Method for Risk Analysis in regard of different types of projects

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1. Introduction and purpose

For every opportunity there will be risk involved so for projects that opens up opportunities there will naturally be risks. To be able to make the project as predictable as possible you will have to understand the project and the risks through risk analysis so the risks can be prevented. There are different kinds of projects that can be defined in a number of ways and for each project type there are different types of risks. So before you identify the risks you will have to know what type of project you are dealing with. With identified risks there are ways to quantify them so the necessary decisions can be made for the identified risks.

The purpose of this thesis is to find out what kind of risks that are associated with different types of projects and to determine the best different ways to make risk analysis and the different types of project, if there is any difference.

1.2 Research questions

Primary:

- What is the best method for analysing the risks for different types of projects?

Secondary:

- What kind of project exists and how do you define them?
- What kind of different risks are there in different types of projects and how do you define them?
- How do you analyse the risks in the different types of projects?
- What can you use the analysed risks for?

1.3 Methodology

Ontology is about how the word or reality is perceived, and therefore how you see the world where the knowledge is obtained. The objectivist, or realist, sees the world as objective and independent from the observer. It is made of concrete, tangible, and relatively stable structures and it is possible
to find absolute truths about it.

On the other hand we got the subjectivist that sees the world is a product of the mind of the person who observes it. There are no real structures that exist in the world outside individuals, so the research is dependent of the researcher’s opinion of the observed individuals.

The epistemology, that concern what knowledge is and how you obtain it, is closely related with the ontology, where you got two extreme points. The objectivist (or positivist) where the reality can be studied by rational inquiry and the knowledge can be communicated in tangible form. On the other hand the subjectivist, where the reality is socially constructed, the world is relativistic and the knowledge can only be understood by the point of view of the researcher.

This thesis will be made in mostly in an objective approach, since I believe that the reality is objective. It exists independently whether it is experienced or not, but observations will be individually interpreted subjectively to some extent. With that thinking this thesis will be made with the approach called the critical realism.

Critical realism uses retroduction that is about collecting data and knowledge about the subject that can explain the phenomenon in this thesis, to find knowledge about assessment of risk in projects and then a quantitative way explain what differs from types of projects and risks, which in the end should give a complete method for risk assessment in a given project.

### 1.4 Delimitation

The purpose of this thesis is to form a method for assessing projects sole by their risks and so does not include other areas of project management that might be used for assessing projects.

Furthermore, the assessing methods will be a generalised method for the different categorised projects types because of the limited time and space for the thesis. So the major diversity that may exist in the categorised project types will only be taken in minor account.

Some projects are so small, uncomplexed or inexpensive that excessive risk assessment will not make sense, so this method is directed to the big, complex and expensive projects where it is difficult to get the big picture and where you got lots of money invested so you want to have more reassurance.
Risks are in risk management not only the threats that can affect the project, but it also involves the opportunities. This thesis will though only concentrate on the threats.

1.5 Construction of the thesis

The thesis will be built in steps to answer the research questions. First step will provide the basic definitions of project, project types, risk and categorisation of different risks. Next the techniques for risk analysis will be explained along with how they are interacting. That will culminate to a generic model for risk analysis that will be explained along with the difference between the identified types of projects.

Reference for the literature will be in the footnotes with reference to the last name of the author of the literature that is listed first in the reference list, further there will be a reference to the page in the books of the referred literature.
2. Projects definitions

The definition of a project is a temporary endeavour to with purpose of making a unique product, service or result, which mean that the project must have a specific start and ending. A product can be considered to be a component of another item or an item itself. A result indicates an outcome or document (e.g. a research project can have a knowledge outcome).\(^1\) Furthermore a project has to meet some objectives and these objectives are most common illustrated in the project triangle which can be seen in figure 1.

![Figure 1 – The project triangle](image)

As seen on figure 1 the objectives for a project to stay within is:

- Time: the project must be completed on time.
- Budget: the project must be accomplished within the budgeted costs.
- Quality: the project must the completed within the specified quality requirements.

Every project will have these criteria though projects can have a priority in one of the objectives. If it is time-bound the project must be completed on time even if it means that it will have higher costs or the quality will be poorer, e.g. if the project must be done for a certain event. And the same goes

\(^1\) PMBOK p. 5
for cost- and quality-bound projects also. So the three objectives are connected to each other, which is why none of them can be ignored.

Some project managers do also include a fourth dimension, which is the criteria of safety, while others argue that it is already in the three dimensional model, and that safety is so basic that budget, time and quality should be reached within safety.²

Another way to make an overview of a project is with the 5x5 model which is illustrated below in figure 2³

![Figure 2 – 5x5 model](image)

**Project management**: is the central part of this model and is involving the ability to plan and structure a project, and make sure that the project is carried out the best way to give the best final end result.

**Project assignment**: it is the reason for the project. It included a definition of what the end result should be, the project frames (e.g. time, budget and quality) and how it will be carried out.

**Interested parties**: are different groups or organisations that are either working for or against the project. So it is important to make sure you have the right acceptance to carry the project through.

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² Lester p. 2-3
³ Mikkelsen p. 31-34
Surroundings: are the surroundings the project and the end result of the project have to interact with. Such as technology, rules, demand, competition etc.

Resources: is the material, equipment etc and the knowhow to use it. And then it also includes money, the project has to be financed.

2.1 Project life cycles

As stated a project has definite beginning and end the processes in between can vary depending on e.g. the organisation, industry, technology, which will determine how the project life cycles will be shaped. The life cycle often provides the basic framework for managing the project. A project life cycle can be mapped in different ways. The most typical is how the cost and staffing levels will behave through the project, to show for the upper management. But most every element in a project can through time be mapped to define the project. Depending on the projects complexity and need of control it can be beneficial to divide the project into different phases, and the most common phases for a project life cycles are:

- **Concept**: The desire for a product, facility or service develops into a need, and different options for the project are evaluated.
- **Design**: Guidelines for the project are made and its objectives are defined.
- **Implementation**: The processes for making the end result of the project, and this will be the phase of the project that is the longest.
- **Commissioning and hand over**: The end result is inspected and approved, and will be handed over to the customer.

In figure 3 an example can be seen of how risk and cost of change varies through the time of a project.

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4 PMBOK p. 16-17
5 Burke p. 28 - 29
Figure 3 - Project life cycle example of development in risk and cost of change

Figure 3 shows how it typically will be in a project. The closer you get to the end of the project the less risk is associated with it, but at the same time it gets more difficult to make alterations in the project so the cost of change goes up with it.

2.2 Types of projects

As stated earlier a project is defined by having a definite start and end, but a project is not just a project, there are many different types of projects. Every project is different and projects can be categorized in numerous ways and levels, even if a project is repeated some aspect of it will be different. Even though, it is possible to classify projects in four different general types after the nature of the product or service the project deals with.6

The four general project types:

1. Industrial projects
2. Manufacturing projects
3. Management projects
4. Scientific research projects

Industrial projects: has been named so just to give it a common title and because these kinds of

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6 Lock (PM) p. 5-6
projects most often are associated with industrial projects, but not limited to though. It is projects of civil engineering, construction, petrochemical, mining and quarrying. A common characteristic is that the concrete work that makes the product/service is must be performed on a location which is exposed to the elements and which are often not near the head office.

These projects often requires large amounts of capital and the huge projects are often carried out by different specialist or contractors, and perhaps there are a main actor or actors working through a consortium or a joint venture.

Examples of industrial project involve building, construction, mining, quarrying, earth moving and land reclamation.\textsuperscript{7}

**Manufacturing projects:** are projects that results in a production of an item. The product may be custom built for a single customer, but these types of projects can also be the internal research and development of products.

The manufacturing projects are often conducted in a home base where the environments are more controllable, but sometimes it may also involve performing activities on customers ground like installing a produced piece of equipment. More difficult can it be with very complex projects where parts of the final product are produced on several different locations and then collected to be assembled in one place.

