DIPLOMA THESIS

Project risk management in a manufacturing company

Řízení projektových rizik výrobního podniku

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Innovation project management

SUBJECT OF STUDY

Enterprise innovation project management

THESIS SUPERVISOR

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Pokyny pro vypracování:

GOAL: The goal of this diploma thesis is the analysis of project risk management in a manufacturing company, as well as creation of a set of recommendations based on such analysis, that aim to improve or give direction to project risk management in the company.
CONTRIBUTION: The contribution of the thesis is in providing a connection between the theoretical aspects of risk management and a more practical, pragmatic company environment, using an unbiased point of view.
CONTENTS: 1. Introduction; 2. Theoretical part - risk definition and classification, risk management process, risk perception, risk attitudes, risk management; 3. Practical part - company introduction, project risk management analysis, assessment and recommenda

Seznam doporučené literatury:

A guide to the project management body of knowledge: (PMBOK® guide), Project Management Institute, Inc. 2013
RAFTERY, John. Risk analysis in project management. New York: E & FN Spon, 1994
DE CEUSTER, Luc. Focus on risk management: manage risks to improve project success. Praha: APraCom, 2010
NICK GRAHAM. Project management for dummies. UK ed. Chichester: Wiley, 2010

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Abstract

This diploma thesis focuses on the project risk management process in a selected manufacturing company. The first part sets a theoretical background regarding risks, risk classification, project risk management and risk perception. It then applies this knowledge to analyse the situation in the chosen company and its projects. Following this analysis, conclusions are drawn and a set of recommendations is presented to help improve the company practice with regards to project risks.

Key words

Risks, risk management, projects, project risk management process, risk perception

Abstrakt

Tato diplomová práce se zabývá řízením projektových rizik vybraného výrobního podniku. První část práce se věnuje teoretickému základu ohledně rizik, jejich klasifikace a vnímání stejně jako procesu řízení projektových rizik. Tuto teorii poté v druhé části aplikuje při analýze podniku a jeho projektů. Následně je provedeno vyhodnocení a jsou uvedena doporučení, která si kladou za cíl zlepšit situaci v podniku s ohledem na projektová rizika.

Klíčová slova

Rizika, řízení rizik, projekty, proces řízení projektových rizik, vnímání rizik

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INTRODUCTION

Risks are an ever-present constant in our lives, be it personal or business. As the world becomes more and more connected, the risks are becoming greater and more difficult to manage. Increasingly dependent systems of a society that is becoming global mean more and more players being affected by more connections. This oftentimes results in environments so complex, that it becomes nearly impossible to determine the true cause of a particular problem. Such situation has shifted the focus of many experts towards managing these risks. Countless books and studies have been written that deal with this topic and various systems and methodical approaches have been developed. This diploma thesis aims to create a theoretical base of knowledge in this area and then use it to analyse and help improve the risk management practice in a selected manufacturing company.

The selected company is a manufacturer of industrial equipment and wishes to remain anonymous due to sensitive information provided in this thesis. In recent years, the company has shifted its focus from standardised manufacturing towards custom made large-scale projects. This shift in focus has brought many challenges and among them, the need for a more structured way to manage risks, that inevitably emerge given the complexity of the projects. This thesis aims to help the company achieve that by combining theory with a practical, company-focused approach.

This thesis is divided into two parts, of which the first one provides theoretical base regarding risks and their management. It introduces various definitions and classifications of risks and devotes a significant amount of text to the risk management process. The theoretical part then discusses various issues regarding risk perception. Publications of various authors are used, such as Chapman, Veber or Kahneman, as well as project management standards, such as PRINCE2 or IPMA.

Following this theoretical background, this knowledge is then applied in the practical part to analyse the situation in the selected company and present a set of recommendations to help improve company practice. A brief introduction of the company is presented alongside of the methodical approach, assumptions and research questions that this thesis aims to answer. An analysis of 23 projects is then presented resulting in an assessment followed by beforementioned recommendations. These recommendations stem from the theory presented in the first part as well as the analysis of the projects, however, it takes into account other aspects of the company practice and environment to provide the most value possible.

I am aware of the fact, that this thesis might be considered as not exhaustive or thorough, or criticised based on the fact, that it considers risks purely in its negative sense when dealing with the company analysis. Though the reason for this is explained in the thesis, establishing a fully fleshed out risk management system is undoubtedly a complicated task that requires significant resources to be developed and implemented. However, I believe that this thesis still provides undeniable benefit to the company, as it combines theoretical basis with a real-world knowledge of the project managers. It does so from an unbiased, unaffected point of view and can improve company practice and provide input for further improvement, a stepping stone for a more complex risk management system.

THEORETICAL PART

1 DEFINING AND CLASSIFYING RISKS

The focus of this chapter is to define risks in the context of this diploma thesis. To examine what constitutes as a risk according to various sources, compare, pinpoint differences and establish common ground. Next, it provides classification based on a number of criteria in order to give a theoretical basis for following chapters. It ends with a statement regarding how risks will be perceived in this thesis.

When defining risks, we run into the same wall as we often do when defining many abstract concepts. Everyone has some form of understanding the concept, but those mental images of what it is might be far from each other. Because of that, there is not a single, universally accepted definition that would express risks in full complexity and detail. Instead, we have many definitions by many authors. Most of them very similar or that share similar characteristics, though, to a various degree, differences occur. We also encounter a number of expressions that are, in many cases, being used interchangeably, potentially creating misunderstanding or confusing readers when not fully explained. For that reason, we will take a look at risks, uncertainty, positive risks, negative risks, threats, opportunities and other terms, to create a shared base of understanding these concepts for the purposes of this thesis.

1.1 Defining risks

We live in a world where the future is mostly unknown. We can, to the best of our abilities, attempt to predict future events based on previous experience, mathematical models, statistical data and simulations. However, in many cases real life becomes complicated enough for us to be unable to assess the initial conditions and foresee what will happen next.

As John Raftery states in his book, *Risk analysis in project management* (1996, p. 6), we can oftentimes come across the distinction between the terms *risks* and *uncertainty*, based on our ability to quantify or measure said concepts.

Risks tend to be quantifiable, uncertainty on the other hand is unquantifiable, unmeasurable and overall considered a greater unknown. In these cases, we define both based on the amount of knowledge we have about a particular event. If we have enough statistical historical data, we can, to some degree, predict what will happen and thus we are talking about risk. For example, the risk of a flood.

On the other hand, Valach (2010, p. 171) defines uncertainty as the *"inability to reliably predict future factors that will affect the business results".* Compared to that he defines risks as *"the danger of the expected results being different from the actual ones"*, which to some extent implies quantifiability of the deviation.
In these cases, the quantifiable nature of risks is often interpreted using risk value. Traditionally, risks have probability of occurring and the impact of that happening. By multiplicating the probability with the impact, we get risk value, which can later be used to deal with risks and order them from the most to the least severe.
IPMA (Doležal, 2012, p. 85) standard also uses this quantifiability and presents the risk value (RV) as

$$RV = P \times I,$$

where P is the probability and I is the impact (usually in monetary values).
Using the same logic, risks are defined by a safety standard ISO/IEC Guide 51:2014
(2014, p. 2) as a *"combination of the probability of occurrence of harm and the severity of that harm".*

From such definitions, one might also conclude that risks are in some way the result of uncertainty. We do not know what the future will be like (uncertainty, lack of knowledge) and in that situation, we encounter risks that the outcomes will differ from our expected results.
This is also reflected in ISO Guide 73 (2009, p. 2) that defines risk as the *"effect of uncertainty on objectives"* and it also states that *„an effect may be positive,*

negative or a deviation from the expected", and that "risk is often described by an event, a change in circumstances or a consequence. "

However, as Raftery (1996, p. 7) also states, for most intents and purposes, differentiating between uncertainty and risks has very little benefits. We are talking about the same phenomenon but with different levels of information about the state of things. Thus, it can, in many cases, be used interchangeably. If we, however, have very limited information about something, we can sometimes learn more to reduce uncertainty. This can be demonstrated on a coin toss and modern technologies. A coin toss is traditionally seen as a random event. If we have no information about the coin and the conditions of the toss, we are uncertain of the result. If we, however, get to know all the information about the coin and the conditions – the material of the coin, force applied to the coin in the beginning, how it is balanced, the surface it will hit upon landing etc., then we can predict the result with certainty. Thanks to modern technology and very precise measurements, machines have been constructed that can flip a coin 100% of the time heads/tails as programmed (Diakonis, 2007, p. 1).

That means that for most risks, there is a way of reducing uncertainty by gathering more information about a problem. When, for example, a bet takes place, a coin toss is made and the winner gets 500€, it is possible to win that bet every time. A team of scientists can be gathered, conditions measured and we will be able to determine the result by gathering more information. At that stage,

an important consideration should take place – how badly do we really need to know the result? If you pay 1 000 € to get the information that leads to a 500 € win, it does not make all that much sense.

In general, an important message can be delivered using the example above. Uncertainty can be reduced by learning more about the issue. However, the price for being certain should not exceed the potential loss/gain created by uncertainty.

In accordance to what Raftery (1996, p. 5) states about the use of the differentiation between risks and uncertainty, he says that *"risk and uncertainty characterise situations where the actual outcome for a particular event or activity is likely to deviate from the estimate or forecast value."* We can note that he neatly goes around defining risk and uncertainty as complex concepts and that he uses a definition that presents them as characteristics of certain situations.

De Ceuster (2010, p. 10) seems to have the same opinion as he clearly does not differentiate between the two concepts.
He also goes one step further to define uncertainty or risk categories: *Known unknowns*, *Unknown unknowns* and *Catastrophes* or so called *"Acts of God"* (De Ceuster, 2010, p. 11):

- Known unknowns are events that have happened in the past and may occur again in the future and the information about such events might be found in lessons learned or historical statistical data.

- Unknown unknowns are events that had not happened before and are inconceivable yet. It is difficult to imagine such events. It is however possible to look around and try to find industries or situations in which such events might have happened. Then it is possible to learn from the experiences of others and apply this knowledge in a different field. Expert opinion can also help with such events.

- Catastrophes or Acts of God are impossible to predict with severe impact on the project. These are oftentimes impossible to prevent so other ways of coping with said risks are appropriate. [1]

[1] These events could also be called Black Swan incidents as described by Taleb in his book The Black Swan – The Impact of the Highly Improbable (Taleb, 2007)

Different ways of dealing with risks will be discussed further in the second chapter.

Above we discussed a few different viewpoints with regards to risks and uncertainty. However different those might be, they all have one thing in common – change. Something else will happen compared to what we expected or predicted. And as De Ceuster (2010, p, 13) states, many people have a negative association with the word *risk*. In many cases in our day to day lives, the word *risk* has been associated with the word *danger*.
Though it oftentimes is the case, not all changes necessarily have negative impacts. Some changes are, in fact, good and beneficial. The price of your shares can of course deviate and become lower, but there is also a chance that the price will be increasing and you will end up with a positive impact, a certain gain rather than a loss.

As Chapman (2003, p. 4) states, thinking about risks and uncertainty only in the negative sense would be *"unfortunate, because it results in a very limited appreciation of project uncertainty and the potential benefits of project risk management. Often it can be just as important to appreciate the positive side of uncertainty, which may present opportunities rather than threats."*

In that case, we are talking about a positive risk or as stated by different sources upside risk or opportunities. On the opposite side of the spectrum we have negative risks or as stated before, downside risks (Raftery) and threats (De Ceuster); (IPMA) as their respective counterparts.

Knowing what risks are allows us to define them for many different fields, in which case we apply the same or slightly adjusted definition to various areas of life. Health risks, financial risks, technical risks and many other areas will have their own definition. One such definition is that of project risks, the risks that are associated with undertaking projects.
Given the topic of this final thesis, it is necessary to define project risks in addition to risks in general.

Considering all that has been written so far, we may now define project risks as "*uncertainties that may have either a positive or a negative influence on at least one of the project constraints*" (De Ceuster, 2010, p. 13). These constraints include time, scope (quality) and price. A project risk is likely to jeopardise at least one of those, but in some cases two or all three of them.
That is similar to a definition of risks, which is being used by the US Project Management Institute (PMI, 2013, p. 309) to reflect both sides of uncertainty:
"Risk — an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives".
Most authors tend to agree on risks having two sides of the same coin as for example Shimizu, Park and Choi in their study (2014, p. 438) define project risks as something that may happen, and if it does, it may have either a positive or a negative impact on the project.

The nature of risks in projects oftentimes stems from a very important characteristic of project and that is uniqueness. If you venture into the unknown, something that has never been done before, something unique, it inherently creates uncertainty and risk. Some projects have less risks associated with them and as a general rule of thumb risk is greater the longer the project lasts, because predicting further into the future is more and more difficult.
In addition to that, bigger projects, more unusual ones or with new technology, processes and projects that the team has little experience with, tend to be riskier, because all these abovementioned conditions create an environment that is more uncertain (Graham, 2011, p. 174)

As stated above there are many types of risks and project risks tend to encompass many of these categories, due to the complex nature of many projects. A project and its constraints can usually be affected by the weather and climatic conditions, technical aspects, financial situation, political situation, health risks, contractors, materials, logistics etc.

