guidelines for Risk Management in NPRA is not shared by the entire project organization. The guidelines state that uncertainty can be either a risk or an opportunity. Furthermore, it statuses uncertainty as the lack of complete security, that is, there exists more than one possible outcome. However, the misalignment in a common understanding is understandable since even in the guidelines there are no clear and easily understood definitions to the risk and uncertainty. The introduction of "uncertainty" as a phrase to use in RM makes an already complex subject even more complicated by adding another dimension. The phrase uncertainty management instead of RM may have been introduced to encourage the employees to work with RM issues in a positive manner. However, by introducing this it is even more important to develop a clear definition separating uncertainty and risk.

6.1 RMP in practice

This chapter is divided in four parts: identification, assessment, response and control. In this chapter an analysis will be given on how the organization works in practice with the four main parts in the RMP. This follows by a discussion in subjects in connection to communication and leadership.

6.1.1 Identification

Employees in the project identify risk either by brainstorming in meetings or discussions. This technique is commonly mentioned in PM literature and our observations show that it is a powerful way to identify potential risks and opportunities. In the initial phase of the project the organization held a big brainstorming meeting for all project employees and key stakeholders. This is in accordance with RM literature and NPRA's guideline that states that the entire organization should participate in the initial process of identifying risks.

In the continuous work with RM the organization held monthly meetings were the managers of the project organization participated. The most frequent way of identifying new risks is done by experience and discussions between the managers. By solely engaging the managers in this process big part of the organization are left out. However, according to the guideline for RM within NPRA these meeting should not be conducted as brainstorming or group meetings.

If any risks were identified by others than the managers these were usually reported to the risk coordinator and later on brought up on the RM meetings. With this structure the urgency and importance of handling the identified risks or opportunities could be lost due to no optimal path in reporting risks and opportunities. Furthermore, the

guidelines recommend that the identified risks should be assessed and valued as soon as possible to increase the value for the project.

According to PMI (2008) it is important to develop a register for the identified risks and opportunities. In the project this is done in the risk meeting where the risks and opportunities are listed in the risk sheet shown in Appendix A. Furthermore the risks that are identified in the risk list are provided a specific number and description of their impacts on the project. This is in accordance with Cooper et al (2005) who recommends that a risk list should contain: main assumptions and mechanisms to the risk arising, the criteria likely to be affected, in which phase of the project the risk is most likely to occur and what consequence the risk will have. Although in the project each risk is assigned to an owner it is currently not specified in which phase it is most likely to occur. The absence of specifying in which phase the risks and opportunities are most likely to occur could create miss prioritizations within the project where efforts and resources are misplaced.

6.1.2 Assessment

In the initial phase of the project the organization performed a quantified Monte Carlo cost analysis with a fifty percent probability distribution, the main risks and opportunities were included in the simulation. These simulations are done by using the NPRA's cost database where the earlier project costs are stored. Chapman and Ward (2003) argue that it is preferable to perform both a qualitative and quantitative assessment process. However, Chapman and Ward find that the qualitative approach is preferable in the early phases of the project. Nevertheless the quantified assessment is useful in the later phases of the project as a foundation for further work.

In most small to medium sized projects it is usually enough to perform only a qualitative analyze. Concerning the scale and complexity of this project the quantitative approach to risk is a necessity. However, the project lacks quantitative data to be able to perform quantitative analyzes on regular basis. This would benefit the organization by providing more accurate assessments.

The monthly risk meetings include a qualitative approach when assessing both old and new risks and opportunities. This qualitative approach is an accepted way of assessing the risk in NPRA since there is no database to conduct a quantitative assessment. This is in contradiction to Chapman and Ward (2003) arguments on how to be effective in risk assessment. If a quantitative assessment had been possible the managers in the organization would be able to develop their assessment process further and increase the accuracy of their estimations. According to Smith et al (2006) and Heldman (2005) techniques adequate in such a situation include Monte Carlo analysis, Decision tree analysis, Event tree analysis and Sensitivity analysis.

A qualitative approach is possibly the most appropriate method in the project at the moment since it is a straight forward process with little need of complicated calculations or training in the field of quantitative assessment models. However if NPRA develops a database dedicated for quantitative risk assessment future project would profit significantly from it. Otherwise they would in a way reinvent the wheel in each separate project.