Manufacturing projects can involve research and development of a new product, equipment manufacture, ship- and aircraft building, food and drink and pharmaceutical.\textsuperscript{8}

**Management projects:** are projects that involves IT projects and projects that conducts change in the management. These kinds of projects is often internal in the company and are for the own interest of the company. This type of projects does not usually give a visible or tangible product, but if the project is not performed with success it can have big problems and consequences for the performance part of the entire company.

Management projects may be associated or based on industrial or manufacturing projects, since a company can be required to make changes in order to able to carry out another type of projects. Other examples of management projects can be to relocate the headquarter, develop and introduce a new computer system, launch a new marketing campaign, restructure the organisation or prepare a

\textsuperscript{7} Lock (PM) p. 6

\textsuperscript{8} Lock (PM) p. 6
Scientific research project: is a special type of project. These projects is trying to extent the current human knowledge on a matter and by that it has the potential to very profitable but at the same time it may just consume a lot of money over a lot of years without any useable outcome. It is the uncertainty of the outcome that makes this type of projects unique since you can not totally predict the result of the project. The result of the scientific research project can have the potential to give birth to projects from the three other types or on some way improve other projects, all depending on what the scientific research is about and what the result is.  

Besides of the above mentioned four types to categorise projects in there are numerous ways to further sort the projects. E.g. by size, tangible/intangible, complexity etc. and they can all define the project in some way and, among other things, help determine what the risks are and how critical they are. In figure 4 is the NCTP model that can be used to map the project further so you can get a better understanding of the project.  

Figure 4 – NCTP model
**Complexity:** how complex is the product.
- Assembly: Subsystem, performing a single function.
- System: Collection of subsystems, multiple functions.
- Array: Collection of many different systems with a common task.

**Novelty:** how new is the product to the market.
- Devirative: Improvement of an existing product
- Platform: A new generation of an existing product line.
- Breakthrough: A product that has not been seen before.

**Technology:** the extent of new technology used by the project.
- Low-tech: No new technology used.
- Medium-tech: Some new technology
• High-tech: All or almost all new, but still existing technology.
• Super high-tech: The necessary technology does not exist at the beginning of the project.

**Pace:** how urgent the project is and what the available timeframe is.
• Regular: Delays are not critical.
• Fast-competitive: It is important for the business when the product gets to the marked.
• Time-critical: The time of completion is essential for success.
• Blitz: Crisis project, an immediate solution is vital.

For all the above four dimension the rule is that the higher complexity, pace, technology and novelty there is the higher the uncertainty and risk of the project will be.

### 2.2.1 Industrial projects

To understand the industrial projects it will be further defined with use of the NCTP model.

**Complexity:** The complexity will normally not exceed the system level. The most complex industrial project type will probably be the engineering of a large building that has different qualities and that requires different specialists or contractors.

**Novelty:** Since industrial projects mostly are done by craftsmanship, work that has fundamentally been done before, the novelty is relatively low. But of course there can be platform projects in this kind of projects as well again the large, complex building can be put out as an example.

**Technology:** As stated before the industrial projects craft work projects, so the technology for these projects will most often be low-tech since the basic work have been done before with the same kind of equipment.

**Pace:** The pace of an industrial project can vary a lot depending what the project is. For example if a new stadium has to be completed for the opening of the world cup it would be a time critical level. But many of these types of projects will probably be regular pace levelled because the quality often
are more important than the time, and there have to be many safety regulations that needs to be respected and cannot be rushed.

### 2.2.2 Manufacturing projects

**Complexity**: The complexity of these kinds of projects is difficult to generalize, it all depends on the product, but many of the projects, such as ship and aircraft building, are fairly complex, so would be levelled as system.

**Novelty**: Since the manufacturing projects often are customised orders the novelty will be categorised as derivative. The projects that involve research and development of a new product are of course platform or perhaps even breakthrough in its novelty.

**Technology**: Again these types of projects are difficult to categorise their technology usage, but most of the manufacturing projects probably use low- or medium-tech, because the manufactures do create products in their industry speciality.

**Pace**: Customised orders and research and development products need to get out relatively fast if there are competitors, which most branches got, so the pace level will at least be fast/competitive.

### 2.2.3 Management projects

**Complexity**: The complexity of the management projects depends on the level of the change that is being made or the IT implementation/creation that is made. Many of these projects often goes up on the array level of complexity, because an internal management style has many ‘subsystenms’ that will have to work together to make an effective company.

**Novelty**: These kinds of projects are mostly internal therefore it is often an improvement on how things already are done, so the novelty level will mostly be devirative or platform.

**Technology**: If the projects are involving change of the management, then the technology probably
will not be higher than low-tech, since the need for that kind of projects is not technology. But if it is an IT project, then it more like can go up to be using high-tech.

**Pace:** Mostly the pace requirement for these types of projects is regular, because it is done internal and the necessity for it to be done right is greater than for it to be done quickly. But the projects, like the one mentioned before, where you have to prepare a stage show, the pace level will instead be time critical.

### 2.2.4 Scientific research projects

As mentioned before the pure scientific research project is a special case of projects. The only dimension you are certain to map a scientific research project in the NCTP model is in the novelty, where it will be breakthrough, since it is projects that try to expand the human knowledge as it is known.

Since these kinds of projects will always be breakthrough at its novelty there is no tailored way to do it, so the other three dimensions (complexity, technology and pace) can vary through all the levels there are, all depending on what the research is about and who is conducting them.

### 2.3 Project risk

Project risk has its birth in the uncertainty that is in all projects. Project risk is an uncertain occasion or condition that has an effect on at least one of the project objectives if it occurs. Objectives can be defined as the three project objectives in figure 1\(^{12}\) time, budget and quality. Project risks are always in the future, can occur at any stage in the project life cycle and may manifest it selves without warning. It may have more than one reason for occurring and if it does it may have more than one impact on the project.\(^{13}\)

Project risks can be classified, like the classifying of project types, in many different ways, all depending how specific you want the definition to be. It can be categorised by which of the project

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\(^{12}\) Page 9

\(^{13}\) PMBOK p. 276
objections (time, budget and quality) it has an impact on, the reason that there are a risk, if the risk occurs how severe the impact is and etc.

For helping to understand what kinds of risks that can be associated with project, and to help identifying the risk for a certain project the categories of risk are defined as below.\textsuperscript{14}

- **External risks**: risk that is associated outside of the organisation. It involves laws, cultural difference, customers and competitors.
- **Financial risks**: monetary risks. Risk about inflation, costs, income, budget and currency exchange rate.
- **Environmental risks**: concerning risks about the weather, nature disasters and, if the project must be conducted a certain location, the conditions of that location.
- **Organizational risks**: related to the management of the organisation. It involves risk about communication, leadership, the structure of the organisation.
- **Resource risks**: risks concerning the capacity of the company. It involves the employees and their competences, material, equipment and facilities and the quality of it.
- **Operational risks**: risk from the plan and execution of the project. It can be about breakdown of key equipment or change in the work requirement and specification.

All risk, if they occur, will have an effect on the objectives of the project, i.e. time, budget and quality, in some way.

### 2.3.1 Industrial projects risks

The industrial project is fairly easy to plan because it is craftsmanship and fundamentally the same work that is being done in every project, a certain firm is planning and executing. That also means that the risks involved in industrial projects are easier to predict and then plan for than many other projects. But since the project work often are being done with heavy machinery or high above the ground the risk can, if they occur be severe. Those kinds of risks that threaten the safety of the employees will always be most important to plan for avoidance, if you can not guarantee for the safety of the employees, the project should not be initiated.