1.2 Classifying risks

To create a bit of a structure, it has proven useful to present some risk classification. Let's have a look at how Veber et al. (2009, p. 600-602) classify risks:

- Speculative and pure risks - some authors tend to differentiate between the two, the distinction being that pure risks have only negative impacts while speculative risks can end up in either a loss or gain.
- Systematic and non-systematic risks - Systematic risk is one that is inherently shared among all economical subjects. These usually include political decisions regarding taxes or government budgeting. Non-systematic risks on the other hand affect only certain subjects within a certain area of business. The lack of snow in winter is going to greatly affect ski resorts, but will have little to no effect on for example baking industry.
- Avoidable and unavoidable risks - there are some risks that can, in fact, be completely avoided, such as staff shortage, by simply hiring more people. But some, such as natural disasters or economic crisis are risks that we cannot avoid. We can only put in place mechanisms to lower the impacts or to compensate for loss.
  This also ties in with the differentiation between external and internal risks. External risks come from the outside of the company, internal from the inside. External risks also tend to be unavoidable while many internal risks can be avoided. Other authors, such as Valach (2010, p. 173) use similar distinction while calling such risks objective (external) and subjective (internal). He also defines a type of risks that is a combination of both.

- Primary and secondary - Primary risks are those associated with generally being in an uncertain environment, while secondary risks are those that arise when we try to deal with primary risks. An example would be primary risk of a flood. To decrease the impact of the flood, it is possible to pay an insurance company to compensate in the case of it actually happening.

A secondary risk arises from taking such an action in the form of for example incorrectly filling in the insurance papers or possibly falling for an insurance scam. That would result in no money being paid.

Another possible way of categorising risks with regards to projects is offered by Graham (2011, p. 181), he divides risks into 4 categories:

- Business: Events that are external relative to the project, such as low company performance as a whole, or government decisions, that might affect the project.
- Product: Risks that the product will not serve the desired purpose, fail etc.
- Resource: If, for example, the development ends up being more complex than expected, existing equipment to finish the project may not be sufficient etc.
- Schedule: The risks associated with the duration of tasks due to new processes, understaffing and so on.

He also states that many organisations use the PESTLE categories to structure risks, dividing them into Political, Economic, Social, Technological, Legal and Environmental risks.

1.3 Risks for the purposes of this thesis

Considering everything that has been written up to this point, I would like to state how risks are going to be perceived for the purposes of this diploma thesis. I am fully aware of the benefits of looking at both sides of risks, not neglecting the positive side and possible opportunities in risk management. However, for the most part, I will be focusing on the negative side of risks when dealing with project risks in the selected company. Furthermore, I will focus on risks within the competences of the project manager as this thesis is focused on project risks.

This could be perceived as very simplistic, but it has been thought through and seems to be the best view to fulfil the purpose of this thesis. That is due to the fact that the changes (recommended in this thesis) tend to be more of a stepping stone to later improvements, first steps on a long way to a fully fleshed out project risk management system.
And as an old chess saying goes: "Most chess players try to win. Grandmasters try not to lose." A more theoretical way that deals with this idea is presented by Grant and Higgins (2013) Here, they divide people into two categories – promotion focused and prevention focused.

- Promotion focused people "play to win", they focus on advancing, gains and rewards. They take chances, work quickly and dream big. This also tends to make them more prone to error or lack of a plan B in case something goes wrong.
- Prevention focused people, on the other hand, focus on staying safe. They work slowly, carefully weigh their actions and worry about what might go wrong. They are not driven by advancement as much as their promotion focused counterparts.

As with most characteristics, these are two end of the same spectrum and the majority of people are somewhere in between. More inclined to one or the other based on what exactly is being dealt with and it is not uncommon for people to be promotion focused in one area of life and prevention focused in another. But to sum up, as Grant and Higgins say, *"the promotion focused are engaged by inspirational role models, the prevention focused by cautionary tales".* This also ties in with the individual's perception of risks, whether the person is risk averse or risk seeking. These concepts are discussed in more detail in the third chapter.
For these reasons, in this thesis, I will focus more on the negative side of risks, though later in the company's development, it would be desirable to move that one step further and consider opportunities as well.

Above, I have presented a number of definitions of risks and how to perceive them in the theoretical sense. Differences in how various authors define risks have been shown. Then, structure has been introduced and in the last part of this chapter, I have stated how I will proceed to perceive risks in this text. The following chapter will now build on the base established here and deal with the project risk management process.

2 RISK MANAGEMENT PROCESS

On previous pages, I have presented a definition and classification of risks. Now building on that shared base, this chapter will focus on the risk management process as a whole. I will first establish why a project risk management process (PRMP) is becoming more and more important in this world. Following that I will present some methodical approaches and project management standards that deal with, among other things, risks. Then, phases of PRMP are introduced and described alongside some methods and techniques that are being used and recommended for each respective phase. In the end, this chapter puts a bit more emphasis on the lessons learned process, as the process of learning from previous mistakes will gain more importance in the practical part of this thesis.

2.1 The importance of managing risks

The world as we know could be described as a constantly changing environment. It is always evolving, it is always attempting to move forward, to progress. And as technological advancements allow us to share information anywhere with anyone, the world is also becoming increasingly entangled. Globalisation is making more and more connections between countries, companies and other subjects and is allowing for great things to happen.

But these advancements come at a price. More connections mean more complexity. More complexity leads to bigger, previously unheard of projects, but with that comes more uncertainty. And as I have already discussed in a previous chapter, more uncertainty leads to riskier environments. The more connections we develop, the harder it becomes for us to keep things under control. There is rarely a single cause to a problem. In such complex systems and projects as we can see in this day and age, it is becoming increasingly difficult for us to identify why things did not happen the way we expected them to. And let's not forget about the fact that the more subjects are tied to a complex project, the bigger the impact of a potential failure.

As De Ceuster (2010, p. 9) states, such complex projects can only be successful with a structured way to manage such uncertainty.

And with growing complexity of projects and more and more money being handled by the people who can call themselves project managers, the importance of formal certification has also increased. To prove that, let's look at the number of PMP (Project management professional) certifications in 2006 and 2016. [2]

In 2006, there were just about 200 thousand people who had the PMP certification (La Brosse, 2007, p. 97) My point above is illustrated by the fact that last year, in 2016 the number of PMP certifications was more than triple that number. There were 729 552 PMP certified project managers which shows a clear increase in the demand for and the importance of formal project management certification (PMI Today, 2016, p. 4)

This trend makes a lot of sense when we consider that a single project might either boost a company to the top 10 or bring it down to its knees if managed improperly. A lot of money is at stake and so the stakeholders prefer to see their investments being handled by professionals. Just like a person would be very reluctant to be treated by a medicine doctor without a diploma. An investing company (stakeholder) is going to be more at peace knowing, that their projects are being handled by people, who have been deemed worthy by an external authority.

Noting the importance of formal certification, it would be appropriate to present some project management standards, that, among other things, deal with risks in projects and provide with useful guidelines. A brief summary of four standards is presented and then, the project risk management process is described.

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[2] The PMP certification is offered by the Project management institute and it is an internationally recognised certification for project managers.

2.2 Project management standards and risk management process

2.2.1 Project management standards

PRINCE2 is an acronym for PRojects IN Controlled Environment. At first, PRINCE was established in 1989 in the UK and was being used for government projects in IT (mostly). It has grown in popularity and in 1996, PRINCE2 was introduced and is now widely recognized around the world. (Unfortunately, numbers regarding how many project managers are PRINCE2 certified could not be retrieved.) PRINCE2 is a generic, scalable method and could be described as process-based (PRINCE2, 2017).

PMBoK *(Project Management Body of Knowledge)* standards have been created by the Project Management Institute. PMI is a US based organisation for project management founded in 1969. PMBoK is currently in its 5th version and is based on years of experience and "good practice". It is also process based and includes 5 process groups and 10 knowledge areas regarding projects. As stated above, as of 2016 there were 729 552 PMP certified project managers. (PMI Today, 2016, p. 4)

ISO 21500: 2012 is a standard by the International Organisation for Standardisation regarding project management. As stated on their website, *"ISO 21500:2012 provides guidance for project management and can be used by any type of organization, including public, private or community organizations, and for any type of project, irrespective of complexity, size or duration."* ISO 21500:2012 provides high-level description of concepts and processes that are considered to form good practice in project management (ISO, 2012)

IPMA Competence Baseline (ICB) is a standard developed by the International Project Management Association and is different from the three presented above. Unlike process-based PRINCE2, PMBoK and ISO standards, IPMA is based on the competences of project managers. It does not build on "good practice" but rather the ability of the project manager to correctly and adaptively apply knowledge, skills and appropriate process steps to each individual situation. It divides competences into three main categories – technical, behavioural and contextual (Doležal, 2012, p. 26). By the end of 2015, approximately 250 thousand people have been IPMA certified (IPMA, 2017).

Of course, these four standards are not the exclusive ways of managing projects. There have been other methodologies developed, different or similar to various degrees with oftentimes certain specialisation involved for particular projects.
All of these standards deal with projects as a whole. Describing how these handle entire projects would provide enough material for several publications. Such an extensive overview is not the purpose of this thesis. I will however, focus on one of the areas of project management. This area is dealing with risks, the process of it and how different standards and methods approach this task.

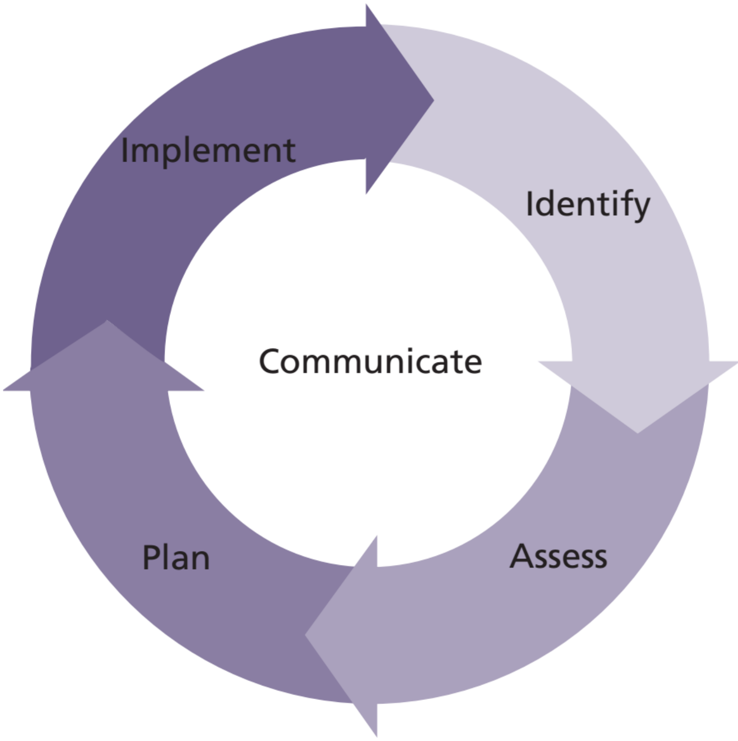
2.2.2 Risk management process

Traditionally, risk management process is thought of as a series of phases that oftentimes run in a cycle, commonly known as the risk management cycle or the risk cycle. According to the PRINCE2 (2009, p. 79) methodology, the risk management procedure has 5 steps:

- Identify
- Assess
- Plan
- Implement
- Communicate

As shown in Figure 1, steps 1-4 are sequential with the step *Communicate* being parallel at all times. That is due to the iterative nature of the process, any findings regarding either of the four steps need to be communicated and oftentimes the cycle starts anew in the light of new information.

Figure 1: Risk management procedure in PRINCE2



Source: PRINCE2, 2009, p. 80

A five-step approach is also being presented by the PMBoK (PMI, 2013, p. 308) and it includes similar steps, with slight differences:

- Risk management planning
- Identification
- Analysis
- Response planning
- Controlling risk

The difference here being that PRINCE2 focuses more on communicating risks and puts more emphasis on it as an individual phase, while in PMBoK, the communication is sort of implied by all the processes of documentation and document sharing. The "Identify" phase in PRINCE2 includes not only risk identification, but also the context identification, which could be compared to the *Risk management planning* phase in PMBoK.

The IPMA standard uses the ISO 31 000: 2009 norm for the risk management process, as does the ISO 21500: 2012. ISO 31 000: 2009 is a risk management norm that provides principles and guidelines for risk management regardless of size, activity or sector. It divides the project risk management into 7 steps, more or less comparable to the steps in PRINCE2 and PMBOK (Doležal, 2012, p. 85-86):

- Establishing the context
- Risk identification
- Risk analysis
- Risk assessment
- Risk treatment
- Monitoring and review
- Communication and consultation

Sometimes *Recording the risk managemen*t phase is being included as well (ISO 31000, 2009).

Though differences may always occur and various authors, guidelines and standards will use a slightly different or adjusted phase methodology, the process is, for the most part, very similar. For the purposes of this thesis, six risk management phases will be described in an attempt to bring together these different approaches.

- Context and risk management planning
- Risk identification
- Risk analysis
- Risk treatment
- Controlling and implementation
- Risk communication

While writing the following part, describing the risk management phases, I have used a number of different sources (Raftery, 1996); (Graham, 2011); (Doležal,2012); (PMI, 2013); (PRINCE2, 2009); (De Ceuster, 2010) and created a summary of what could be found in this literature. [3]

[3] Note: To provide description of all the methods and techniques used in risk management, namely identification and analysis, would provide for an extensive publication and as such is not within the scope and purpose of this thesis. Certain techniques however will be talked about to some extent, useful for the purpose of this text.

2.2.3 Context and risk management planning

Phase *Context and risk management planning* is generally the phase in which the groundwork is laid out for further phases. Most standards and current methodologies include this phase though there are some authors who introduce a bit simpler approach starting with risk identification (the second phase here) such as Raftery or Graham (Raftery, 1996); (Graham, 2011). As De Ceuster states, this phase is the *"framework for further risk management. It consists of a set of rules how to handle risk."* (De Ceuster, 2010, p. 124).