In the monthly meetings the organization proves difficulties in how they should assess the risk and opportunities in financial terms. The current way of working includes a rather chaotic approach where the costs or savings for the project are estimated by the

project managers in the risk sheet. Issues concerning how to translate time delays into financial costs prove to be one of the major difficulties to estimate in the project. Although it is hard to develop an accurate figure on time delays the organization has much to gain if it develops an estimate on how much it would cost the project if the delay is for example, a month. This would facilitate the work with the risk sheet as well as help the organization to prioritize which risks or opportunities that are most important to focus on.

The probability / impact matrix used in the projects risk sheet is virtually identical to the theoretical model from PMI (2008). Although the risk sheet is very close to the academic model the employees found it too difficult to use in an effective manner. This included the academic layout, few possibilities to adapt the sheet to a specific project and errors while running the program. However, it is not unexpected that the interpretation of the risk sheet is slightly negative when no formal training in the tool has been provided in the organization.

The scales of the matrix were not adjusted to fit the project until the very late planning phase. According to Heldman (2005) it is important for the organization to develop or adjust existing probability and impact scales early in every new project, hence reducing the subjectivity in the assessment of risk and opportunities.

6.1.3 Response

The employees share a common understanding in the methods that are available for the organization to respond to risk. However, the term "response" had a negative association in the company; it was solely associated with risk rather than opportunities. With this negative attitude to the risk response many important opportunities could be lost by simply discarding the positive attributes of responding in a proper manner.

The company is currently transferring risks into contracts as a strategic aspect of RM. By transferring risks into contracts the risk owner has to be certain that the assessment of the risks are properly evaluated, otherwise the project could suffer from higher costs and time delays. This is in conformity with Potts (2008) who argues that one of the downsides with transferring risks to a third party is that it could lead to additional costs and work for the project.

6.1.4 Monitoring and Control

Both Cooper et al (2005) and NPRA's guideline argue that monitoring and control should be done on a regular basis to get a good control in the project. This is applied in the project where continuous RM meeting and the use of the risk sheet is the base of control for the project. However, by developing the risk list to consist of more than fifty identified risks the project shows difficulties to monitor the risks. Nevertheless, by dividing the risks into smaller and more tangible parts, the project will gain control in which areas the risk is most likely to have an impact.

The current meeting structure involving managers once a month is not appropriate in the current situation. Monitoring so many risks in a proper way is problematic with only a single meeting a month. According to Cooper et al (2005) the risk sheet should contain the risk owners and their role. In the initial phase of the project the risk owners consisted of the participating managers in the risk meetings. However, when

the focus was put on developing the risk list and expanding it, it proved impossible for the managers to handle the extensive workload of monitoring and controlling the risk list. By engaging more employees in the organization the managers reduced their work load, but gained new challenges such as to handle communication flows and meeting structures. This way of handling the process is supported by the guidelines which recommend that monitoring and control of the risks should be done by the employee with best knowledge in the field.

According to the guidelines of NPRA the project owner is responsible for making sure that the risk monitoring and control is performed in an effective manner this includes developing knowledge of the personnel. Nevertheless, the project has received no formal training in the monitoring and control methods. This creates misunderstandings and a suboptimal monitoring and control process. It must be in the project owner's interest to optimize the process, hence providing training and education in the tools used in the project. The risk owner is responsible for monitoring and controlling big impacts on the project, this can have catastrophic consequences if it is handled by employees with wrong qualifications.

6.1.5 Communication

Employees in the organization were perceived as open-minded and skilled in interpersonal communications. The interviewees showed great trust in the project managers. This is a result of the project manager's strategic work in achieving an open climate when it comes to the internal communications. The project managers believe that successful RM involves inspiring and engaging people in the entire organization. However, as one stated;

> *"Governance is important, but one has to spread the knowledge and information of the RMP beyond just the managers. "*

Even though the employees did not share the same level of education, experience or background their thoughts were respected and appreciated at all levels in the project. It is of importance for the project to be successful to have good communications. This is supported by Olsson (2007) who agrees that the internal communication is important and claims that it is one of the key factors for a project to achieve success. Even though the organization proves good routines in the internal communication it lacks in issues concerning RMP. As one employee stated during one of the interviews:

> *"I am aware of the existence of the risk list. However, I am unaware of what it contains."*

Even though the project office is relatively small the project is already experiencing some complications concerning communication issues connected to the RMP. Nevertheless, by currently engaging approximately one fourth of the organization in the RMP the chances of success are rather large at this stage. Following the contracting phase, the project will expand their staff to roughly three times its current size and be divided into different geographical locations. Consequentially it will prove

inappropriate with their current communication routines. Heldman (2005) brings up lack of communication as one of the main reasons that projects fails. He recommends that the communication concerning RMP should be held as a continuous point in the project meetings. This indicated that the project should try to involve everyone, to some extent, early on in the project especially the employees that will participate thought-out the whole life cycle of the project. Furthermore, Olsson (2007) considers that the project employees should share a holistic view of the project when it comes to the project's limitations, scope, goals and stakeholders. If so they should find it less difficult to identify and reflect on opportunity. To get this holistic view he introduces three major internal factors considered important to succeed: team spirit, competence and internal communication.

6.2 Key Findings and Recommendations for Further Work

During the work of this thesis the authors have located areas that needs further work in the organization. The key findings can be divided into three main categories: implementation of RMP, risk tool, and communication.

- The project organization would benefit by receiving increased support from the project owner where the RMP needs to be acknowledged as an important process for NPRA.

- With an increased support from the project owner it will encourage a culture where RM is an accepted natural part of the organization. The main goal by increasing the support is to achieve a top down - bottom up approach to RM.

- The organization is perceived as risk aware and tries to focus on positive aspects of RM. However, the term "risk" was perceived in a negative manner. Furthermore, the organization lacks common definitions regarding uncertainty, risk and opportunity.

- Many employees show an increased interest in issues related to RM. NPRA would gain by offering training and education in RMP as well as to encourage them to work continuously in RM related matters. By encouraging employees to participate and develop their RM knowledge, the studied and future project will profit from it.

- The risk sheet lacks the possibilities to be adapted into specific projects. It would profit from a simpler layout as well as technical support staff who knows the model in detail.

- The organization shows difficulties in estimating risk and opportunity costs for the project. The project would benefit by creating common standardized costs to apply in the risk sheet. This could be applied when calculating for example a time delay for the project.

- By dividing the work load of the RMP to the entire project organization the current accountable employees involved in the RMP will be able to concentrate on coordinating and controlling the process rather than "putting out fires".

- Even though the organization proves skills in communication the lack of visualization is noticeable. The organization would benefit by introducing use for example monitors which are located so that they are accessible and visible for everyone. These monitors could be used to visualize key activities as well as the most relevant risks and opportunities.

6.3 Reflection

The process of writing this thesis was interesting and provided the authors with valuable insights in the RM theory and practice. However, during the literature study the authors had difficulties choosing adequate literature that was not considered too radical in its views. The process of the thesis has been beneficial for the studied company as their interest in the subject has grown and the managers has become even more aware of the importance of sharing workloads of the RMP. The authors find that the research question has been answered in the discussion of this thesis and that many other issues related to the RMP has been addressed.

We are very grateful for the openness and hospitality we received from the studied project organization. We would also like to thank our supervisor at Chalmers University of Technology for interesting discussions during our meetings.