\textsuperscript{14} Kayis
Other more uncertain risks can be bad weather or even natural disasters, depending on where the project is being performed, material shortage, labour disputes or design errors.\textsuperscript{15}

### 2.3.2 Manufacturing projects risks

The risk in the manufacturing projects may also have large risk for the safety of the employees since they may also require some big machinery. Otherwise the projects with the system or array complexity will have many organisational or operational risks because when many subsystems will have to work together on a project and if there are many, more or less independent, divisions in a organisation that are involved in the project the possibility of error are greater. When doing a research and development project they are initiated because there is an opportunity but where there are opportunities there will also be risk, and when you are exploring relatively new and unknown territory there will often be more risks. Furthermore can the time frame be important in the research and development projects because of the risk that a competitor will develop a similar product.

### 2.3.3 Management project risks

If a there is a project involving management change or implementing a new IT system in a company it can easily affect the entire company and therefore also have a potential effect on every action the company takes. So the type of risks can range from most of the categorised risks mentioned, but the most common will probably be the organisation risk as it is related to the management style of the company.

If it is an internal project, e.g. implementing a new and better IT system, the time may not be the big concern since the organisation already have an IT system they are using, so they can take their time and do it so they may avoid some risks.

IT projects are somewhat especially difficult to stay within the budget. Some records are: 50% overrun their budget, only 18% of software projects are completed within budget and 30% are so

\textsuperscript{15} Lock (PMiC) p. 106
expensive that are abandoned before they are completed.\textsuperscript{16}

\subsection*{2.3.4 Scientific research project risks}

Scientific research projects are the type of projects that has the most uncertainty in it because you do not know exactly what the end result will be. Therefore the number of risk will be more numerous than in other types of projects, and furthermore the risk will be more difficult to predict. These kinds of projects are very difficult to plan and are the kind of projects where the objectives of time, budget and quality is the vaguest.

\footnote{Burke}
3. Project risk management

It has been established that there will be risk in a project that will need attention, and it is done by risk management. There are many ways to confront the risks, but one of the more generally accepted structured risk management model, is the one that is pictured in the figure 5.17

![Figure 5 – Model for risk analysis](image)

**Risk management plan:** It is a formal approach for a systematic process of identifying, analysing and responding to project risks. So the risk management plan will document how you suggest dealing with the risk on your project.

Risk control is a part of the risk management plan. Since the risk and work environment may constantly change it is important that you continually monitor and review the level of risk and the capability to effectively respond to the risk. That makes the risk management plan an ongoing process that can be subdivided as listed below.

1. **Define objectives:** Define the context of the work and the plan for success. This defines what will have to be achieved and establishes a basis for what will have to be done for dealing with the risks. The elements in this part of the plan are basically the context of the 5x5 model in figure 2.18

2. **Identify risk:** Identify areas of risk, uncertainty and constraints that may affect your project

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17 Burke p. 252-269
18 Page 10
and limit or prevent you for achieving your objectives.

3. **Assess risk**: Evaluate the identified risks and prioritise the level risk and uncertainty and then quantify the rate of occurrence and impact.

4. **Develop response**: Define what the responses to the identified and assessed risk are going to be.

### 3.1 Define objectives

As risk may be defined as any event or constraint that can prevent you from the projects goal and objectives, there is a need to define these goals and objectives in details and make and make them transparent as the first step of risk management for later to be able to identify the risks. Most obvious is it to define the end result you are going for, what service or product is it you are providing through the project. Next is to define what will make the project a success, here will be natural to include the objectives, and define what the success rate is when looking on the quality, costs and time. To get a more complete overview of the organisation and project objectives you can subdivide different areas of the project and organisation where you will be able to define more specifically by using different techniques.

#### 3.1.1 Feasibility study

A feasibility study should be made which is an initial to determine whether the project is feasible and making sure the company’s resources are used in the best way. The feasibility study is to be treated as a pre-project and should at least include:\:^{19}

- **Stakeholder analysis**: People and organisations that in some way are involved in the project or can affect the outcome, e.g. customers, project team, legal requirements and subcontractors.
- **Define the client’s needs**: The goal of the project needs to be defined properly, so the product or service is what the customer has requested. It also involves aiding the client

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\(^{19}\) Burke p. 43 - 54
with the viability of the proposal, so that the end result will be satisfactory.

- **Evaluate constraints**: The constraints that may be at the project. E.g. is the product possible to make, does the company have the technology, and does the company have the economic to take on the project?

- **Cost-benefit analysis**: To determine if the project is profitable by weighting the costs and benefits in money terms.

### 3.1.2 Work Breakdown Structure

The work breakdown structure (WBS) is basically a product oriented family tree, from the final product or system at the top level through subsystems, components, hardware, data and services that are used to produce the end product. Therefore the WBS has the advantage of identifying every part used in all the subsystems. The WBS is an important element since it is providing a general framework for the entire planning of the project and thus for the risk management.  

The WBS is typically divided into 5 levels:\n
1. Is the entire project and what the end product will be.
2. Consists of sub-projects, that combined gives the end product
3. Are the tasks that the sub-projects can be broken in to.
4. The tasks can further be broken in to sub-tasks.
5. The sub-tasks are consisting of low-level tasks, which are called work-packages.

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20 Lanford
21 Kerzner p. 591 - 601
In figure 6 is an example of a part of a work breakdown structure. The top three levels are called the managerial levels and are normally customer specified understood in that way that it is constructed after what the customer wants. The top three levels are also useful for e.g. for budgeting and schedule making.

The level 5 work packages are a term that is used to identify discrete tasks that have a definable end result. It describes the work that has to be accomplished, and are used for monitoring and reporting progress of the work. As it is seen in figure 6 the work packages are linked with a part of the functional organisations where it is being carried out, also called a organizational breakdown structure (OBS), which means that the actual management may be performed by line managers which further means that the communication in the organisation needs to function so reporting to manger of the higher level of WBS will be provided. The OBS is a hierarchically organisation illustration made so you can relate the work packages to a part of the organisation. That way it can make a base to define the responsibilities, cost reporting, billing, budget and project control.
3.1.3 Critical Path Method

When it comes to the time objective it is important to schedule all the work, and a tool to help doing that is the critical path method (CPM). The critical path is the longest path of activities planned in a project, and further it calculates what the earliest and latest every activity can start and finish, within the time of the critical path and without the project being delayed. So with the CPM you determine what activities that is critical and which that can be delayed without making the project longer and you find out what the shortest time possible is for the project. Any delay on an activity in the critical path will give a delay on the overall project so you will have to pay extra attention on those activities, but still you cannot just neglect the other activities. It can be paths that run parallel to the critical path that has the potential to be longer due to delays. 22

A technique for CPM is to list all the activities required to complete the project, the time duration it takes to complete each activity and how the activities are dependent of each other. For that purpose is the WBS great for.

A CPM schedule needs to be updated continually according with start and end dates and percentage of process completion, reflecting to delays, order change, etc. 23 That can be helped with be schedule bar chart (or the Gantt chart) where you give each activity a bar on a chart with a timeline on it when it starts and ends, and so you can follow it progress and constantly updating it.

To use the CPM and schedule bar charts prober you need to have some estimated times that you can follow, and the formula below is for that.

\[
T = \frac{(T_p + T_o + T_{ml} \times 4)}{6}
\]

T = The estimated time
T_{ml} = Most likely estimate: The time you would you estimate it would take knowing what you know at the time.
T_o = Optimistic estimate: The time it would take if everything went right.
T_p = Pessimistic estimate: The time it would take if everything went wrong.

22 Wallwork
23 Wallwork
Of course the time estimation can change after you have made risk assessment, to again make it clear that it is a constant process.  

3.1.4 Budget

To be able to control the costs of a project, a budget will need to be made. The first step is to divide the project into cost relevant tasks, which already is the case if a WBS has been made, that is the work packages. The work packages are connected to cost accounts where direct labour, material and other direct costs are compared with the actual work performed for management control purposes. There may be several work packages grouped together for a cost account for cost purposes, e.g. if the same resource is used in different work packages.  

The next step is to calculate the cost for each level on the WBS, where the duration of the task is taken in account, with start and end date, the cost the task will consume and how it is calculated, so there will be an budget estimation all the way up to the total project, that way you can have an overview of the entire project costs in every level, and that is flexible to schedule changes. To do this historical data, cash-flow statement, forecasting and CPM with bar chart schedule can be used.