There is generally a lot of input going into this phase such as company policies and guidelines, lessons learned, the project management plan and many other documents Including work breakdown structure or project statement.
In this phase, everything is defined: the risk approaches and methods, responsibilities, the way the meetings will be held, rules for further phases such as risk analysis are defined and a reporting and data keeping system is put into place. Risk analysis scales are defined as is the timing and structure that will be used. The risk appetite and attitude will be made clear as well as the maximum risk value allowed (risk capacity). Ownerships, records to be kept, the reporting format and potential risk management budget will be set.

The output of this phase will be the risk management plan or project risk management strategy or some variation of such. Put simply, this phase will define how we will handle the risk management processes from this point onward.

2.2.4 Risk identification

Phase *risk identification* can be considered the base for successful project risk management. That is due to the fact that if a risk is not identified in this phase, it will not go through the rest of the risk management process. A risk that is not identified cannot be managed.

The purpose of this phase is rather simple, but easier said than done. As written in PMBoK, (PMI, 2013, p. 319) it is "*the process of determining which risks may affect the project and documenting their characteristics*". Once again, a number of inputs goes into this phase such as project documentation, technical documentation, project statement, the output of the previous phase (RM plan of some sorts), human resources plan, information about stakeholders and customers, environmental factors or information from the financial markets, political scene etc.

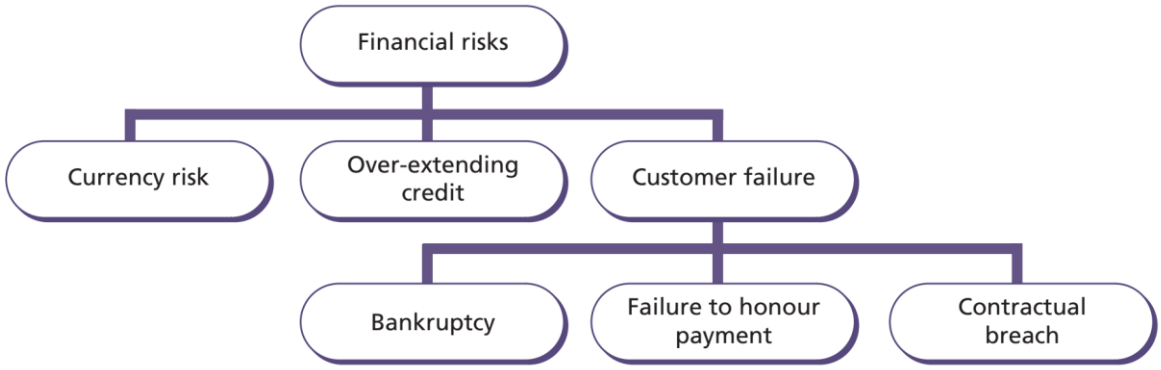
There are several helpful techniques and methods being used to assist in identifying risks. An overview of some of the methods used was created by Rodriguez-da-Silva and Crispim (2014, p. 946) and among others it includes Brainstorming, Ishikawa diagram, Delphi method, Interview with Expert, Failure Mode and Effect Analysis (FMEA), Life Cycle Cost Analysis, Hazard and Operability studies (HAZOP). Other methods and techniques such as the Risk checklist, Root cause analysis or 5 Why's can also be used. Taking a look into the lessons learned from previous projects is also advisable, as to not make the same mistakes again (PMI, 2013); (PRINCE2, 2009); (De Ceuster, 2010).

Lessons learned will be described in further detail later in this chapter.

As noted in the first chapter of this thesis, it is oftentimes quite useful to introduce some structure to the identification phase, commonly known as risk breakdown structure. There are quite a few ways to break risks down and one methodology offered by both Graham (2011, p. 182) and PRINCE2 (2009, p. 81) is using the PESTLE categories. It can also be broken down by project breakdown structure or project phase or using some previously defined method by the company that has proven useful in the past.

An example of the risk breakdown structure relating to financial risks is shown in Figure 2.

Figure 2: Risk breakdown structure example



Source: PRINCE2, 2009, p. 82

Risk are written down into a formal document, which is commonly known as the Risk register or Risk log.

This document contains the information about identified risks in a reasonable detail. Enough information should be presented, but an extensive 150-page document including every possible piece of information loses its purpose and becomes counterproductive. The information contained in the risk register commonly includes the NAME of the risk, some form of DESCRIPTION, the CAUSE of such a risk and the EFFECT it will have. Potentially it is advised to identify TRIGGERS for each risk. Sometimes it is also useful to set the person responsible for the individual risk, so called RISK OWNER. Later in the project risk management process, the Risk register will be updated to include some metrics (probabilities and impacts) and planned actions or possible solutions, ways to handle said risk.

Such a document full of identified risks is the basis for the following phases and is by no means definite for the duration of the project. New risks may arise or old ones may become irrelevant, so it is necessary to keep it updated.

2.2.5 Risk identification

In the phase *risk analysis,* the identified risks need to be further analysed for us to be able to manage them properly. This oftentimes comes to trying to establish the probability (or likelihood of happening) and the impact of said risk. Other things to consider beyond just the probability and impact are for example the time frame for such a risk or the organisation attitude towards certain risks established in the first phase *context and risk management planning*. Surely, responding to a risk bound to happen no earlier than three years from now is likely to be of lower priority compared to a risk that might happen tomorrow.

By doing so we can identify the most pressing issues and effectively choose which risks can affect our project the most. Given that at that point our risk register might contain dozens of identified risks, focusing on the important ones has its merits. Risk analysis will help us set priorities for the next phase – *risk treatment*.

Once again, many useful techniques are at hand for the project manager to choose from. Not all of them are suitable for all the projects and being able to use the correct one with the most value being added is oftentimes the key to success.

Rodriguez-da-Silva and Crispim (2014, p. 946) have, as well as in the previous part, identified many techniques and methods collected from literature review. Among these we can find Probability and impact grids, Risk matrix or Risk map, Project risk ranking, Delphi method, Probabilistic analysis and Reliability analysis, Monte Carlo simulation, PERT, CPM or Critical path analysis, SWOT analysis and other.

Other sources also identify methods/techniques such as Expected monetary value, Probability trees, Sensitivity testing, Scenarios or Decision tree analysis (Raftery, 1996); (Graham, 2011); (Doležal, 2012); (PMI, 2013); (PRINCE2, 2009); (De Ceuster, 2010). Oftentimes various statistics are being used as well concerning different risk factors such as the weather, water levels etc.

Notable development in IT and capabilities of today's computing power, Monte Carlo, sensitivity testing and simulation techniques are in many cases a very useful tool to assess project given high precision and accuracy of the calculations. Some authors such as Tysiak (2011) strongly advocate for the use of Monte Carlo, since it can, in many cases, be used by simply creating a MS Excel file and letting the computer do the work. Tysiak states that results of such an approach are reliable and most of all, easy to read, digest and effectively use. It is also not by any means difficult to adjust the model should there be a change in the project to get an idea of how the change can affect the results. Tysiak also points out the limitations such as the increasing complexity, should multiple correlating or dependent risks be involved.

Risk analysis can be quantitative or qualitative. The difference being in mostly how good of an idea we have regarding the values of probability and impact. Some approaches to risk management, such as the RIPRAN (Risk Project Analysis) use verbal (qualitative) assessment of risks regarding the probability and impact using *low*, *medium* and *high* for both (Doležal, 2012). Some authors use points on a scale (Graham, 2011); (PRINCE2, 2009); (De Ceuster, 2010), ranging from 1 to hundred point scales with some authors using 3, 5 or 10 point scales for both risks and impact. These scales and risks are very often presented in the form of a Risk matrix (P – I grid, Risk map etc.) to be able to quickly identify the most important ones and help effectively set priorities. An example of a Probability – Impact grid is shown in Figure 3 though there are other examples to be found in literature as well.

Figure 3: An example of a Probability – Impact grid

Probability							
	0.9	Very high 71–90%	0.045	0.09	0.18	0.36	0.72
	0.7	High 51–70%	0.035	0.07	0.14	0.28	0.56
	0.5	Medium 31–50%	0.025	0.05	0.10	0.20	0.40
	0.3	Low 11–30%	0.015	0.03	0.06	0.12	0.24
	0.1	Very low up to 10%	0.005	0.01	0.02	0.04	0.08
			Very low	Low	Medium	High	Very high
			0.05	0.1	0.2	0.4	0.8
			Impact				

Source: PRINCE2, 2009, p. 84

Risks are then filled into the grid and the upper right corner represents the most pressing issues. An example of that is shown in Figure 4. We can see in the examples above and below that the importance of risks is oftentimes asymmetrical.

Figure 4: An example of a Probability – Impact grid with risks

Very high				1 3	
High	2				4
Medium		8		6	
Low		10		7	
Very low	9		2		5
Prob. / Impact	Very low	Low	Medium	High	Very high

- - - - - Risk tolerance line

Source: PRINCE2, 2009, p. 84

This asymmetry can be explained easily. Risks with immense impacts are likely to be somewhat more important even with a minuscule probability of happening, compared to risks that will very likely happen but are not going to impact the project whatsoever.

An example of such can be an explosion and a construction worker getting sick. An explosion on the worksite is not very likely to happen, but if it does, the impacts are severe. On the other hand, workers get sick all the time, so the probability of someone staying a couple days in bed is quite high. In projects that last years, almost a certainty. Then again, how much of a problem can that be, if a single worker gets sick. The impact in this case is vastly inferior and such a risk is not going to be a priority. It would however, be worth taking a closer look into, if we were considering for example an epidemic of flu. That would cause considerable changes to our ability to perform and could lead to great delays. In that case though, the impact of said risk is much higher.

In the Figure 4 we can also see the *risk tolerance line*. Risk tolerance for a particular company should be defined and established in the first phase *context and risk management planning*.

Many risks are too complex to be analysed in their entirety. Some sources, such as IPMA (Doležal, 2012), recommend breaking the risks down to smaller parts. These can be more easily analysed and the impacts and probabilities can be set.

Once we have our risks from the risk register analysed and priorities are set, we can then move on to the next phase – *risk treatment.*

2.2.6 Risk treatment

Analysed and prioritised risks are now prepared in the updated risk register and in the phase *risk treatment*, the manager decides what course of action he/she will (or will not) take in order to manage each individual risk.

First consideration the manager has to make in this phase, is which risks are going to be accepted and which not. That is why the prioritisation took place in previous phase. The most important risks cannot be ignored (technically they can be ignored, but naturally, there are consequences to that approach) but there might be some that we do not have to manage that closely and some we can do nothing about. The "bottom of the list" risks with negligible probabilities and impacts do not have to take up mental space of the manager, they can be accepted.[4]

Traditionally, literature defines 4 ways of dealing with risks: Avoid, Transfer, Mitigate and Accept (PMI, 2013); (De Ceuster, 2010). Sometimes we can find other strategies such as Sharing (PRINCE2, 2009), Risk Retention (Raftery, 1996) or Contingency (Graham, 2011). Some basic explanation alongside a few examples is presented below.

- Avoid: The strategy that leads to the risk not happening. An example might be choosing to use a different procedure that does not involve particularly risky technology, or producing a mechanical part within the company as to not risk shortage due to late supplier delivery etc. As PMBoK (PMI, 2013) states, the most extreme case of risk avoidance is shutting the project completely.
- Transfer: Traditionally insurance. Transfer the risk to another subject that is going to cover for the loss in case of the risk happening. This is mostly being used with risks that we cannot avoid or mitigate. Sometimes self-insurance, or risk retention is the preferred approach. In that case money is being put aside by the subject to compensate for the possible loss. Other ways of transferring risks are warranties or guarantees.
- Mitigate: Actions and decisions that lead to the risk value being lowered, either by lowering its probability or the impact it would have. If we want to, for example, lower the probability of a human error, we can use

[4] Note: These risks do however need to be further monitored in case their characteristics change.

experienced staff only, or implement some poka-yoke[5] elements. If we want to decrease the impact of a key person leaving our project, we can have someone shadow his work. That way, if the key person leaves or becomes sick, the new employee will still have some learning to do, but not as much as if he was appointed on the spot.

- Share: Sharing a risk leads to a distribution of consequences among more subjects, so that the risk does lower impact to each individual.
- Contingency: This usually involves having a plan B, or sufficient time/money reserves. If for example a plane is delayed, take the train etc.

When planning different treatments for each risk, taking a look into what worked in the past and what proved effective is advisable. Also, risks are not limited to only have one treatment. Some risks can be transferred, mitigated and have contingency plans put in place for them all at the same time.

An important note should be made that ties in with what has been said in Chapter 1 of this thesis regarding the cost of information. The way we decide to handle the risk should not cost more than the risk value, otherwise it is financially ineffective. If we risk losing $100, taking precautions that cost $200 to avoid that risk makes little to no sense.
In some cases, it might be acceptable if the risk brings other than financial effects, such as losing credibility in the eyes of your customer. That is a difficult aspect to quantify and it may be preferable to pay more than the risk could cost us to avoid having to deal with it.

[5] A Japanese term that means mistake-proofing. The term comes from lean manufacturing and refers to elements that help eliminate human error by preventing, correcting or signalling errors. (Robinson, 1997, p. 1-12).

2.2.7 Controlling and implementation

The phase *controlling and implementation* of the risk management process is the result of all the previous ones. We have set the context and made plans. We have identified risks, analysed them and decided how we would handle each individual risk should it occur. It is now time to proceed with executing the project. During that it is necessary to keep an eye on the identified risks and monitor the situation for any triggers or changes that would make us adjust our plans.

If a risk happens we then implement our pre-planned action and see if it serves its purpose. If not, we may need to reconsider our actions or re-analyse the risk. It is also advisable to keep monitoring even the "unimportant" risks, to see whether there is any chance they might suddenly become more pressing. If so, we go back to the analyse phase. It is oftentimes the case that to each individual risk there is a dedicated risk owner. Such a person has the responsibility to keep track of any changes, watch out for triggers and implement risk responses should it occur.