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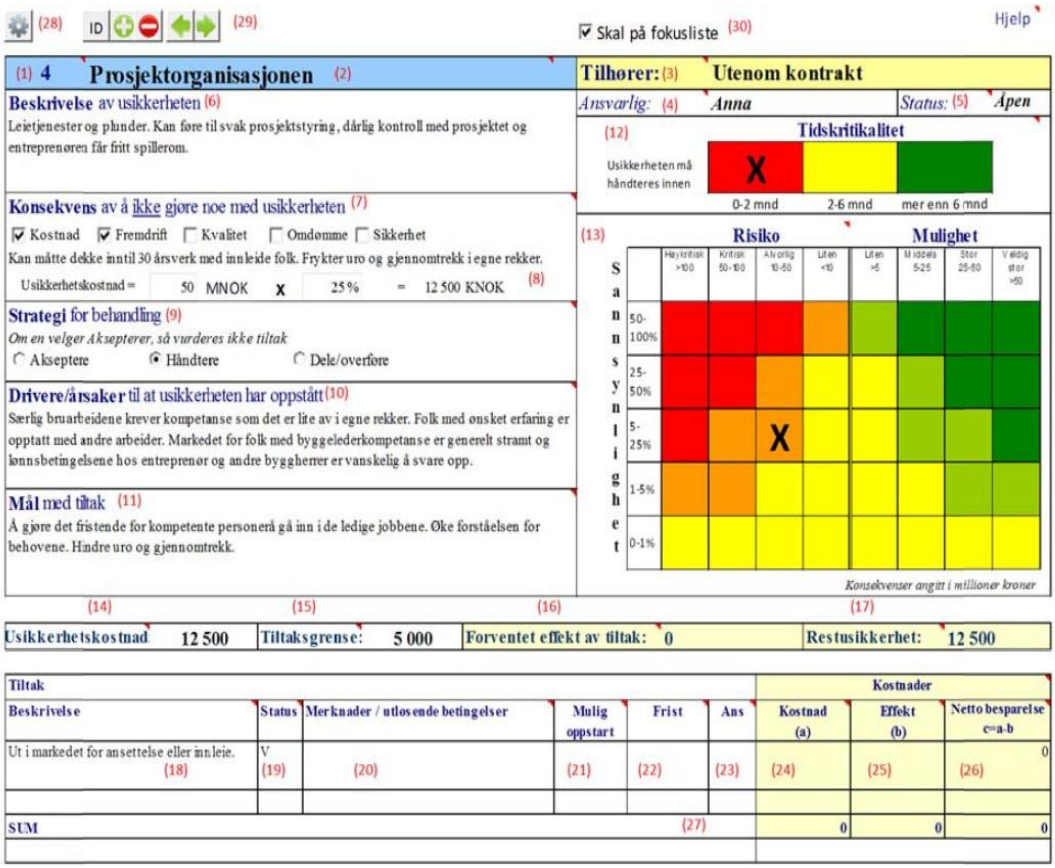
8 Appendix

8.1 Appendix A: Uncertainty sheet used within NPRA



1. Specific number for the risk/uncertainty.
2. Name on the risk or uncertainty.
3. Specify which contract or part of the project the risk in located to.
4. States who is responsible for the risk.
5. Gives the statues on the risk in terms of new, open, or locked.
6. Description of the risk.
7. Description of consequence in terms of which consequence is the worst if no response is done for the identified risk.
8. Cost for the risk, the cost is calculated as risk X probability. In this box there is an opportunity to transfer the numbers from the risk matrix. If this is done the risk cost will be transferred to box number 13.
9. Which strategy is chosen for the risk, the options that are available is:
   - Acceptance, the risk is accepted as it is and no further response is done.
   - Handling, the project organization decides how to respond to the identified risk in terms of elimination or reduction.
   - Share/ Transfer, the risk is preferred to, in part or as a whole shared or transferred with a third part.
10. Gives a description on what is the underlying reason for the risk.

11. Description on what the goal is with the chosen response.
12. Time criticality, gives a description on how time critical the risk is. This is divided into green, yellow, or red.
    - Red, the risk has to be handled immediately.
    - Yellow, may be handled within 2 – 6 months.
    - Green, no need to handle within the next 6 month.
13. Risk matrix, shows how the risk is valued in terms of risk an opportunity.
14. Uncertainty cost, this is the expected cost for the described consequence for the uncertainty since the last update.
15. Limit on how much the organization is willing to spend to reach the expected outcome.
16. Expected effect of response, this sum is the effect of all the adopted and initiated response.
17. Rest uncertainty, shows how much rest uncertainty the project are left with after the expected response have been calculated.
18. Description of the response that has been chosen.
19. Shows the statues on the response that has been chosen, this can be done as M- opportunity, V – adopted, I – started, F – finished, S – stopped, or U – expired.
20. This field can be used to make a more descriptive description on response, status, and eventual initiating factors.
21. Earliest date to start up response for the uncertainty.
22. Latest date when the response should be finished.
23. Field for who is responsible for the risk response.
24. Cost for implementation of the risk response.
25. Expected effect of the implemented risk response.
26. Field for net savings of implemented risk response.
27. Summarized cost of the effect and net savings from the uncertainty that ether have status as adopted (V) or started (S).
28. Button for settings.
29. Maneuver button.
30. Button to generate focus list.