3.1.5 Quality plan and control

Good quality is defined by the customer and may not be a constant measurement, and mostly quality improvement is a constant process, where you aim to be better. Planning quality for a project is a process of identifying quality requirements and standards for the product and project and document how it will be done.

To plan the good quality you make a cost-benefit analysis, where you compare the cost of the

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24 McGhee p. 145 - 146
25 Kerzner p. 806
26 Arthur
quality to the benefit. There you can look at the cost of quality where you distinguish between cost of conformance, which is money spend during the project to avoid failures, and cost of non-conformance, which is money spend during and after the project because of failures. Other tools for planning good quality could e.g. be benchmarking or control charts (like 6-sigma), but it can be difficult if it is a unique project that does not have some comparable standards. In the end it should give a quality plan that has objective which is implementable, understandable, with defined goals and deadlines. The control also need to be defined, as what needs to be controlled, what the standards for correction is, what measurement methods that is used and make sure that the actual results are compared with the quality standards. In all the quality plan will identify all of the organisations external and internal suppliers, design processes after the what the customer wants of the product, be able to response to customer needs and aspire to reach the goals.28

3.1.6 Communication plan

Communication is important for a project to function. Bad communication can lead to problem as delay on messages, sensitive information leaked to the wrong people or lack of information to those who need it. Effective communication means that the information is given to the right people, at the right time, with the right format and with the right impact.

To help make a communication plan the WBS and OBS can be used to identify the channels and how many that is involved in the project, and define the responsibility of the organisation. Further find out what is needed for the internal communication (e.g. across the organisation) and for the external communication (e.g. media, contractor or the public).29

3.1.7 Procurement Plan

27 PMBOK p. 196 - 198
28 Kerzner p. 1052 - 1054
29 PMBOK p. 243, 252 - 256
There might need to be purchased products or services from outside to complete the project, so there need to be a clear plan to do that. The plan involves selecting a seller, place responsibility of purchasing and making of a contract, that include administrating the obligations and eventual requirement of change.

When selecting a seller a make-or-buy analysis has to be made, to determine whether or not it can be made in the project, if not it further has to be decided if it should/can be purchased in another part of the organisation.

Other things to help make the procurement plan is, cost estimation, budget, requirement plan of the project, project schedule etc.\(^\text{30}\)

### 3.2 Risk identification

The risk identification establishes which risks might affect the project and register what their characteristics are and in what way they might affect the project. The risk identification might be the most important step in the project risk analysis, meant in that way that if the risk is not identified you will not be prepared should it occur. So a risk response can only be planned if the risk is known. That is also the reason for the importance of doing the preliminary work properly, in form of defining the objectives, so it is possible to identify the risks and how and where they will occur in the project. The risk identification is a repeated process since risks may evolve or be discovered through the life cycle of the project. In the next step it is the identified risk that will be used to the risk assessment.

There are a lot of techniques to identify risks, but there is not a recognised best method and none of the techniques are perfect, and an appropriate mix of the techniques will have to be used depending of the project. The risk identification techniques include historical data, brainstorming, workshops, checklists, nominal group technique, Delphi technique, cause-effect-diagrams.\(^\text{31}\)

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\(^\text{30}\) PMBOK p. 315 - 321  
\(^\text{31}\) Mojtahedi
3.2.1 Identification by risk analyst

Risk identification by the risk analyst is where the identification is solely done by the risk analyst, or a small risk analysing team and it is done by what ever information the risk analyst can gather by him selves and those techniques he got.

Experience from other projects where the same risk has occurred or otherwise had been assessed is a great way to identify risks. Especially if the project is similar to the current project then there will be an even better opportunity to manage the risks, through experience of previous successes and mistakes. There is a good opportunity to improve through each project completed. 32

When risks are identified they should be placed in the project risk register which is a document of risks that might occur. The risk register should include a list of defined binary events, which will or will not occur with a disadvantage for the project, and also the affect of the event will have to be documented there. Further it also includes what actions there will be made to prevent the risk from occurring, this will of course happen after the identified risks have been analysed. But if it should be the case that the organisation has made risk registers from previous projects it is a great tool for collecting data for the risk identification of a current and future projects. 33

Another technique, related to the risk register, is the checklists where you structured work through all of your processes to identify any risk that might occur. For this it is especially important that the ground work for defining the objectives has been done thorough. With proper WBS, OBS, budgets etc. this method is effective for risk identification through the entire project. 34

3.2.2 Risk identification by work group

A work group for identifying risks is led by a responsible risk analyst and is aid to identify risks with supplementary tools and techniques.

You can get information from many different people such as the project manager, different

32 Flouris p. 54 - 55
33 Williams
34 Burke
appropriate project team members, risk management team, experts of project risk management, which may or may not be involved in the project, customers or the end users.\textsuperscript{35}

Some of the above mentioned people, such as end users, project team members and customers, can provide their information through structured questionnaires or structured interviews, which can be processed to identify risks.

### 3.2.2.1 Brainstorming

Brainstorming is an effective technique to identify risks, where a select group is getting the freedom of imagination to come up with every likely (or maybe even unlikely) risk they can think of. The ideas will then have to be sorted or review for further development. The identified risk will have to be described with course of impact and the affect on the project, so it later will be able to be documented in the risk register.\textsuperscript{36}

The brainstorming is based on that there will be a synergy effect, where group thinking is more productive than individual thinking, where ideas can be combined or further build by others. The brainstorming is also based on that avoidance of criticism improves the production of ideas, whereas more ideas gives a higher chance of being useful ones and with no criticism people are encouraged to think more out of the box, which may give new discoveries.\textsuperscript{37}

A SWOT analysis is a good way to identify the internal weaknesses and external threats of the organisation that can lead to risks for the project, and may well be combined with a brainstorming group.

### 3.2.2.2 Nominal group technique

The nominal group technique (NGT) could be classified as a kind of brainstorming technique,

\textsuperscript{35} Mojtahedi

\textsuperscript{36} Flouris p. 55

\textsuperscript{37} Chapman, Robert J
where people in an assembled group individually in silence write down what they see as potential risks. After that each person briefly presents in turn their ideas until none in the group has any more ideas. After that each potential risk will be discussed and all the group members rank the risks, which in the end will give an aggregated risk evaluation.

In comparison to brainstorming the NGT is more structured and does not have the risk of be dominated by few individuals and therefore there is an opportunity that the number of ideas, numbers of unique ideas and the quality of ideas is to be better.38

3.2.2.3 Delphi Technique

The Delphi technique is a method for systematic collection and collation of judgement from isolated suitable individuals on a specific topic. It is done through carefully designed questionnaires with sections for summaries and feedback from earlier responses. The Delphi technique is done over at least two rounds where the participants get the chance to revise their opinion, through the answers from the earlier questionnaire. After each round the estimates for the variables are collected and summarised along with reason for the estimation. The rounds continue until the estimates stabilises.39

Before risks can get estimated values, there need to be some risks to value. One way is to conduct an initial risk identification and bring those risks in the questionnaires, or you can through the first round have the participants discover the risk factors themselves, and maybe supplement with own identified risks. After the first round the risk factors are being summarised with description and participants comments for the second round, where the participants will evaluate the risk factors of importance. The next rounds are the rounds to validate the evaluated risks of comments and average ratings from the second round of questionnaires which in the end should give a stable result.40

The advantage of the Delphi technique is that you are able to use external expert in any location and

38 Chapman, Robert J
39 Chapman, Robert J
40 Nakatsu
like NGT no one will dominate the discussion or be bullied. The downside on the other side is the lack of opportunity to clarification on the feedback and there can be conflicting or incompatible ideas from the feedback.