During the project, we might also happen to identify new risks that arise from a change of status quo simply from new light being shed on the situation as we move forward. Also, some of the risks might become irrelevant due to their time frame or changes done during the project.

During this phase (which oftentimes last for the entire duration of the project) we can encounter the use of trend analysis and technical performance measurements. Updates on this phase are being presented through dedicated risk meetings or simple as part of the agenda of regular meetings.

2.2.8 Risk communication

The phase *risk communication* is not really a *phase* by standard definition. It is rather a continuous effort throughout the whole course of the project with regards to risks. Effort that aims to communicate the risks to everyone who might be concerned. That includes the project team, people working on the

project or on other projects and important stakeholders such as some statutory bodies or the customer.
Some organisations are not particularly keen on talking about possible risks with their customers. And some customers do not like to hear about possible risks. They see it as something negative, a sign of weakness or a way to create excuses beforehand. Risk management though, is not negative - it means giving your project the very best chance to succeed by carefully managing the things that might go wrong. Telling your customer about such issues might not only make them more acceptable to possible changes but also, might even provide you with some information that you would not get otherwise. Trying to get them to add their insights during the risk identification phase for example is a good idea, since they often possess knowledge the project team does not.

Communication about project risks should be done for the entire duration of the project. Keeping people in the dark serves no purpose and might be harmful.
However, that does not mean that you should tell everyone every little concern. It is not necessary to flood your boss and your customer with enormous amounts of emails, documents and information that they need not to know or cannot effectively use. Who should be kept in the loop and updated, how often and by which means the risks and issues should be communicated - this all should be defined and clearly stated in the project risk management plan developed in the first phase.

Also, documents regarding the way risks were handled during the project should be kept. This not only protects the project manager by having proof or a clear factual way to explain his actions. In addition, a very useful summary can be created at the end of the project, which might help the manager or his colleagues on other projects further down the line. This process of learning from previous mistakes and successes is called lessons learned and I believe it is appropriate to discuss it in further detail.

(In addition to that, my initial impression of the company suggests, that there might be an issue with repeating previous mistakes, which leads to more space being devoted to lessons learned.)

2.3 Lessons learned

A very useful definition of lessons learned is presented by Secchi et al. (1999 in Carrio, Ruikar and Fuller, 2013, p. 568) as according to them it is *"a knowledge or understanding gained through experience. The experience may be positive, as in a successful test or a mission, or negative, as in a mishap or failure. Successes are also considered sources of lessons learned".* The notion of learning not only from failures but also from successes is important here. Also, they state that the lesson learned must have impact and be applicable as to reduce/eliminate the potential for failure or reinforce positive results.

The importance of learning from previous events to further improve future performance is oftentimes overlooked by companies because "*the project is considered finished and resources are immediately devoted to other operations*" (Marcelino-Sádaba et al., 2014, p. 335). Because learning takes place throughout the entire project which may take years, summarising in the end what has been learned can prevent knowledge from being forgotten.

As such, lessons learned can improve the performance of further activities through continuous learning if successfully implemented. But previous studies suggest that even with significant investments in these systems, problems oftentimes lie in the successful employment of the lessons learned system (Parangamage 2012 in Carrio, Ruikar, Fuller, 2013, p. 568). Other authors seem to also identify this issue. Learning from projects rarely happens and when it does, it usually fails to deliver the intended results (Atkinson et al., 2006; Keegan and Turner, 2001; Kerzner, 2009; Klekegg et al., 2010; Milton, 2010; Chindler and Eppler, 2003; Williams, 2008; Wysocki, 2004 in Duffield and Whitty 2015, p. 311).

This is further proven by Milton's research, in which he found that out of 74 organisations that attempted the lessons learned process, 60% were dissatisfied with the results (Milton, 2010 in Duffield and Whitty, 2015, p. 312).

Another issue with lessons learned is pointed out by Nonaka and Takeuchi as such knowledge is more often than not tacit and held in people's minds (Nonaka and Takeuchi, 1995 in Carrio, Ruikar, Fuller, 2013, p. 567).
Carrio, Ruikar and Fuller also identify in their research the access to lessons learned to be an important issue. Other authors pinpoint the organisation-wide commitment to be a key factor in successfully implementing lessons learned (Clawson and Obberhettinger, 2001, p. 94).

But it is not only failures and successes that the organisation can (and should) learn from. Shimizu, Park and Choi (2014, p. 439) state that *"Although organisations appear to learn from obvious failures, they do not necessarily and easily learn from "near misses" – disastrous events that were averted in part by chance. Dillon and Tinsley (2008) formalised the concept of near misses and hypothesize that organisations and managers fail to learn from near misses because they evaluate such events as successes and thus feel safer about the situation."*

Obviously, as studies and research suggest, learning from past events to improve our business and project endeavours in the future is easier said than done. That however, does not mean a company should not keep trying to learn, however difficult it may prove.

To summarise all that has been said here regarding studies and research on lessons learned, I will proceed to write that the lessons learned should:

- be created using experience from the entire project,
- be widely accessible to all who might be concerned or interested,
- be systematic and continuous,
- be based on successes, failures and near-misses,

- be accepted and understood as a valuable tool by the entire organisation.

This chapter was devoted to the risk management process. First, the importance of managing project risks has been established and some project management standards have been briefly described. Then I have dedicated a number of pages to the process of managing risks itself, pointing out some of the different approaches. After that, a six-phase management process has been described concerning context and planning, identification, analysis, treatment, controlling and communicating risks. In the end of this chapter a bit more emphasis has been put on the process or lessons learned, reviewing some of the literature and recent studies.

The third and final chapter of the theoretical part of this thesis is presented further, dealing with risk perception and attitudes, various biases and mistakes when dealing with risks.

3 RISK PERCEPTION

Human mind is perhaps the greatest tool we will ever use. It is the reason why we have advanced as humanity. It is the birthplace of science, art, movement, faith and all the things that make us who we are. It still can outperform the most advanced computers in many tasks to this day and it is human mind that created these computers in the first place. Our mind is capable of complex calculations regarding distance, depth and speed in an instant without us even noticing. But as such, it is not perfect. It is flawed.

As scientists, such as Starr or Kahneman, have been studying for decades, it is especially flawed when dealing with risks and probabilities. And that will be, for the most part, the focus of this chapter. I will begin with describing some of the mental shortcuts our minds do when dealing with risks and probabilities of events. There are far too many to deal with all of them in this thesis, but at least some will be discussed and examples will be given. I will briefly describe various biases and heuristics that people dealing with risk management should be aware of in order to account for them in their estimates and judgements. In the end of this chapter I will also briefly introduce risk attitudes.

3.1 Mistakes in our judgement

In this part, I will go over several heuristics or misjudgements our minds do when dealing with risks. This is by no means an exhaustive list, which is out of scope of this thesis.

a) Risk control

Controlling the risk, being able to manage it in at least some way and have effect on the outcomes seems to be a very important factor in how our minds perceive such risks. We tend to over-exaggerate risks we have no control over while showing little to no fear in the eyes of risks we are in control of. Chauncey Starr's study in 1969 found out that people are willing to accept 1000 times

greater risks if they have control over them, compared to equal risks they could not control. Examples of those given are driving a car and a nuclear disaster (Starr, 1969, p. 1232-1238).
Another example of this is in a study by Jani (2011 in Shimizu, Park, Choi 2014, p. 438) Jani found out that project managers tend to underestimate the risks of a project with endogenous risk factors, factors that originate within the company thus having some degree of control over them. That is compared to projects with mostly exogenous risks, external factors.
As suggested by some authors, control over risk has a connection to another flaw in our judgement – the optimism bias.

b) Optimism bias

It has been proven that the average person considers himself anything, but average. People tend to believe that they are less likely to have negative event happen to them, such as getting cancer, becoming alcoholics, get killed in a car accident. The average person also believes he/she will live an above average life as far as age is concerned. And a positive relationship between control and optimism bias has also been found. People tend to be more optimistic about event they have some degree of control over e.g. driving a car[6] (Weinstein, 1980 in Klein and Hegweg-Larsen, 2002, p. 437).

This bias seems to be hardwired into our brains as it is "*widely considered to be one of the most reproducible, prevalent and robust cognitive biases observed in psychology and behavioural economics*" (Sharot, 2011a in O'Sullivan, 2015, p. 12).
Some research also suggests that it is not only humans who are affected by this bias. The optimism bias has also been demonstrated in mice (Harding et al.,

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[6] As Klein and Hegweg-Larsen state, it is not clear what is the cause and what is the effect in this relationship. According to them, greater control may lead to more optimism OR greater optimism about an event may lead to greater perceived control over it.

2004 in O'Sullivan, 2015, p. 12) and birds (Matheson et al., 2004 in O'Sullivan, 2015, p. 12) using similar experimental models.

With regards to optimism bias, its counterpart - pessimism bias has also been documented, though only in patients suffering from severe depression (Wisco 2009 in O'Sullivan, 2015, p. 12).

c) Anchoring

The existence of a preceding judgement. A number (the anchor) that when given to subject (even arbitrarily) will have an effect on the final judgement task. Specifically, the final judgement will be skewed towards the anchoring number. If we, for example, ask people to estimate whether *"the percentage of African nations in the United nations is higher or lower than an arbitrary number that has been determined by spinning a wheel of fortune"* (Tversky and Kahneman, 1974, p. 1128), either 65 % or 10 %, the final estimate will be adjusted towards the anchor on the wheel of fortune. Anchoring might be one of the hardest heuristics (mental shortcuts) to avoid, since it has been proven to persist even in expert judgement, using irrelevant anchors and in some cases, even if the subject is told about the number given being the anchor prior to the experiment. (Wilson, Houston, Etling, Brekke, 1996, p. 387-402).

d) Availability of instances heuristic

If an event is recent, or easy to recall for the judging individual, his or her ability to set the probability of said event is flawed. If a person, for example, reads about a plane crash in the newspaper, he/she is more likely to give higher probability estimates to a plane crash as a result of the availability of that instance (Tversky and Kahneman, 1974, p. 1127). Also, people are more likely to assess as more probable the events, that are unknown or more immediate, more shocking, than equal risks with more long-term and less shocking effects. This oftentimes leads to downright irrational, illogical judgements.

In one of his many interviews, Kahneman mentioned a research done on the flaws we make when assessing risks and emotions are involved. People were asked how much they would pay for insurance policy that would cover

$100 000 in the event of death for any reason. Others were asked the same question regarding insurance policy but one that only covers terrorist attacks. Turns out the second one is worth more even though a terrorist attack is included in the "any reason" category. Fear oftentimes beats logic (Kahneman in Talks at Google, 2011).

Another example, more of a thought experiment, is presented by K. C. Cole (Vsauce, 2014). Imagine a world where cigarettes are harmless. But every 18 750th pack contains a single cigarette (i.e. every 375 000th cigarette) with dynamite, that upon lighting explodes, violently and shockingly decapitating the person smoking. In that imaginary world, the same number of people would die from smoking, as they already do in the world we live in today. But the results would be immediate and definitely more shocking, so chances are, not many people would dare to smoke at all.

e) Reporting bias

Not as much a flaw in judgement as it is an understandable and predictable way of reacting to certain corporate culture. As Raftery (1996, p. 44-45) states, many companies have reporting systems that ask managers to explain when their projects exceed budgets. Oftentimes negative sanctions are associated with exceeding the initial forecast. There are rarely however, negative sanctions associated with the project coming under the expected budget. It is seen as a success, the manager doing his job right. But this can in many cases lead to the initial estimates being quite conservative and over exaggerated to provide for that bonus further down the line or at least stay away from negative consequences of exceeding the budget. The same applies for project return in which values will be estimated that are likely to be exceeded. This after some time inevitably leads to misallocation of precious resources.

Another issue can arise due to different risk attitudes of various individuals. Different people have different understanding of what high probability means for example. These issues should be made clear when dealing with risks.

Speaking of risk attitudes, I will now finish this chapter with a brief introduction of different risk attitudes.

3.2 Risk attitudes

Some individuals and even entire companies thrive on risky situations. Some, on the other hand, are careful and cautious. This distinction depends on many variables, including the task at hand, previous experience or the ability to control the risk as discussed earlier in this chapter.

Depending on these characteristics, we traditionally divide people into three categories:

- Risk averse
- Risk neutral
- Risk seeking

An example for all three risk attitudes will be shown using a simple bet scenario:

Suppose a bet where you can either win $20 or nothing, based on for example a coin flip is presented. The expected value of such a bet is $10, with 50 % being the chance of either a win or a loss. The person is also offered a chance to “buy” this chance from another person for a certain amount of money.

- Risk averse person will prefer certainty and would “buy” this opportunity for less than the expected value of such a scenario, let’s say $8. He/she would not be willing to pay that much for a chance.
- Risk neutral person would be willing to pay exactly $10 for such a bet, the exact expected value. No more, no less.
- Risk seeking person is willing to pay even more for such a bet, suppose $13, because he/she believes the winning scenario will happen, thus gaining money.

In many situations, people engaging in situations commonly seen as risky, such as gambling, are actually very risk averse. These people do everything in their power to tilt the odds in their favour. Card counting or systematic bets, those people spend a lot of time devising optimal strategies to in fact minimise the risk.

The purpose of this chapter was to introduce some of the psychological aspects of dealing with risks. Several judgemental flaws and heuristics have been described and examples were given. In the end, different risk attitudes were briefly described to conclude this chapter. Building on the knowledge base that has been established in this thesis so far regarding risks, the practical part applies this knowledge to solve a real world business issue in an existing company.