K5 – Catastrophically

- Costs bigger than 20% of original cost estimate
- Time delay more than 2 months
- Nationwide criticism
- End result is not in compliance with standards and there are danger for life or health

M4– Big

- Savings between 10-20 % of original cost estimate
- Time saving between 1-2 months
- Positive mentions in the local press
- End result will give reduced operating costs

8.2 Appendix B: Information lists generated from risk sheet.

Fokusliste 30.11.2009

T	R	M	Usikkerhet	Konsekvens	Tiltak	Merknader/utløsende forhold	Frist	Ansv
			3 - Dårlige planer	Kostnad - Tid - Kvalitet -	V - Planmøte med Veg og Vatn		01.03.2009	PL
			4 - Prosjektorganisasjonen Leietjenester og plunder	Kostnad - Tid - Kan måtte dekke inntil 30 årsverk med innleide folk. Frykter uro og gjennomtrekk i egne rekker. I verste fall kan dette føre til svak prosjeltstyring, dårlig kontroll med prosjektet og entreprenørene får fritt spillerom.	V - Ut i markedet for ansettelser eller innleie		15.02.2009	PL
			7 - Kuttliste	Kostnad - Kvalitet -	V - Holde mulighetene åpne ved kryss Grønnstad			M M
			9 - Utrasning i stor skjæring Den ensidige skjæringen gjennom Smånuten blir 30 m høy, fjellet er oppsprukket og det går flere markerte slepper parallelt med vegen. Jernbanelinjen går parallelt med vegen på andre siden. Det meste av den betydelige sikringen som er planlagt vil skje etterhvert som spregningsarbeidene går frem. Det er reist tvil om dette er omfattende nok, og de vurderes sikring også på forhånd.	Kostnad - Tid - Omdømme - Sikkerhet Risikerer å sprenge foten unna inntil 20 000 m3 fjell, som kan rase ned på jernbanelinjen. Det kan lokalt skli ut slik at avstanden fra skjæringstopp til grensen for Småsnuten boligfelt blir uforsvarlig kort	V - Forbolting med lange bolter. Små salver som sikrer at det som kan gli ut har fot. Bolting etter hver salve.			KK
			10 - Sprengingsuhell – tett bebyggelse Sikkerhet	Omdømme - Sikkerhet	V - Små salver. Ekstra dekning. Ekstra kontroll av fjell og slepper og boring og ledning. Ekstra varsling			AA
			12 - Mister bruelementer ved montering	Kostnad - Tid - Sikkerhet	V - Ekstra kontroll av beregninger og alt feste og løftemateriell			BB
			17 - Store trafikkforsinkelser ved omlegging	Omdømme -	V - Sidemannskontroll av planene for omleggingen. Simulering av omleggingsoperasjonen			FG
			18 - Ikke enig med grunneiere Omdømme	Kostnad - Tid - Kvalitet -	V - Nytt samlemøte		01.04.2009	NN
					V - Forbered ekspropriasjon i f.t. Krangle Kranglesen		01.04.2009	NN

An example of a Focus list which has been generated from the risk sheet.

Tid	Ris	Mul	Id	Usikkerhet	Tilhører	Ansvarlig
			3	Dårlige planer	Utenom kontrakt	
			4	Prosjektorganisasjonen	Utenom kontrakt	
			6	Nye krav	Utenom kontrakt	
			7	Kuttliste	Utenom kontrakt	
			9	Utrasning i stor skjæring	Kontrakt 1 (delprosjekt)	
			10	Sprengingsuhell – tett bebyggelse	Kontrakt 1 (delprosjekt)	
			11	Peler til brufundamentet sklir på skrått fjell	Kontrakt 3 (delprosjekt)	
			12	Mister bruelementer ved montering	Kontrakt 4 (delprosjekt)	
			13	Bruelement passer ikke	Kontrakt 4 (delprosjekt)	
			14	Båtpåkjørsel på sårbare elementer	Kontrakt 3 (delprosjekt)	
			15	Ras i tunnel	Kontrakt 2 (delprosjekt)	
			16	Konkurs hos entreprenør	Utenom kontrakt	
			17	Store trafikkforsinkelser ved omlegging	Kontrakt 1 (delprosjekt)	
			18	Ikke enig med grunneiere	Utenom kontrakt	
			5.1	Uspesifisert	Kontrakt 1 (delprosjekt)	
			5.2	Uspesifisert	Kontrakt 2 (delprosjekt)	
			5.3	Uspesifisert	Kontrakt 3 (delprosjekt)	
			5.4	Uspesifisert	Kontrakt 4 (delprosjekt)	

An example of an uncertainty list generated from the risk sheet.