### 3.2.2.4 Brainstorm, NGT and Delphi technique

What to choose of the three group techniques are depending on the organisation structure and the nature of the project. The brainstorming is probably the most used of the three, but does lack the benefits from a more structured method, regarding giving space to every aspect of project. The NGT will be the best structured method, and has the best opportunities for discussion to get every aspect of the risks. If the risk identification and assessment process needs external experts the necessity will be for the Delphi technique.

### 3.2.3 Cause-and-effect diagrams

The cause-and-effect diagram is a good technique to identify the source of the risks which later can be used to determine what and where your response should be conducted. And it is especially good for making an overview for risk which can be triggered by more than one cause.

The technique is done by working backwards from the risk. The first step is to decide the risk that you want to control or otherwise do something about. The second step is to identify the main factors which might make the risk occur. The next step is to identify more detailed from the main factors what could be regarded as the cause for the risk, and if possible continue to the next step to make the cause even more detailed, and go on until the cause is as detailed as possible.

When illustrated it is drawn as a diagram of branches as in the figure 7, where the risk is that a staff member might leave, the main factors could be satisfaction, remuneration, environment or career prospects. The diagram then gets more branches until the causes are detailed satisfactory.\(^\text{41}\)

\(^{41}\) Ishikawa p. 18 - 24
Another way to use the cause-and-effect diagram is to identify the risks and causes for the risks through the entire project process, where you will identify risks and causes according to which process stage it might occur in. That way it gives an understanding of when and where the risk might occur.

A further way to use the cause-and-effect diagram is to determine risk correlation. It can be that different risks might occur at the same time and even produce a synergy effect or one risk might give birth to another risk if it occurred. The cause-and-effect diagram can then clarify what connection there might be between risks.

### 3.2.4 Risk breakdown structure

The risk breakdown structure (RBS) is a hierarchically organized depiction of the identified project risks arranged by category and a way to provide risk data in structured and organised way to help understanding, communication and management. In figure 8 is a small example of RBS where the top level represents the total risk exposed to the project, level 1 divides the risks in to the categorised risk defined in chapter 2.3\(^{42}\), and each descending level represents an increasingly described definition of source of risk to the project.\(^{43}\)

\(^{42}\) Page 19

\(^{43}\) Hillson
3.2.5 Risk register

Risk registers from earlier projects has already been mentioned to be helpful when identifying risks in new projects. When the risks have been recognised it will be documented in the risk register where it is described as detailed as reasonable with what the nature of the risk are and what the event of the risk might be. When the analysis is progressing the risk register will be updated until it is completed with impact: which objectives, time, budget or quality, the risk will affect on occurrence and severity of the impact. Responses: which actions that can be taken to reduce the probability of the risk occurring, which actions that must be taken, should the risk occur and
possibly the degree of risk that can be transferred.

The risk register has two main functions. First it is a collection of knowledge that should give a good overview of the risks. Second it is to initiate the further analysis, assessing and planning through the data from the risk register.\(^44\)

### 3.3 Qualitative and quantitative risk analysis

For filling the information on impact in the risk register the risk will be analysed by qualification and quantification.

Qualitative risk analysis is the process of prioritising the risks by assessing the probability of occurrence and impact.

The quantitative risk analysis is the process of numerically analysing the effect of the identified risks on the projects objectives.\(^45\)

#### 3.3.1 Qualitative risk analysis methods

The risk probability assessment is the investigation on the likelihood that each risk will occur and the risk impact assessment is the investigation of the effect from each risk on the objectives or the safety.

The risk probability of each risk will be assessed by the historical data or otherwise experts on the field and in the same way the risk impact will be assessed by expert on the field through meetings and interviews where explanatory details and justification assumed for the assessment also will be recorded.\(^46\)

The project risks can be divided to recurring risks and non-recurring risks. The recurring risks are risks that recur on regular basis, so there might be statistical data available, e.g. how big the

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\(^{44}\) Williams

\(^{45}\) PMBOK p. 54

\(^{46}\) PMBOK p. 291
probability for bad weather is and how many days will be lost because of the bad weather. With the recurring risks a more objective analysis can be made, where the non-recurring risks will need a more subjective analysis, because there will be no historical data to back it up.\footnote{Burke p. 261}

3.3.1.1 Probability and impact matrix

The priority of the identified risks can be determined by combining the probability of risk and the impact on the risk.

Risk rating = risk probability * risk impact

<table>
<thead>
<tr>
<th>Probability</th>
<th>0.9</th>
<th>0.7</th>
<th>0.5</th>
<th>0.3</th>
<th>0.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0.27</td>
<td>0.21</td>
<td>0.15</td>
<td>0.09</td>
<td>0.03</td>
</tr>
<tr>
<td>Medium</td>
<td>0.45</td>
<td>0.35</td>
<td>0.25</td>
<td>0.15</td>
<td>0.03</td>
</tr>
<tr>
<td>High</td>
<td>0.63</td>
<td>0.49</td>
<td>0.35</td>
<td>0.21</td>
<td>0.07</td>
</tr>
<tr>
<td>Impact</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>0.9</td>
<td></td>
</tr>
</tbody>
</table>

With the risk rating a probability and impact matrix, like the example on table 1, can be made to determine the importance of the rated risks, so the risk will get the ranking of low, medium or high.
importance and priority.
The risk ranking helps when further analysing and responses has to be made, to determine that the high ranked risks requires priority action and aggressive responses, whereas the medium and low ranked risks might be put at a monitoring list. That a risk is ranked as low does not necessarily mean that no action will be made towards it. If the probability for the risk to occur is small but the impact is high (or the other way around) the need for response can be there. For instance if a project is done close to a volcano, there is only a small risk that the volcano will erupt, but if it does the consequences will be severe, so a response plan has to be made ready, if it should occur.48

3.3.2 Quantitative risk analysing method

The quantitative risk analysing is performed on the risks that are prioritised from the qualitative risk analysis and is the process that analyse the numerically effect of the identified risks impact on the overall objectives. The numerically effect could be measured in monetary value, for the effect on the cost objectives, and with time (hours, days, weeks etc.). What is more difficult is to quantify quality, since quality is more relative and subjective. Some risk might also correlate on the impact on the objectives, if the time schedule is exceeded then it might cost more, and if a quality control is not accepted it might take longer and cost more to fix it, etc., so one risk might affect all of the objectives.

3.3.2.1 Quality risk quantification

A quality measurement will have to be agreed upon, and the most naturally is to take the customers product demand as a basis, which again makes it important that you get a detailed description of all of the customer’s demands for the product. In addition the organisation can have its own quality policy, which it is branding it selves on, that needs to be taken in consideration, e.g. some design requirements or that the product has to be co² neutral. The last comparison option for the quality measurement is the historical data from earlier quality measurements done in similar project, or where similar resources had been used.

48 PMBOK p. 291-292
The resources, components used in the project, or the entire end product of the project can be measured on the durability, e.g. how many miles can the tire go before it is worn down, how many tons can the material hold or the top speed of a vehicle. The quality may also be binary, like either there is used child labour or there are not. The risk impact on the quality measurement will be relatively compared to the customers demand, organisational standards and the historical data. The quality is the objective that is most difficult to slack on, because the company needs to provide a product in terms of the contract and further it will put the company in a bad light if it is compromising on it values.

To assess all risks impact on the objective of quality the quantity value needs to be the same for all of the risks, so incompatible values are not used to determine the same objective. So the first step is to determine what the value for measurement should be, it could be monetary where the quality gets a monetary value and the risk impact will do a change in the value should it occur. The quantified value will be more subjectively than the impact on cost and time, but I should still take into consideration that the customer would think the value of the quality is and second what the organisation think the value of the quality is.

Some have defines quality as a ratio based on W. Edward Demings philosophy of quality in the following equation:

\[
\text{Quality} = \frac{\text{Result of work efforts}}{\text{Total costs}}
\]

Based on the ratio above the idea is that when focusing primarily on quality the costs decline and the quality will improve over time, otherwise if the focus is primarily on the costs, the costs tends to rise and the quality declines over time.