PRACTICAL PART

4 COMPANY ANALYSIS

The previous 3 chapters focused on creating a theoretical base for the following part of this thesis. I will now use this theoretical base and apply it in a business environment to help solve an existing issue on the following pages. First, the company is briefly introduced with regards to its development and the challenges it is facing. Next, a set of research questions is introduced, that this thesis aims to answer through analysis as well as any assumptions there might be. Following that, the methodical approach is defined, the scope and set of data acquired as well as the methods for collection and analysis. Logically, an analysis follows including a summary of the outcomes. That eventually leads to a set of recommendations to help improve the existing situation with regards to findings from the previous part.

I would like to point out, that this thesis is not the only attempt to help improve the current situation in the company. Parallel to this, various improvement efforts are happening within the company management, which means, that by the time this thesis is completed, the current situation might already be slightly different. That is unfortunately unavoidable in a constantly evolving and improving environment. However, the benefits this thesis can bring are the connection between theory and practice as well as an unbiased point of view, unaffected by professional blindness. Also, given the current workload in the company, the lack of time to analyse large sets of data is limiting the company's ability to effectively tackle the issue. That is why I believe this thesis can provide benefits to the company and its development.

4.1 Company description and current situation

The selected company is a manufacturer of industrial equipment. Further specifications of the company are not present, since a significant portion of the information in this thesis is considered confidential.

The company has gone through a long list of changes since its beginning. It was communized, part of other companies and it has undergone a number of various changes and industrial re-specialisations. Weapons, chemicals or agricultural equipment, all of these were once manufactured on its premises.

Figure 5: An example of the company's product (hidden to preserve anonymity)

[redacted]

Source: Company archives

Since 2013, the company has been focusing its efforts on larger projects, as opposed to more standardised production, prevalent until then. These large-scale projects brought many changes to the company and many challenges as well. The company has been trying to consistently up its manufacturing capacity. However, due to its location in a relatively weak region as far as economic conditions and labour market is concerned, it has been struggling with attracting enough skilled people. The shift of focus to large-scale projects has its challenges and the company is still learning and slowly evolving to accommodate for the specific needs.

4.2 Assumptions and research questions

Based on what was written in the previous part about the situation in the company, I have decided to define the following assumptions and research questions for analysis.

First, an assumption exists, that the company suffers from repeating the same mistakes from previous projects or situations. Furthermore, that the inability to share and learn from previous mistakes is detrimental to the company's performance on such projects. This assumption stems from previous experience with the company and interviews with various employees. Based on that, the preconception is that the lessons learned process is formally in place, however, ineffective and not well shared. I have decided to verify this assumption through analysis.

Second, a research question has been formulated: Were there incidents that affected one or more of the project's constraints, such as time or scope, that could have been easily predicted and prepared for by using a simple project risk management process?

Lastly, I aim to answer the second research question: If there were such incidents, what was their financial impact on those projects, i.e. how much money could have been potentially saved if a project risk management process was in place?

A third question has also been formulated: Had those incidents an image/goodwill impact on the company in the eyes of the customer in addition to the time/scope/cost impact mentioned before? Answering this question though is more rooted in personal feelings than hard data, since such problems are difficult to verify or quantify.

4.3 Methodology

With research questions formulated, data collection took place. First step was an initial interview with one of the project managers. This interview took place in the company offices and was aimed at getting an overall feeling for the situation. Main issues were discussed and possible approach defined, as well as the documents that might provide the necessary information for the analysis.

Next, I scheduled an interview with the business director of the company. A more in depth discussion took place and I formally requested access to the documentation and cooperation of the project managers involved.

I received a list of 26 projects since 2013, with a project value of 500 000€ or higher, as well as the corresponding project managers who oversaw the project. All of these projects were carried out within the last 4 years, since before that, the company focused more on standardised manufacturing.

With this list, I scheduled a meeting with all the project managers and asked them for the project documentation, which included:

- closing meeting documentation (the lessons learned process),
- planned time schedules,
- actual time schedules,
- customer claim reports (warranty claims),
- quotations (sales offers),
- variation notices (variations found before expedition, the customer does not get to see these, internal documents),
- manufacturing orders (product specification of what is to be manufactured).

In this phase, the first issue emerged. The complexity of the documentation proved to be a problem for the project managers themselves, some documents were hard to find or even inaccessible. Some information was to be filled in two separate systems, some was not available, some was not properly labelled or kept only formally. Overall the situation was such that for an external person or

(a new employee), it is considerably difficult to understand or even access the proper documents. However, after initial confusion on both sides, we managed to secure access to most of the required documentation. A quick analysis of the dataset showed, that some of the documentation will not yield the desired outcomes. Other documents that might help were identified, such us the FATs (factory acceptance tests) mentioned later.
With most of the documentation in my possession, I began my analysis, but eventually concluded, that another interview might be advisable with some of the project managers to clarify certain issues. With the main issues identified, I also scheduled an interview with the finance director to be able to determine the financial value of these issues.
I would like to point out that not all of the requested documentation was acquired. Some project managers refused to cooperate, or failed to provide the documents for various reasons. However, I eventually managed to acquire the documentation for 23 out of the 26 listed projects, which provides a sufficient dataset for this thesis.

4.4 Project overview

My analysis consisted of looking through the acquired documentation and interviewing key personnel associated with the projects. I identified the main issues to be able to answer my research questions stated in a previous part of this thesis and to verify my initial assumption. The following pages contain a description of the projects followed by a summary of the issues found during the analysis.
There were, in some cases, very specific and technical issues stemming from the complexity of the equipment. These will not be the main focus, since such issues are impossible to predict or affect without professional technical

knowledge, which the project manager cannot have. In the case of a repeating issue however, these will be considered.[7] For similar reasons, equipment malfunction or warranty claims will not be taken into account on externally purchased equipment. There were, for example, a number of warranty claims for some individual pieces of equipment, such as gas detectors, which led to the company purchasing and sending a new piece. This of course had certain financial implications, which simply caused lower margin on the project. As such, supplier quality control and supplier management is within the competency of the purchasing department.

The 23 projects are grouped into 4 separate units, super-projects for 4 separate customers, with 2 standalone projects as well. The projects within those groups are similar in many respects, but in many respects, still unique projects.

4.4.1 Project group Alpha

Project Alpha was a super-project, consisting of 7 separate smaller construction projects for the same customer. The situation was complicated from the beginning. Initially, there were supposed to be 10 projects, 8 of which were planned for another country. After almost a year of discussion and meetings, an order was sent in March 2013. The customer however, then decided to cancel those 8 projects when the material was already ordered and equipment being manufactured. After long court proceedings and numerous discussions, it was decided that the cancellation will be accepted without fees and five additional projects will be carried out in the other country, resulting in 7 projects in total.

Five of those have already been finished, the remaining 2 are still ongoing projects, with the 6th one soon to be finished and the 7th one on hold.

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[7] For the purposes of this thesis, such specific, technical issues are described in a generalised fashion to prevent unnecessary, overly complex and detailed descriptions and to preserve anonymity.

This was a unique project for both parties, the customer and the company as well. The customer had previous experience with large scale super-projects, but lacked the experience with the given technology. The company has significant experience, but the scale of the project was a considerable challenge. There were also some new technologies within the project, so it was a painful learning experience for all participants.

The capacity requirements proved to be severely over what the company could offer, which led to complications and delays. The customer did not make the situation any easier. Coming from a slightly different field with different specifications of the technologies and being in the position of power, it enforced strict conditions and requirements.

The requirements were often times even higher than safety norms or ISO specifications for the industry. They put in place checks before ordering material, which caused numerous delays. They demanded material to be purchased from certain pre-chosen suppliers, which proved to be a significant issue as well. In many cases, the company found out that the required supplier does not even produce the required equipment or that it has been placed on "blacklist" due to problems with delays, payment terms or quality. Not having enough

experience with the technology, the customer specifications were often times incorrect, which led to further complications.

It was a complicated learning experience, but the strict conditions set by the customer led to the team being under significant pressure[8]. Such pressure led to unnecessary mistakes, such as over-pressurised equipment. This particular mistake was done by a construction engineer, but could (and should) have also been stopped by the construction workers themselves. The solution was to adjust and repurpose a slightly different equipment for the second project, which was already delayed.

[8] The interviews revealed that this led to certain long term health issues, due to prolonged high amounts of stress placed on the project managers.

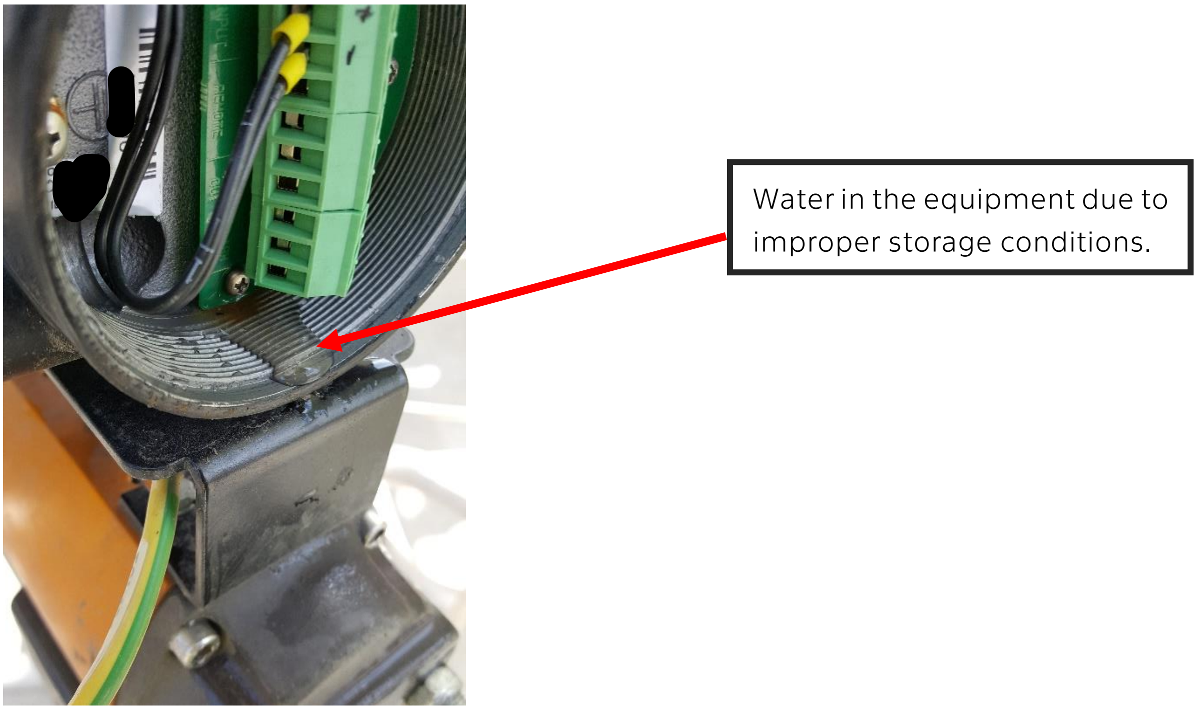
More problems emerged from one sub-contractor that provides mechanical installation and service, which was demanded by the customer. Late deliveries, payments, low quality etc. The issue was that this supplier has long and good relationship with the customer, but it was a sub-contractor to the company. Any problems caused by this supplier caused problems for the company and an explanation was demanded from the customer. But because the supplier was given by the customer, the nature of solving these problems was problematic. Eventually, the contract was changed to make this supplier directly responsible to the customer instead of the company, which solved the problem.

Another issue was the welding quality. The company practice required random checks for quality. However, unofficial information is that this practice over the years naturally changed to the workers choosing the welds themselves, leading to their ability to affect the randomness. This led to low welding quality, which was experienced by the customer. They enforced 100% quality checks and the company practice was improved due to these incidents.

However, thanks to this incident, an issue regarding the contract has been discovered. The additional welding works were done on site and then, the company was asked to pay for it without previous cost assessments. The resulting sum was significantly higher than expected. This led to a request to include a clause into future contracts, that would require any additional works to be assessed and accepted by the company prior to execution. This part of the contract, according to inside sources, does not exist to this day. It may lead to future complications and additional costs.

Later a delay was caused by the customer. This led to the equipment being stored outside, due to insufficient storing capacity inside. Because of the weather and the storing conditions, the equipment (Figure 6) got wet and had to be replaced.

Figure 6: The equipment that got wet due to improper storage conditions



Source: Company archives

After expedition, problems with the software on site emerged. It was a new design with little company experience. This led to improper use and errors being experienced. As a solution, various poka-yoke elements were introduced to the new SW version to prevent this from happening again.

Another issue was with improper use of the equipment on site. The company was responsible for training part of the staff on site which they did. However, the customer was then supposed to train the rest of the staff, which was more or less just formal training with low priority which then led to the staff using the equipment improperly. After identifying the root cause, repeated training was introduced and the problem was solved.

The customer had very strict and specific requirements, as stated before, and one of those were so-called FATs, or Factory Acceptance Tests. A customer representative visited the factory and made a formal point based assessment of the equipment and work, as well as the factory conditions. These happen for each of the seven projects. An example of an FAT output is presented in Figure 7.