Nr	Usikkerhet	Tiltak	St*	Merknader / utløsende forfold	Frist	Ansv.
3	Dårlige planer	Planmøte med Veg og Vatn	V		01.03.09	PL
4	Prosjektorganisasjonen	Ut i markedet for ansettelser eller innleie	V		15.02.09	PL
7	Kuttliste	Holde mulighetene åpne ved kryss Grønnstad	V			M M
9	Utrasning i stor skjæring	Forbolting med lange bolter. Små salver som sikrer at det som kan gli ut har fot. Bolting etter hver salve.	V			KK
10	Sprengingsuhell – tett bebyggelse	Små salver. Ekstra dekning. Ekstra kontroll av fjell og slepper og boring og ledning. Ekstra varsling.	V			AA
11	Peler til brufundamentet sklir på skrått fjell	Flere boringer for å kartlegge forholdene. Vurdering av fundamenteringsløsningen.	V			SS
12	Mister bruelementer ved montering	Ekstra kontroll av beregninger og alt feste og løftemateriell	V			BB
13	Bruelement passer ikke	Ekstra kontroll av prosjektering og bygging i begge ender av leveransekjeden	V			RR
14	Båtpåkjørsel på sårbare elementer	Møte med Havnevesenet om behovet for tiltak				RR
17	Store trafikkforsinkelser ved omlegging	Sidemannskontroll av planene for omleggingen. Simulering av omleggingsoperasjonen	V			FG
18	Ikke enig med grunneiere	Nytt samlemøte.	V		01.04.09	NN
		Forbered ekspropriasjon i f.t. Krangle Kranglesen	V		01.04.09	NN

An example of a response list generated from the risk sheet.

Usikkerhetsregnskap

Nr	Usikkerhet	Usikkerhets-kostnad (a)	Kostnad av planlagte tiltak (b)	Forventet effekt av tiltak (c)	Restusikkerhet (a-c)
Utenom kontrakt					
3	Dårlige planer	10 000	0	0	10 000
4	Prosjektorganisasjonen	20 000	0	0	20 000
6	Nye krav	1 000	0	0	1 000
7	Kuttliste	-18 000	0	0	-18 000
16	Konkurs hos entreprenør	3 000	0	0	3 000
18	Ikke enig med grunneiere	6 000	0	0	6 000
Sum		**22 000**	**0**	**0**	**22 000**
Kontrakt 1 (delprosjekt)					
9	Utrasning i stor skjæring	12 000	0	0	12 000
10	Sprengingsuhell – tett bebyggelse	0	0	0	0
17	Store trafikkforsinkelser ved omlegging	0	0	0	0
5.1	Uspesifisert	2 500	0	0	2 500
Sum		**14 500**	**0**	**0**	**14 500**
Kontrakt 3 (delprosjekt)					
11	Peler til brufundamentet sklir på skrått fjell	6 000	0	0	6 000
14	Båtpåkjørsel på sårbare elementer	0	0	0	0
5.3	Uspesifisert	2 000	0	0	2 000
Sum		**8 000**	**0**	**0**	**8 000**
Kontrakt 4 (delprosjekt)					
12	Mister bruelementer ved montering	0	0	0	0
13	Bruelement passer ikke	0	0	0	0
5.4	Uspesifisert	1 000	0	0	1 000
Sum		**1 000**	**0**	**0**	**1 000**
Kontrakt 2 (delprosjekt)					
15	Ras i tunnel	5 000	0	0	5 000
5.2	Uspesifisert	500	0	0	500
Sum		**5 500**	**0**	**0**	**5 500**
Totalt for prosjektet		**51 000**	**0**	**0**	**51 000**

An example of a cost sheet for uncertainties generated from the risk sheet.