Statistics can be used for the quality control, where the output and controllable input of processes are being measured, evaluated, monitored and controlled for the purpose of improving.\(^{49}\) Six sigma is a statistical way of ensure constancy of the quality. The purpose of six sigma is to reduce the

\(^{49}\) Montgomery p. 11
The risks that threaten the safety of an employee should have the most attention and highest priority. Even though there can be done a lot to prevent the accident there will always be a risk of accidents, especially at the industrial projects. The Tye-Pearson’s principle says that accidents can be categorised in fatal/serious injury, minor injury, first aid treatment injury, property damage injury and near misses (non injury/damage incidents), with a respectively distribution of 1, 3, 50, 80 and 400, as it is also illustrated in figure 9.

But as such accident is not fixed the risks that threaten peoples safety should still be identified and quantified for the purpose of reducing them. To quantify the safety risks the risks must have a relative numeric value that represent the seriousness of the occurrences of the risk.

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50 Yang p. 21-22
51 Okabe
3.3.2.3 Estimation, probability and expected value

The impact of a risk can be estimated similar to the way the time estimation was made in chapter 3.1.3, where the impact will range between pessimistic, most likely and optimistic, that will give an expected value for the risk impacts. The estimation can be made from historical data, experience and interviewing experts in the matter and can additionally be integrated in the budget and the scheduling.

With further using the probability of occurrence and the impact estimation a proper distribution, with the relative likelihood of the risk and the value of time or cost, can be applied to each risk and through modelling or simulation measured in time or money an aggregated estimation of the risk impacts can be made. If historical data is available a fitting distribution system is possible, where a distribution that best fits the existing data are made. Otherwise a distribution will subjectively be made after what characterises the risk variables. Risk distributions can be:

- **Normal distribution**: Is a distribution that can describe many natural phenomena and is important because it is the distribution that a Monte Carlo simulation will approximate. The mean is the most likely value, and the distribution is symmetrically around the mean, so the probability of the value being higher is the same as being lower, and the variable has a higher probability of being in the vicinity of the mean than further away.

- **Binomial distribution**: Either the risk occurs or it does not, and if it does it has a fixed impact.

- **Lognormal distribution**: Is a distribution that is positively skewed, that can mean that the probability of the risk impact are smaller the higher the impact might be. The uncertain values can increase without limits but can not fall below zero which is what makes it good for simulating risks.

- **Uniform distribution**: The probability for each outcome between a maximum and minimum of impact are the same, so risk occurrence with different impact has the same

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52 Page 26
53 PMBOK p. 296
54 Mun p.108 - 128
55 Are explained in chapter 3.3.2.4 p. 42
likelihood of happening.

- **Triangular distribution**: Is a distribution where the minimum, maximum and the most likely value to occur is known. It is like the optimistic, pessimistic and most likely value of impact that is used for estimation.

- **Hypergeometric distribution**: Is for risk that might occur more times during performance of a certain event the project. The risk will change the probability of occurring during the performance of the certain event, depending on what the last outcome was. If the risk occurred during the last performed event, then the probability of it occurring in the next will be lower, but not impossible.

- **Poisson distribution**: Describes the number of times the risk occur in a given interval, could be a process or the entire project, the impact must of course be fixed per occurrence, so it can be implemented in the model.

- **Beta distribution**: Is very flexible and often used as distributing risks. It is used to represent the uncertainty in the probability of occurrence of the risk and further used to predict random behaviour. More important it is used as a conjugate distribution for the binary distribution.

- **Extreme value distribution**: Is used to describe the largest value of response over a period of time, e.g. rainfall or earthquake.

### 3.3.2.4 Simulation Modelling

When using an iterative simulation it is often the Monte Carlo technique that is used with a software programme. The simulation is done by a model where the input is the possible risks with an appropriate distribution. The model random generate a value for the risk and aggregate them if more than one risk is included in the model, the simulation is computed many times, so it is a deterministic, and the output is then a distribution of the total cost, time or what measurement is used for quality or safety of the risk(s).

The output distribution can be used to supplement the budget and the schedule durations, so there will be a higher probability of staying within the project objectives. Analysing the output can be done through summary statistics where mean, skewness, standard
deviation etc. are assessed. The simulation can provide a forecast chart with a histogram, with the output illustrated with probability or likelihood of different outcomes, it can be used to make confidence intervals, where you determine the probability is that the project will be to stay within the objectives and what the time schedule or the budgeted cost should be to have a certain likelihood to stay within the objectives.

Another output from the simulation is the sensitivity analysis. The sensitivity analysis shows the relative relationship with of an output of the forecast and the variation of the input of the model. It helps to see which risk has the most impact on the project, by examining the element affect on the objective that is being measured, while the other elements are being held steady. This helps identify the key sources of variations and what the variations might do.\(^{56}\)

The strength of the Monte Carlo method is that all kinds of probability of distribution can be used and that complex systems with some extend of correlations can be modelled. Also there are many types of software to compute Monte Carlo simulations, so it is relatively easy to implement. The weaknesses of the Monte Carlo method is that the output from the simulation is not stronger than the input, so if the data used are poor then will the analysis to be poor. That is why the needs for high data availability is great, so the data can be as complete as possible and that is why there has to be an expert judgement to avoid misleading observations or errors.\(^{57}\)

### 3.4 Risk assessment

The risk assessment is making a decision of what to do with the risk and the project. The decision can be that the current level of risk are so small that no further actions are necessary to make the project work, the decision could be to develop responses to the risks and the last and most extreme decision could be to stop the project because the risks are too great.

If risk responses have been developed, the risks should again be qualified, quantified and assessed, and risks responses should at least be performed once before the final decision, on whether to carry out the project or stop it, are made.

\(^{56}\) Emmet  
\(^{57}\) Smid
3.4.1 Scope Expected Deviation

The scope expected deviation (SED) is an index to measure the deviation caused by the quantified risks on the planned costs, time and quality.\textsuperscript{58} The SED can be done individually on the three objectives or it can be done for the entire project scope:

\[
\text{SED}_{\text{Time}} = 100 \times \frac{T'}{T_0}
\]
\[
\text{SED}_{\text{Quality}} = 100 \times \frac{Q'}{Q_0}
\]
\[
\text{SED}_{\text{Cost}} = 100 \times \frac{C'}{C_0}
\]

\(T_0\) = The project aim on time
\(T'\) = The additional project time from risk
\(Q_0\) = The target quality for the project output
\(Q'\) = The quality deterioration causes by risk (will have to be quantified as a positive value)
\(C_0\) = The approved budgeted cost of the project
\(C'\) = The additional cost from risk

The SED for each of the objectives is basically for seeing how many percent the objective are exceeded by because of the identified risks.

\[
\text{SED}_{\text{Project}} = 100 \times \left( t \times \frac{T'}{T_0} + q \times \frac{Q'}{Q_0} + c \times \frac{C'}{C_0} \right)
\]

Where \(t + q + c = 1\):

\(t\) = The weighted coefficient of the project time
\(q\) = The weighted coefficient of the project quality

\textsuperscript{58} Seyedhoseini
\[ c \] = The weighted coefficient of the project cost

The parameters \( c \), \( q \) and \( t \) are subjectively decided depending on the objectives importance for the project. The guidance for the deciding the coefficients can be done with pairwise comparison, which is done by taking two of the objectives at a time and weighing them against each other to decide which is the most important. So whether the project is time, cost or quality bound it can determine the how the coefficients are weighted.

The SED can be made on the different levels of the WBS, from the entire project down to each work packages, depending on how the organisation structure is and the complexity of the project. The SED provides an index for measurement of deviation, and decision concerning the next step of action for the project, and can be made by comparing the actual SED, by the desired SED that in advance has been made for an accepted deviation.

Further the SED can be used for evaluate the project after it is finished, by seeing how well the objectives have been fulfilled.