Figure 7: Example of an FAT output

	[redacted]	Cleanliness and grease. main lines => OK Used endoscope to look inside.[redacted] opened. Several end caps opened.		
	[redacted]	Cleanliness tubing[redacted]=> loose, dry particles are found in tubing ends. [redacted]to blow lines for cleaning. 	OPEN	

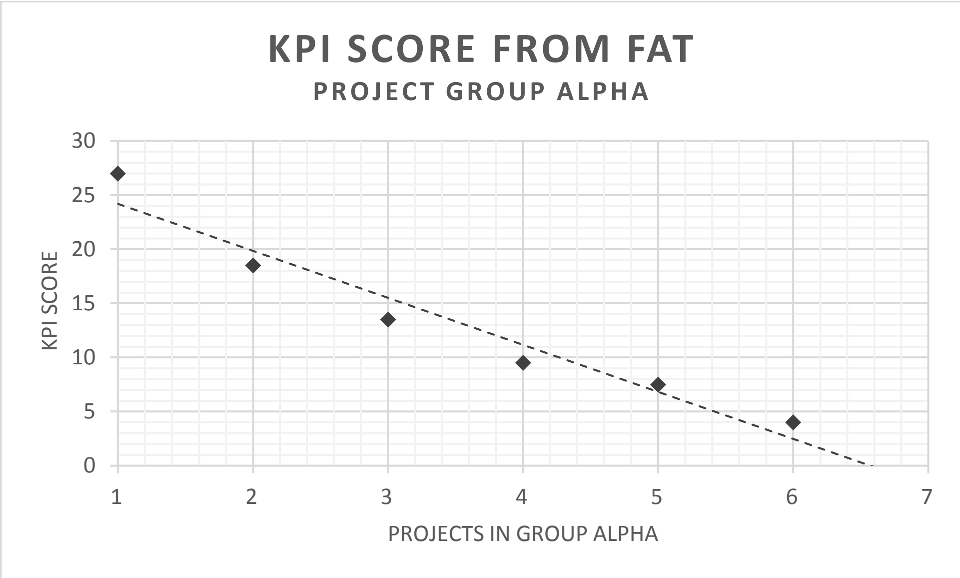
Source: Company documentation

Most issues were single isolated incidents, most unable to be predicted by the project manager. Some were very technical and could have been predicted by the construction engineer and designer, some were results of improper customer specification and overall confusion and learning. Some of the issues however, were repeating and thus easy to predict and fix. Some equipment is missing or not installed yet, that seems to be a repeating issue, same goes for labels on equipment. In addition to that, the customer requested certain bolts to be switched for another type, non-corrosive. The mistake was repeated by the company on 2 more projects. This could a) have been predicted, since the project is intended for outside use and b) have been fixed the first time. Another issue was dirt and dust in piping, which will become more important later, in Project Gamma description.

A workplace safety issue was discovered, which damaged the company reputation. Another safety issue appears again in Project Delta.
The overall performance, however, has been improving throughout these connected projects. The final scores (KPI, the lower the better) from the FATs

are displayed in Figure 8 and we can see a notable improvement and a downward tendency of the KPI score.

Figure 8: KPI scores from FAT in project group Alpha



Source: created based on provided documentation

Another new issue is that a 24 hour-leak test was not performed, even though it was marked in the documentation as "performed". This is a current problem the project manager is facing on the 6th subproject, which will cause a significant delay and will also have financial impact. Root cause of this problem is still being investigated.

To sum up and create an overview, the problems and issues during these 7 projects (last 2 still ongoing) are:

- Capacity problems
- Forced suppliers
- Incorrect equipment specification
- Over-pressurised equipment
- Sub-contractor problems
- Welding quality
- Improper storing outside
- SW issues
- Training issues
- All the FAT issues

- Safety issue
- 24-hour leak test
- A number of other minor problems, that had negligible impact

All of the beforementioned problems, challenges and issues led to significant delays on the first project. This led to delays on other projects as well, since the customer did not want to proceed on the following projects until the major issues were solved. An overview of the timelines is displayed in Figure 9.

Figure 9: Project group Alpha timeline overview

Source: created based on provided documentation

The delay on the 5th project is greater due to the customer not having the site prepared and having to acquire additional permits and documentation.
Overall, given the complexity and novelty of these projects, delays were to be expected. Summary of the most important issues from this and other projects will be mentioned further, alongside a financial assessment.

4.4.2 Project group Beta

Project Beta is certainly less complex and complicated than project Alpha. It is, however, another super-project, consisting of 5 individual sub-projects. The customer is less strict and there was already more experience from previous projects.

Figure 10: The site of one of the sub-projects in project group Beta (hidden to preserve anonymity)

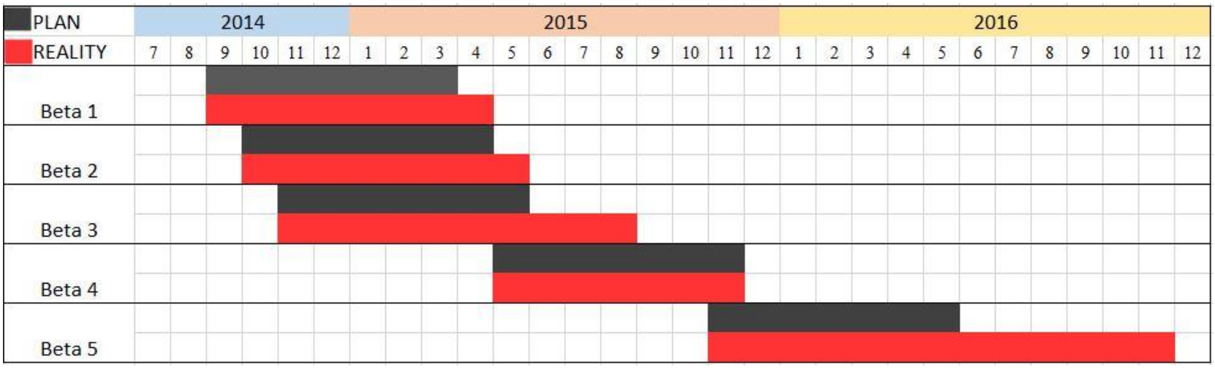
Source: company archives

There was a repeating issue from construction design, that causes additional work to be done during manufacturing and additional costs as a result. This issue however is difficult to avoid, since some further specifications are made after the design, which sometimes create insufficient space for maintenance or bad access etc.

Another repeating issue was missing equipment or labels on site. It happened on 3 subsequent projects and seems to be an issue on other projects as well. This is a problem with low financial or scope impact, but it creates bad atmosphere and damages reputation of the company in the eyes of the customer.

Other than that, the project seems to have been without any major issues. There were only minor problems which were solved quickly. From available information, none of these could have been easily anticipated, except for those mentioned before. The project timelines are displayed in Figure 11.

Figure 11: Project group Beta timeline overview



Source: created based on provided documentation

As we can see in Figure 11, the projects were for the most part done within reasonable tolerances for the industry time schedules. Given the complexity of these projects, it is not unusual to see projects delayed for several months. Slight delays for the first and second project were mostly due to lesser additional works and specifications. Those delays were a couple of days, but managed to cross the boundary to another month, that is why it may seem as a month delay. Delays for 3rd and 5th project were caused by the customer, who requested the equipment to be stored due to complications on his side. There were no issues during storage as there were for example in Project Alpha. Project four was done exactly one time as planned.
Overall this project was quite successful with only minor issues emerging from the unique nature of these projects. However, some problems, such as missing equipment or labels were repeating and even though those are easy to fix, it contributes to creating a bad image in the eyes of the customer.

4.4.3 Project group Gamma

Relatively small in scope, Project Gamma consists of two separate projects linked together. This project is still being troubled by capacity issues, which seems to be a prevalent problem in the company. Due to these capacity problems, the company was forced to delay the project. Coincidentally, at the same time, the customer asked for a delay on his side as well, so the situation resolved itself without problems.

After expedition, unexpected problems occurred, which required the company to send qualified staff on site. The problems were caused mostly by improper installation by the customer or one of his subcontractors. Key company staff sent on site resolved all the issues within three weeks. However, their absence slowed down progress on other parallel projects. This could have been anticipated to some extent, however, with current capacity and only a handful of people able to perform certain tasks, there is not much the project manager could have done.

All the customer issues were resolved successfully and to his satisfaction, which eventually led to two more projects being ordered.

There were however certain problems on the side of the company:

- First, there was dust and dirt in piping again, as it was previously in Project Alpha.
- Second, more labels were missing as in Project Beta.
- Third, a flaw appeared in the design that prevents the equipment from being properly secured during transport. This flaw has been reported. However, from an interview, it became apparent, that another, current project led by another manager has the same issue despite this report.
- Lastly, an action list contains a task regarding inspection and maintenance space. Certain specifications and requirements for site preparations are to be sent in the beginning of new projects to customers. From available information, at least two new projects have been started since then without sending these specifications.

From a time-schedule perspective, the project was without any major delays. The only one, caused on the first project, was the one mentioned before. It could be considered a lucky coincidence, that the delay occurred simultaneously on both sides. The timelines are displayed in Figure 12.

Figure 12: Project group Gamma timeline overview

Source: created based on provided documentation

These two projects could be considered successful. The issues that emerged were resolved to customer satisfaction which led to more business brought to the company. However, there are clearly challenges associated with information sharing and organisational learning, which are apparent from the project description.

4.4.4 Project group Delta

The last one on the list, Project Delta, is a super-project consisting of 7 separate, though interlinked projects for the same customer. The first project, as with most similar situations in this industry, was sort of a trial project. Such is likely to get delayed, but will provide a learning experience for the team and help resolve any early issues. Due to the unknown nature and unclear specifications, there were many design changes and additional requests from the customer. This caused some delay, which is apparent from Figure 13.

In the beginning, an issue was discovered when incorrect cables were ordered, as it was not in accordance with local safety norms. These required armoured cables to be used.

Once again, the equipment was not properly labelled, which caused confusion. In addition to that, some of the equipment was labelled differently, compared to the design plans. This created even more confusion on site. The staff was experienced and managed to put the equipment together, but a request to update the part list was issued. This problem however, occurred again on two more projects later.

As in project Beta, there was some equipment missing in the deliveries.

There was an issue with too much welding being done on site. This caused complications and minor delays on two subsequent projects. The amount of welding was later reduced using longer piping, which solved the issue. Problems with wiring designs and specifications also appeared on multiple projects, but were eventually solved.

Another issue was that a change in design was made and the customer was not informed of that change. This caused confusion and complications on site and could have easily been avoided.

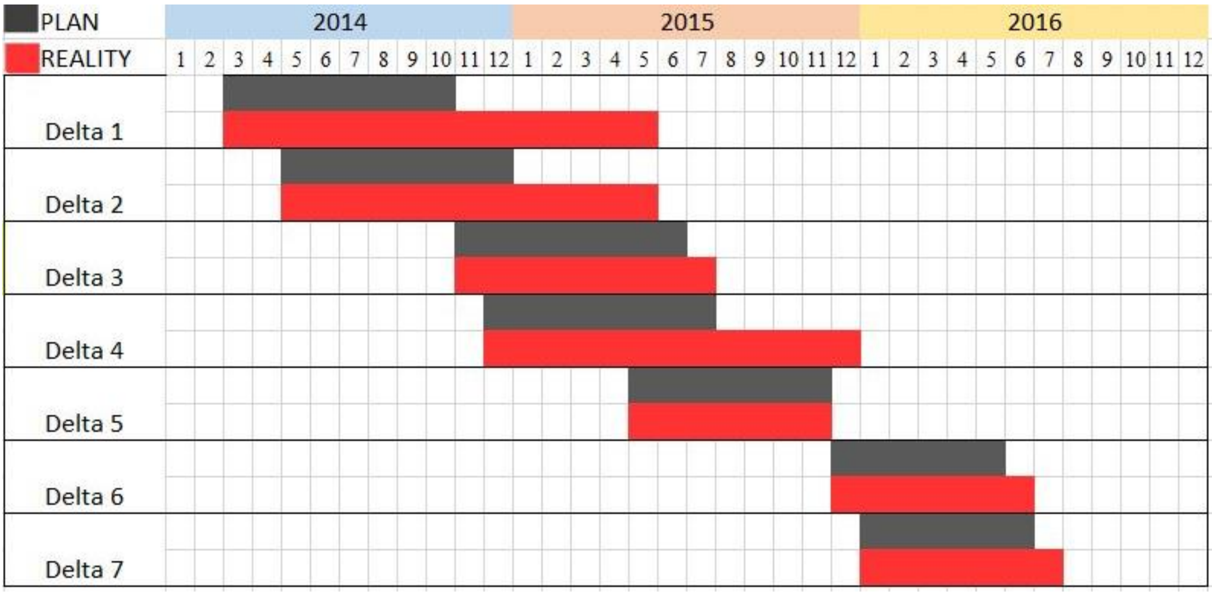
The last two projects suffered the same problem with improper civil works to prepare the site for installation. Both caused some delay and additional works to be done. An item was added on the action list from Project 6 for future projects, to inform the customer about this particular requirement for the site. However, the issue repeated on the last project. The customer was informed, however, given the project timeline, the site had already been prepared without these changes.

Safety on site problems and near misses were also present as there were in the Factory Acceptance Tests in Project Alpha. Another issue was insufficient capacity, which caused minor delays throughout the project.

To sum up and create an overview, as in Project Alpha, the problems and issues during these 7 projects were:

- Frequent requirement and design changes
- Cables not according to local norms
- Missing equipment and labels
- Labels and numbers not according to the design
- Too much welding being done on site
- Wiring design and specification issues
- Customer not informed about a design change
- Unsuitable civil works on site
- Safety issues

Figure 13: Project group Delta timeline overview



Source: created based on provided documentation

As for the project timelines, there were expected delays on the first project. Other than that, there were some minor delays and one major delay caused by the customer. An overview is in Figure 13.

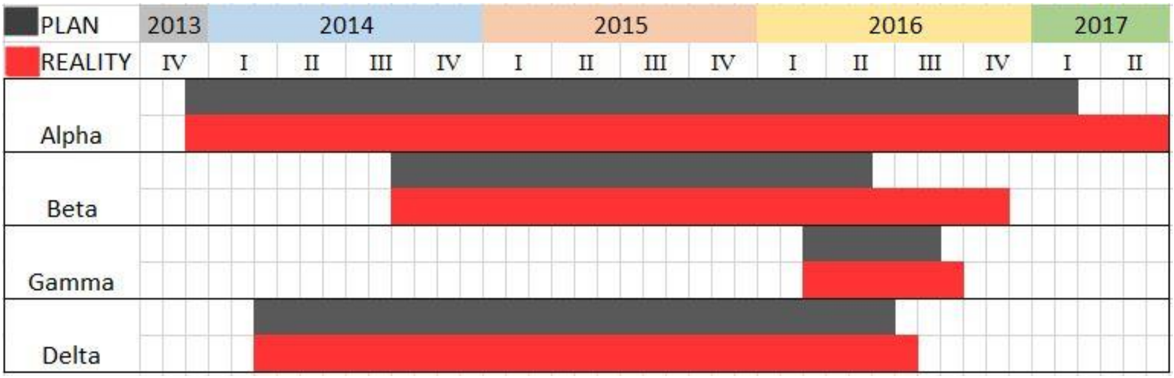
4.4.5 Two standalone projects

The two standalone projects were analysed, but as it was already apparent during the interview with the project manager, those were rather insignificant for the purposes of this thesis. These were not too unique and no noteworthy issues emerged within their timeframe. Both were finished on time without delays or any scope changes, generating expected profits and staying on budget. It appears as though these two projects were put on the project list that I acquired accidentally by the company, as they were standard projects with low project value and no significant issues.

5 SUMMARY

Next, a summary of the four major groups, Alpha, Beta, Gamma and Delta is presented. It aims to pinpoint major or repeating issues (Table 1) along with the timelines for these entire super-projects (Figure 14). Some of these issues are further analysed, as to how difficult they were to avoid or predict. The main problems are then financially assessed to provide context for the recommendations that follow[9].

Figure 14: An overview of the timelines for all four project groups



Source: created based on provided documentation

The issues that emerged during the beforementioned projects are summed up in Table 1. This table contains the issue, which project(s) it occurred in, the impact it had and additional notes where necessary. The issues are sorted by financial impact value:

[9] Financial impacts are rounded, to simplify the information.

Table 1: A summary of issues in analysed projects

SUMMARY OF ISSUES IN ANALYSED PROJECTS

ISSUES	Project				∨ IMPACT ∨	Notes
	Alpha	Beta	Gamma	Delta		
Welding quality	x				6.500.000 CZK	Could have been less, contract issue might re-occur
Over-pressurised equipment	x				2.600.000 CZK	
Equipment not according to norms/ specifications	x			x	750.000 CZK	
Design flaws			x		Safety hazard, potentially 500.000 CZK	Re-occurring on future projects
24-hour leak test not done	x				Bad reputation, potentially 200.000 CZK	Still being investigated
Improper storing outside	x				30.000 CZK	
Problems with training	x				12.000 CZK and further capacity problems	Caused by the customer
Capacity	x	x	x	x	Many various delays, hard to quantify	
Missing labels	x	x	x	x	Bad reputation, *NFC	
Missing equipment	x	x	x	x		
FAT issues	x				Bad reputation, *NFC	Major FAT issues are separate
Dirt in piping	x		x		Bad reputation, *NFC	
Improper civil works on site				x	Minor delay, *NFC	
Labels don't match the design				x	Confusion, minor delay	
Safety issues	x			x	Safety hazard, bad reputation	
Design changes				x	Bad reputation	Customer not informed about change

Source: author

*NFC - negligible financial costs

As we can see from Table 1, all of the projects mentioned in this thesis have capacity problems. This issue is being solved by hiring and training new staff, but it obviously takes a long time. Thanks to these efforts, the capacity problems are becoming less impactful. According to available information, the company was aware of the lacking capacity and difficulty of acquiring new staff when starting these projects. Due to the business environment in this particular industry, every project is important and it is often times advisable to take on a new project for a large customer knowing the capacity is not enough. Some delay will be caused, which will require fees to be payed, but the overall effect on the company will be positive. This seems to be standard industry practice and even though delays are undesirable, given the nature and complexity of these projects, delivering later is somewhat expected and tolerated by the customer as long as the result is satisfactory. In addition to that, in many cases, the customer is directly responsible for the delay, due to a number of reasons.
In these cases, however, if the customer requests to put the project on hold, proper storing should be discussed and secured, as it may result in equipment damage, as it happened in Project Alpha. Even though the financial impact was not particularly significant, this issue was unnecessary, as it could have easily been avoided.

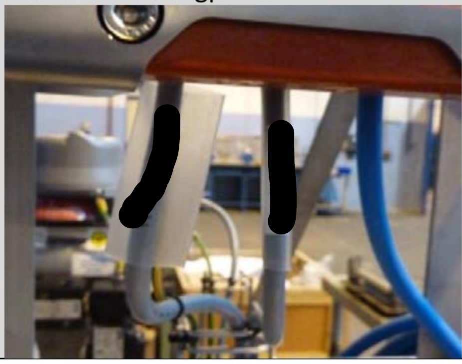
The capacity issues, however, led to increased pressure on the engineering team, which eventually resulted in a costly mistake. As mentioned before, the over-pressurised equipment was a mistake caused by chaos, pressure and stress on the construction engineer. This cost the company 2,6 million CZK in total, including extra material, additional works and fees for late delivery.
The issue that cost the most money were problems with welding quality. The costs for additional works and material, as well as the customer's requirement for an external inspector paid by the company were 6,5 million CZK in total. This is by far the biggest financial impact from all the identified issues. As far as the ability to predict such an issue is concerned, during the interview it became apparent that yes. It could have been anticipated, however, it became

overlooked and to some extent tolerated company practice over the years and nobody thought there could have been mistakes. The professional blindness led to the entire company trusting the process and it eventually, over the years decreased in quality. It resulted in extraordinary additional costs and significant reputation impact. However, it eventually led to improvements in the welding practice for the entire company. Or rather than improvements, increasing the welding quality back to the level it was supposed to be at in the first place.

The incorrect equipment specification done not according to local safety norms in Project Delta was an issue that cost the company approximately 750.000 CZK. However, this would require the project manager to double check the project engineer's work to uncover. Since there are systems in place to prevent such things from happening, such as a designated control person for the design, the project manager could have hardly predicted this problem. There were other issues regarding incorrect specifications in Project Alpha, but those were caused by the lack of experience and new technology and for the most part, caused by the customer, rather than not reading the safety norms.

The problem with missing labels and equipment (an example is presented in Figure 15) prevails in all the projects. The financial impact of such mistakes is negligible, additional shipping does not cost more than a 1.000 CZK, which compared to the project costs does not have any impact. However, in the eyes of the customer, the reputation suffers unnecessarily. Given the complexity of the equipment, the number of shipped parts is often times in the hundreds. It is understandable, that under the time pressure, some minor things get forgotten, such as labels. However, it is unnecessary and relatively easy to avoid.

Figure 15: An example of an FAT output mentioning missing tags and labels

	[redacted]	Tagging of cable [redacted] is missing. [redacted] to install correct tagplate. 	OPEN	
	[redacted]	Tension: For offload and [redacted] no tension in piping or tubing was noticed, that is not within acceptable range. OK	Closed	

Source: company documentation

Similar to this are for example the FAT issues, such as the bolts not being changed for subsequent projects as mentioned before. The impact is small, but unnecessary and might reflect badly on the company.

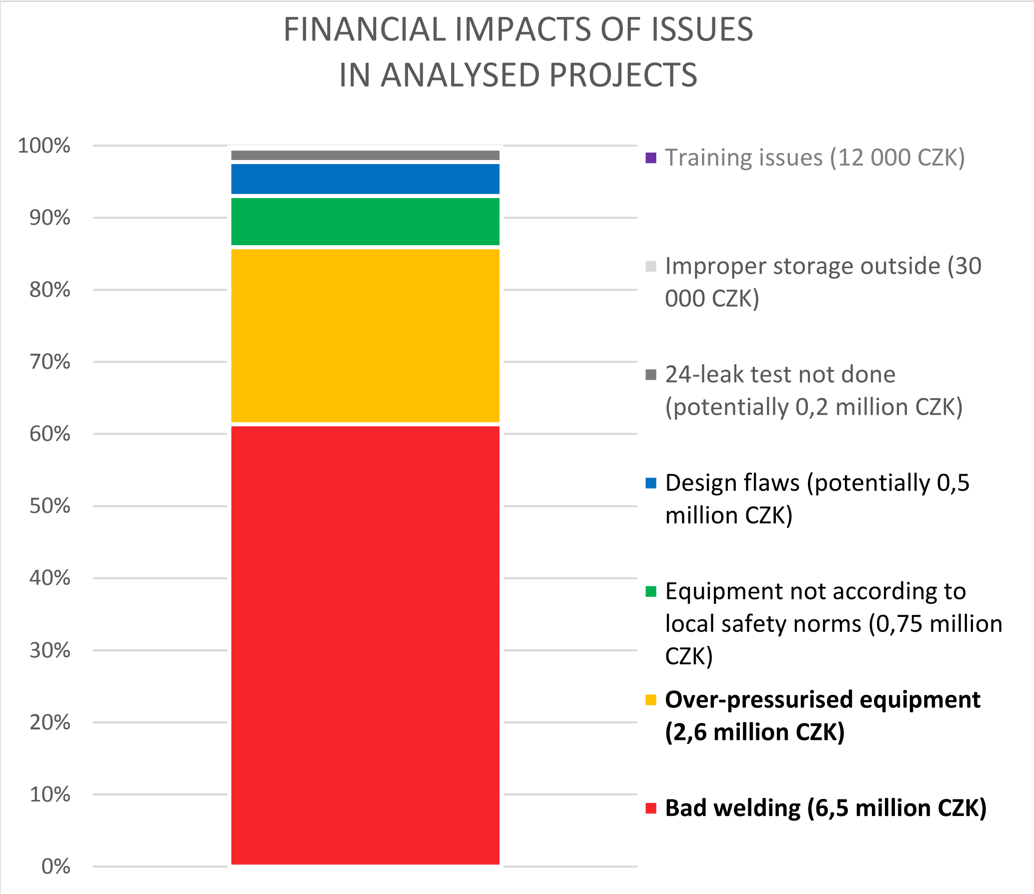
Likewise, the dirt in piping causes some bad reputation. However, this issue has already been discussed by the management and the solution would be unreasonably cost and time ineffective compared to the impact it has.

6 ASSESSMENT

Considering all the beforementioned issues, it can now be concluded that:

- The company suffers from unnecessary bad reputation created by repeating issues, missing labels and equipment, safety issues and improper communication with the customer.
- The company, on many occasions, fails to learn from previous mistakes and near misses and repeats them again on following projects. Those are smaller in nature, as the severe issues cause enough of a roadblock to change the company practice.
- The communication between project managers regarding their projects is also lacking, as in many cases, they could learn from the issues that their colleagues were facing.
- As apparent from Figure 16, there were a relatively small number of issues with significant financial impacts, which corresponds with the Pareto principle. The two most impactful issues (roughly 30 % of the issues on the graph) account for more than 85 % of the total financial impact of all the listed issues. The numerous minor issues cannot be compared financially to the severe ones as they do not even appear on the graph (though included), such as improper storing or training issues. Those are included in the graph to show the difference in financial impact. Other issues, such as missing labels, have costs that are negligible even compared to the training issue, which is the reason those are not included in the graph.
- Issues with 95 % of the total financial impact appeared during project group Alpha. That is somewhat understandable, given the complexity and uniqueness of this super-project.

Figure 16: Financial impacts of identified issues



Source: Created based on the analysis of the documentation

- Regarding those impactful issues, there was little the project manager could have done without also being a construction engineer. Being the project manager, it is impossible to possess the specific engineering knowledge and a clear division of work has to be done. The welding problem described before in further detail. The over-pressurised equipment was a construction engineer's mistake as well as the equipment not being according to local safety norms.
- The only issue with a financial impact, that was not negligible and could also have been easily predicted by the project manager, is the improper storing outside (30 000 CZK), which led to the equipment getting wet.

With these conclusions, the initial assumptions and research questions are presented again as well as their verification or answers. Following that, I present a set of recommendations to help improve project risk management practice in the company with regards to the findings of this analysis.

First, an assumption was presented, that

- the company suffers from repeating the same mistakes from previous projects or situations.
- Furthermore, that the inability to share and learn from previous mistakes is detrimental to the company's performance on such projects.
- Based on that, the preconception was that the lessons learned process is formally in place, however, ineffective and not well shared.

The first assumption was confirmed, with a number of repeating issues identified in the analysed projects, some present in all of them. As the analysis has proven, these issues, in some cases, cause additional costs, delays or bad reputations in the eyes of the customer, as well as presenting potential safety hazards. The lessons learned process is in fact in place, with closing meetings after projects (in most cases) and action lists with issues to solve. The current process, however, is of limited use as only the project team for the current project attends the closing meeting. As it was identified in the analysis part of this thesis, there are instances in which other project managers could benefit from the lessons learned by their colleagues.
All three assumption were therefore confirmed and correct.

Regarding the research questions:
Were there incidents that affected one or more of the project's constraints, such as time or scope, that could have been easily predicted and prepared for by using a simple project risk management process?
The analysis has shown that yes, there are such incidents affecting time and scope constraints of these projects. Not all of them, however, could be easily predicted and prepared for. This is due to the unique nature of the projects and

their technical complexity, which causes the project manager to be reliant on the work of construction engineers and technical staff. The issues that could be anticipated are mostly after a problem has already emerged.
The second question was: If there were such incidents, what was their financial impact on those projects, i.e. how much money could have been potentially saved if a project risk management process was in place? Based on the results of the analysis the answer is as follows:
The only issue that could have been easily predicted by the project manager prior to any previous problems emerging was the improper storing. This led to the equipment getting wet and destroyed, which caused additional costs of 30.000 CZK.
Other problems that could have been predicted involved the construction design, which would require the manager to double check the engineer's work and possess corresponding knowledge. These mistakes cost the company almost 10 million CZK in total. Considering the value of these projects, 10 million CZK is a significant amount of money that lowered the generated profit. However, all the projects were still profitable.