### 3.5 Risk response action

The risk response action is the step in the process that concern searching and classifying the responses for each identified source of risk. Identifying a response to a risk may very well be a simple task, but the most easily and logically identifiably responses are not necessarily also the most effective responses against a risk. To get the best response for a risk, examination of several possible responses will have to be made.\(^{59}\) The identification and assessment for responses can be conducted in a similar way as the identification and assessment for risks, where experts and teams will identify possible responses for each risk, possibly through TNG, brainstorming and Delphi technique. The assessment for the responses will be done quantitative where a new SED with responses are made and compared with the previous SED.

Events that have a risk on employee’s safety will always need a respond, because the safety of people will always be the most important, so any respond that can improve the safety should be conducted.

\(^{59}\) Chapman, Chris  p. 113
3.5.1 Types of risk responses

There are 4 general types of responses to the identified risks:\(^\text{60}\):

**Avoid:** Risk avoidance involves changing the project plan so the threat are entirely eliminated, and are the most desirable response to risks, since it means that it will not occur, but when changing the project plan there is the possibility that new risk will appear. The most extreme type of avoidance is to shut down the project.

**Mitigate:** Mitigation implies a reduction of the probability of occurrence and/or the impact a risk event to an accepted level. Adopting less complex processes, change stock system or choosing a more stable supplier are examples of mitigation.

A mitigate response against risk that threatens quality is, as mentioned before, six sigma. The improvement is done by describing the process and then identifying the sources of variation in the process. The next step is reducing the variations and put the process under control, which ensures less failures and thereby better quality. The reducing must be done continually so the quality can keep its required level and improve it selves, also called kaizen.

Further famous mitigation tool are LEAN which runs on the principles of creating the perfect value stream whit the aim of no lead time, no failure, fully used capacity and with a pulled demand. And ISO requirements which are another guaranty for quality standards are followed.

**Transfer:** Transferring risks is done by shifting some or all of the impact and possibly the ownership of the response from the risks to another party. It does not eliminate the risk, it gives another party the responsibility of the risk.

The risk transfer will most of the times involve a payment for the party the risk are transferred to. It could be insurance, guarantees, warranties or performance bonds.

The contract might involve a transferring liability for specific risks, where the risk can be transferred both ways between the client and contractor.\(^\text{61}\) The kinds of contracts that can determine

\(^{60}\) Chapman, Chris \ p. 113 - 123

\(^{61}\) Burke p. 266
the risk can be:

- **Fixed price contract:** The contractor is obligated to complete the project within the agreed time and quality to a fixed price. The client will have to make a detailed scope of work before a company can tender on the project. This type of contract will leave most of the risks at the contractor, though it can be complemented with clauses for risks, e.g. a clause for inflation.

- **Cost plus contract:** Is a flexible type of contract, where the all the direct costs are paid by the client and an additional agreed fee or percentage of the profit are paid to the contractor. This type of contract transfers most of the risks to the client, which might make the client monitoring the contractor’s progress on the project. This contract may be used in the beginning of the project, where there are many risks, and then change to another contract, e.g. to fixed price contract, when the project has progressed and are less risk heavy.

- **Unit rates contract:** All payment will be based on measurement on negotiated unit rates for a specific work completed. This kind of contract is often used when the scope of work is ill defined, and therefore it might be difficult to define the risks as well.

- **Turnkey contract:** The contractor is responsible for the entire project, from design to commissioning, which also includes all the risks. This is the principle of fixed price, but the client input is minimal.

- **Partnership contract:** A joint venture where the client and the contractor share the risks and the benefits on the project. This kind of contract does not remove the risks entirely from the organisation, but it might give it more resources to deal with them.

- **BOT contract:** With a built, operate and transfer contract the contractor operates the product it produced in a period of time, during which time they will charge the client for the use, and then after that period of time they will transfer the operation to the client. This type of contract leaves all of the risks at the contractor, not only for the design and construction, but also for the operation afterwards.

**Acceptance:** It is the response that is mostly adopted if it is not possible to identify any other suitable response, and it means that the project plan will not be changed to deal with the risk. There are two kinds of acceptance, the active and the passive. With passive acceptance there will not be done anything, so the risk will be dealt with when/if they occur. With active acceptance a
contingency reserve will commonly be established including time, money or resources to handle the risk. Another option is changing the project objectives as a proactive response. With this option the problem does of course not go away, and permission may have to be given from the customer, so the contract, if one made, are being fulfilled. On the other hand a change in one objective might influence one of the other objectives, if for example more time for the project is given, the work might not be rushed so the errors will be less, and then the quality might be better and cost might be less.

Other options might be to monitor the risks, to see if the probability and the impact might change, and then make a decision about a response later in the project life cycle. It could also be to keep some options open and delay of choices, where early commitment is limited and to see if some uncertain conditions are fulfilled before a decision are made. Monitoring the risks is a good idea to do, even if responses for them are made or not, because the risk management is a continually process, that will need constant assessment and adjustment to ensure the project.

As mentioned earlier the objectives might correlate, which means that a response on a risk, that have potential to affect more than one objective, might also affect more than one of the objectives. An example could be adopting the Deming philosophy where the improvement of the quality is at focus instead of monitoring and controlling the quality, which will both ensure better quality and will lower the costs.62

The kind of response is different depending on the risk and the nature of the risk. Some type of responses is more suitable for a certain type of risk. In table 2 the most likely response proper for the type of risk are listed.

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62 Walton p. 16 - 20
Table 2 – Responses for different types of risk

<table>
<thead>
<tr>
<th>Type of risk</th>
<th>Type of response</th>
</tr>
</thead>
<tbody>
<tr>
<td>External risk</td>
<td>Acceptance</td>
</tr>
<tr>
<td>Financial risk</td>
<td>Transfer, mitigation</td>
</tr>
<tr>
<td>Environmental risk</td>
<td>Mitigation, acceptance, transfer</td>
</tr>
<tr>
<td>Organisational risk</td>
<td>Avoidance, mitigation</td>
</tr>
<tr>
<td>Resource risk</td>
<td>Avoidance, mitigation</td>
</tr>
<tr>
<td>Operational risk</td>
<td>Avoidance, mitigation, transfer</td>
</tr>
</tbody>
</table>

The external risks are risks that the organisation most likely does not have any influence on, therefore they will not have any option than adapt and accept, and make a contingency reserve to deal with the risks if they should occur.

Financial risks are not able to be avoided, but mitigation and transfer in the form of contracts, insurance and guaranties are possible and good responses for this type of risk.

Environmental risks are again something the organisation can not influence, so it can accept the risks or it can mitigate so the impact of the environment does not influence the project. The possibility of transfer might also be an option, by paying a third party for the handling of a certain environmental risk.

Responses suited for organisational risks should be avoidance or at the very least mitigation. If risks occur on organisational level it can have severe consequences for the entire project or even the entire organisation, which is the reason those risk should be eliminated.

Resource risks can be mitigated by training of employees, purchasing or upgrading of equipment and facilities. Avoidance might also be a possibility for instance if the organisation decides to produce some resources internally, the risk about resource quality and acquisition can be eliminated.

Operational risks can be mitigated through maintenance or purchasing of new equipments, at the same time those risks can also be transferred by having a third party be in charge of the
maintenance or by outsourcing some of the tasks. The risk that threatens the safety should as far as possible be avoided and at the very least mitigated as much as possible.

3.5.2 Decision tree

A decision tree diagram can be a good tool to assess different responses for a risk. It can take the probability for occurring, impact severity and the price for the response.

In figure 10 is an example for a decision tree, to compare three different responses for an earthquake risk. The organisation does not have any influence on whether earthquakes occur or not, so avoidance is no option. The responses are acceptance with no earthquake solution and two mitigation responses, one where the probability of occurring are mitigated and one where the impact are mitigated, respectively earthquake solution 1 and 2. Both the earthquake solutions costs 1,000,000, where no solution does not require any investment, and at the bottom of the decision tree the monetary impact are listed.