The last question has also been answered: Had those incidents an image/goodwill impact on the company in the eyes of the customer in addition to the time/scope/cost impact mentioned before?
Though hard to quantify, it is apparent that the issues mentioned before continue to have negative impact on the company image in the eyes of the customer. These issues are often times minor in the impact, such as missing labels or equipment. Solution is simple and not expensive. In some cases, communication with the customer about changes is insufficient. These might seem as negligible minor problems, but in the long run, damaging company reputation and image in the eyes of the customer might potentially lead to more significant problems. Given the nature of the projects and the industry, every client is important and every project can potentially bring more business to the company. Or in the case of repeated problems – to the competition.

To sum my findings up:

- The assumptions were correct; the company fails to learn from previous mistakes and lessons learned process is not exactly effective.
- There are certain issues that could have been easily predicted.
- The highest financial impact had the problems that stem from design and construction works due to the technical and complex nature of these projects.
- In many cases, the company suffers from bad reputation due to unnecessary, predictable and avoidable problems, often times repeating the same mistakes.

With these questions answered, I present I set of recommendations to help improve the company practice.

7 RECOMMENDATIONS

Given the results of the analysis and following conclusions, I present a set of recommendations for the company to consider. These recommendations focus on improving company's risk management practice in a meaningful way.

The current state of this company must be respected, if any valuable change is to be achieved. The organisational environment in the company is not in favour of big impactful changes. Recommendations such as a complete formal risk management process for all projects might be formally implemented, but only on paper. In practice, the people themselves would not, in the current situation, accept such large-scale changes and norms. This became apparent from both the initial impression of the company and the interviews conducted for the purposes of this thesis and blindly following theory would not bring value to the company. For such reasons, the recommendations that follow are simpler, small-scale guidelines that should serve as a stepping stone to further change and improvements.

1. First recommendation is to introduce a shared closing-meeting practice. At the time of writing this thesis, only the project team for a particular project attends the meeting. This prevents organisation-wide project learning as other project managers are mostly unaware of the projects other people work on, not to mention the mistakes and issues that emerged. This leads to two separate project managers encountering the same issue for the first time (as shown in the analysis part), which is unnecessary and further facilitates potential problems.
   Therefore, the recommendation is to introduce a shared closing-meeting practice, which will allow project managers to learn more effectively and apply gained knowledge in their own projects.

2. Second recommendation is to introduce at least some project risk management process, even if in a very simplified form. From the nature of these projects, fully fleshed out large-scale PRMP would not work in this company's environment. For this reason, my recommendation is to

focus the risk management process aspects on big changes occurring during the project – *change events*. Delays caused by the customer requiring additional storage, design or specification changes etc., these are the situations in which the project team should get together and brainstorm a number of issues that could emerge from this change.

I recommend focusing on two main areas: customer and company Within these three areas, I recommend breaking the possible issues down to categories:

- Political,
- financial impacts,
- people,
- technical aspects,
- legislative aspects,
- and prevention/solution

Though rather simple, this system will make the project team at least consider different aspects of the change from different angles, potentially helping them to prepare and react better. In Table 2, I present an example as to how to break the possible issues down according to what was recommended. The "prevention/solution" part of the table is intended for addressing all the issues from the areas on the left. In this case, a delay was caused by the customer, so examples of the issues to consider are visible in this table. The process scheme for such a system is then presented in Figure 17.

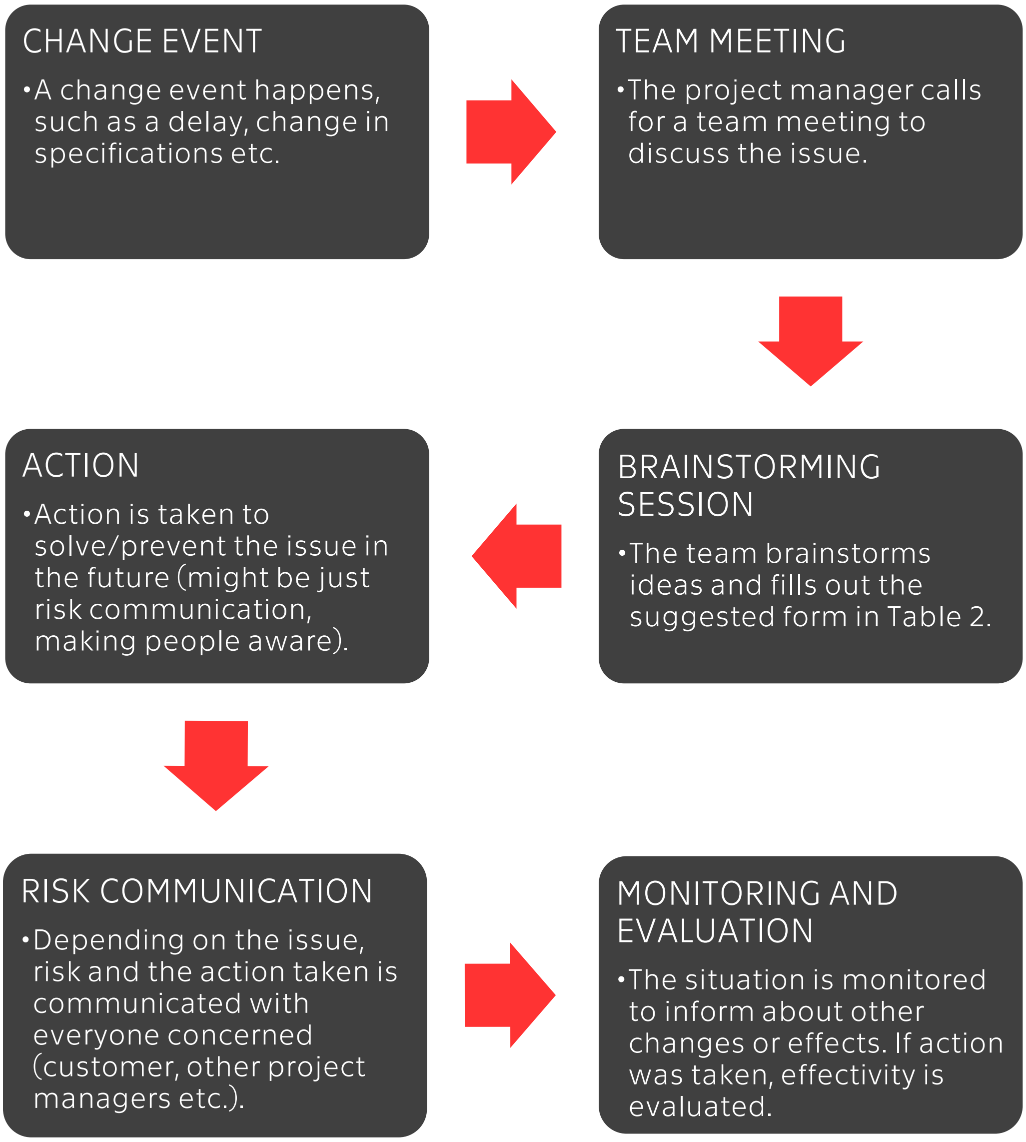
Table 2: An example of possible risk breakdown

		Political	Financial	People	Technical	Legislative	Prevention/ solution
Delay caused by the customer, 6 months	Company	What caused the delay? Can we help?	What costs will it bring?	What capacity/ skills do we need? Who needs to know?	Storing conditions? Later transport conditions?	Any safety norms for storage?	What can we do to prevent any issues during this or help the customer in the future?
	Customer	What does the customer expect from us?	Will it be paid for by the customer?	Do we need to discuss anything with the customer about this issue?	Any technical aspects regarding the customer, site preparation etc?	How about later transport? Can there be any problems?	

Source: author

This is of course not an exhaustive list of issues to consider. The professional expertise of the project team will provide for a useful brainstorming session that might discover some underlying problems or connections to address. Another suggestion is the inclusion of another person outside of the project team to provide an unbiased opinion.

Figure 17: Process scheme for the change event system



Source: author

3. Third recommendation is to introduce a shared, updatable register of sorts for all project managers to have at their disposal when dealing with projects. This register would include the problems that emerged during their projects, their impacts and solutions/possible implications or additional notes. It would have to be left to the project manager's best judgement as to which problems he/she would include in the register for all to see. Including all the problems encountered would mean that the project managers would eventually stop filling the register in and it would seize to fulfil its function. Not including enough might prevent

other managers to learn from the issues not included. The recommendation is to include the information from the closing meetings as part of the whole process.

A part of this system would be the ability to search within the numerous issues that would accumulate over the years. Searching by name, key-words, parts, locations or sorting by impact severity is recommended, however, further discussions are to be had with the IT department to offer the best possible solution. The idea is that if a project manager encounters a difficult or impactful issue, he/she might easily search the register for any possible information that might help and possibly consult with the corresponding project manager of his/her team. Furthermore, this input would be shared among other project managers to be aware that an issue has emerged and that it may concern their project as well. An example of the report form to be filled in is presented in Figure 18.
These reports would be converted into the company's internal system which would then allow the management of the company to further analyse the data. For example, the top management would sort the problems by financial impact and focus on the 20 % of the most pressing issues. Repeating issues would also be possible to identify using this system.

Figure 18: Project issue report suggestion

PROJECT ISSUE REPORT

PROJECT MANAGER NAME

*As a contact person for further consultation

PROJECT

PROBLEM NAME

KEYWORDS

*For example, the name of the equipment, location, conditions, procedure etc.

PROBLEM IMPACT

FINANCIAL

*Financial impact of the issue.

TIME/SCOPE

*Time/scope impact of the issue.

PROBLEM DESCRIPTION

*A brief description of the problem that emerged.

CAUSE & SOLUTION

*What caused the problem and what solution was implemented, how effective it was in solving the problem.

Source: author

4. The fourth recommendation is to focus more on the seemingly small issues, such as labels or missing equipment. Those problems might seem unimportant and acceptable, but damaging the company's reputation is hazardous in the long run. The company operates in an environment where every project counts. Customers are scarce and projects last for a long time. If a bad image is created in the eyes of a customer, it may not only lead to the customer refusing to do further business, but other customers starting to doubt the company's ability to deliver as well. Such issues help create unnecessary bad reputation and should be eradicated. Though a checklist is in place, there are obviously challenges and areas to improve the company practice.
5. The last recommendation is to revisit the contracts and consider putting in the part regarding additional works having to be financially assessed and accepted by the company in the future. If legally feasible, which it should be, this part could potentially save a lot of money in the future or at least prevent any big surprises.

CONCLUSIONS

Risks are a constant part of our world that stems from our inability to know the future. We can extrapolate, we can forecast, but as such, future is largely unknown and uncertain. With the world becoming more and more entangled and interconnected, the future becomes even more unpredictable and risks become greater. The increasing complexity of human endeavours calls for structured, solid ways to manage these risks. This is the topic my diploma thesis focuses on as it sets two goals - to describe the topic and then apply the theoretical knowledge to analyse and help improve the situation in a selected manufacturing company.

The company in question is a manufacturer of industrial equipment, who remains anonymous due to sensitive nature of the provided documentation. The company has undergone a number of changes in recent years, including a shift of focus towards project based manufacturing compared to a more standardised business model it operated on in the past. These changes brought many challenges, among them the need for a more structured risk management system, because of the increasing complexity of undertaken projects. This thesis aims to analyse and help improve the company risk management practice by bringing together theory and practice to provide the most value possible.

Its first part is devoted to describing various terms and topics, such as risk definition and classification, risk management process and project management standards. The theoretical part is then concluded by a section focused on risk perception and various biases in our judgement. In creating this part, I have used a number or different sources, books and articles by authors including but not limited to Chapman, Veber or Kahneman, as well as project management standards, such as PRINCE2 or IPMA.

The practical part then analyses 23 projects of the company from recent years, with project value over €500 000. Through analysis, it confirms three initial assumptions and answers presented research questions.

The initial assumptions are that 1. the company repeats previous mistakes in its projects, 2. it doesn't learn from those mistakes, which is detrimental to its performance and 3. the lessons learned system is in place, however ineffective. All of these, as stated before, were confirmed.

As for the research questions, the conclusions drawn from the analysis are as follows: There were certain issues in the analysed projects, that could have been easily predicted. The two most impactful issues were the cause of more than 85 % of the total financial impact. Those issues stem from design and construction, that the project manager could not have anticipated given his position and competency. In many cases, the company suffers from bad reputation due to unnecessary, predictable and avoidable problems, often times repeating the same mistakes.

In response to the findings of my analysis, I present a set of recommendations that aim to improve the company risk management practice, while simultaneously respecting the company culture and environment. Those recommendations include a shared closing-meeting practice, an updatable risk register with a project report suggestion and a simplified version of a risk management process, that focuses on big change events. This simplification is due to the company environment and serves as a stepping stone to further improvement, to a fully fleshed out risk management process later on. Other recommendations are also presented that focus on some of the less financially impactful issues, that could however potentially damage the company's reputation. These recommendations will be presented to the company and hopefully help improve the company practice regarding project risk management.

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Evidence výpůjček

Prohlášení:
Dávám svolení k půjčování této diplomové práce. Uživatel potvrzuje svým podpisem, že bude tuto práci řádně citovat v seznamu použité literatury.

Jméno a příjmení: Pavel Kilián
V Praze dne: 19. 05. 2017 Podpis:

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