To assess the alternative responses in the decision tree an expected monetary value (EMV) analysis can be conducted. EMV calculate the average outcome from future scenarios, where each possible
outcome is being multiplied with the probability of occurring and adding them together. The EVM can be compared and the result can be an addition to decide which response that should be arranged against the risk. The EMV for the response alternatives from figure 10 would be:

No earthquake solution:
\[0.2 \times 0.7 \times (100,000 \times 0.1 + 2,000,000 \times 0.4 + 5,000,000 \times 0.5) = 463,400\]

Earthquake solution 1 EMV:
\[1,000,000 + 0.2 \times 0.3 \times (100,000 \times 0.1 + 2,000,000 \times 0.4 + 5,000,000 \times 0.5) = 1,198,600\]

Earthquake solution 2 EMV:
\[1,000,000 + 0.2 \times 0.7 \times (100,000 \times 0.5 + 2,000,000 \times 0.3 + 5,000,000 \times 0.2) = 1,231,000\]

As the EMV analysis shows the cheapest solution will be no earthquake solution. But a decision might not only be decided by the costs, the decision might also be concerning what gives the highest safety for the employees. If the investment is only a one time investment and also lower the risks at future projects, it will also be a decision variable. Then they might only look at the impact cost from the risk, which in this example will make earthquake solution 1 the best response with EMV at 198,000.

3.6 Monitoring and controlling the risks

As it has been mention many times before the risk management is a constantly ongoing process. Risks might change, both in probability and in impact, and new risks might appear. Already after the responses have been identified the process of risk identification and risk assessment will be repeated, so an updated picture of the project for an overview is constantly available to action assessment.

The monitoring and controlling of risk is the process of implementing the risk response plan, tracking the identified risks, identifying new risks and evaluating the risk management.

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63 PMBOK p. 298
effectiveness.64

Reassessing the risks might result in identifying new risks, the reassessment of the current risks might show that the conditions for the risks might have changed, and the risks that are outdated and no longer are a threat should be closed. Auditing the risks involves documenting the effectiveness of the responses for the identified risks and their root causes.

Variance analysis, can also give an indication of how the project responses are working as a performance measurement. If the project deviates from its objectives it might suggest that a new risk is threatening the project, and a reassessment might be necessary to determine if that is true.

The contingency reserves, which is additional time and money to deal with unpredictable risks and the some identified risks that has an acceptance as response, which might influence the budget and the schedule. A reserve analysis compares the amount of contingency reserve that is left with the remaining identified risks that are left, to determine whether the remaining reserves are adequate.

Monitoring, controlling and reassessment of risks should be done frequently, so it is possible constantly to be in advance of the risks. Status meeting should be kept with the appropriate persons, involved in the project and the risk, where evaluation and decisions of the project, risks and responses will be made.

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64 PMBOK p. 308
4. Generic model

In figure 11 the final generic model for the risk analysis is illustrated. The model consist of 6 modules, project definition, risk identification, risk quantification, risk assessment, risk response action and implementation, monitoring and controlling, which all are parts of the process of risk management, and consist of the theories and tool described until now.

![Figure 11 – Generic model](image)

The model will in the next sections be described through a detailed chronological description of the 6 modules.
4.1 M1: Define project

Module 1 are going to identify the objectives for the project, that is the time, cost and quality and will end up in giving the variables $T_0$, $C_0$, $Q_0$, $t$, $c$, $q$ and the tolerated SED ($SED_t$) that will be used for the risk assessment.

First the project needs to be defined, where project type is determined, NCTP model, feasibility study, WBS, OBS, CPM, budget and the quality plan are conducted, which will help determine the variables.

Table 3 – Techniques used for determining variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_0$</td>
<td>CPM, Feasibility study, WBS, OBS</td>
</tr>
<tr>
<td>$C_0$</td>
<td>Budget, Feasibility study, WBS, OBS</td>
</tr>
<tr>
<td>$Q_0$</td>
<td>Quality plan, Feasibility study, Procurement plan, WBS, OBS</td>
</tr>
<tr>
<td>$t$, $c$ and $q$</td>
<td>NCTP, feasibility study</td>
</tr>
<tr>
<td>$SED_t$</td>
<td>$T_0$, $C_0$, $Q_0$, $t$, $c$, $q$, Feasibility study</td>
</tr>
</tbody>
</table>

$T_0$ is the time for when the project will be finished on time. To determine the variable the customer’s needs and deadline is the first thing to take in to consideration, which can be found in the feasibility study, and the CPM, that contains the longest way for the product to finish, will be useful. Further there is the WBS and OBS, which can give the time specification for different levels and work packages.

$C_0$ are the approved budgeted costs for the project, so basically it can be taken from the budget, with added information from the feasibility study. Though like $T_0$, the WBS and OBS can provide additionally help in cost accounting on different levels of the project and work packages.

$Q_0$, that is the targeted quality for the output, can be determined with the help of the quality plan, the feasibility study and in some extend the procurement plan, so the quality form the organisation and the suppliers, and the quality demand from the customer are taken in to account. The WBS and OBS can help determine where in the organisation the quality is made.
To determine the variables $t$, $c$ and $q$ is done by pairwise comparison of $T_0$, $C_0$ and $Q_0$ with the help of the NCTP model and the feasibility study to complement the process, so the weighted variables is coherent with the project and the objectives.

The SED$_t$ must be determined by assessing all of the above variables found against the feasibility study to find out what the highest tolerated SED depending on the organisations resources, capacity and the customers demand. This process might best be done through each work packages where the tolerated limits for the objectives will be determined and in the end the aggregated tolerance will be decided.

The defined objectives will be documented in the risk register, for documentation and further use in the future.

4.2 M2 Risk identification

The second module will be identifying the events, that might occur, and their roots that will threaten the project. The risk identification can be conducted by a risk analyst, an assembled group and/or experts. If groups are used, the techniques for the process can be brainstorming, NGT or the Delphi technique. The primary techniques for identifying the risk are the historical data/experience, where earlier risk registers can be useful, RBS, and cause-and-effect diagrams. And secondary tools for identifying can be OBS, WBS, CPM, budget, communication plan, quality plan, feasibility study, procurement plan and possibly other.

The output from this module will be a number of risks, $R_i$ ($i = 1, 2, 3, 4, \ldots, I$), and the knowledge of what might cause the risk to occur and which objective(s) they might have a impact on. When the risks are identified they will have to be documented in the risk register.
4.3 M3 Quantify the risk

Module number 3 will quantify the risks that were identified in module 2, and give an output of the variables of T', C' and Q', which are the additional costs and time and decrease of quality made by the impacts of risks.

The first step is to qualify the risks by multiplying the probability with the impact in a probability and impact matrix, which will lead to ranking of the risks.

The next step is to give all the risks a distribution and a numerical value for the impact in monetary value, time or a kind of quality measurement. The quality measurement will have to be a positive value even though it explains a decrease of the quality.

The distribution will have to be made explicit for the risk. The risk distributions will be computed through a simulator for all of the objectives to determine T', C' and Q'. Every risk impact will be simulated in accordance to which of the objectives it will influence. One risk might also have an impact one more than one of the objectives.

When the C', T' and Q' are identified they will have to be documented in the risk register.

4.4 M4 Risk assessment

The fourth module is for assessing the risks, and it will determine which module the next should be in the process.

First of with the variables found in module 1 and 2 the SED will be calculated:

\[
SED = 100 \times \left( t \times \frac{T'}{T_0} + q \times \frac{Q'}{Q_0} + c \times \frac{C'}{C_0} \right)
\]

The calculated SED will then be compared with the SEDt which will determine the next step. If the SED > SEDt there need to be taken action against the risks, and the next step should be module 5, where risk responses are developed. If the SED \(<=\) SEDt then the next step should be module 6, where the risks will be monitored and controlled. However if it is the first time in the process this
module has been conducted, the next step should still be module 5, since it always will worth to investigate ways to do things better.
All these information will have to be documented in the risk register.

4.5 M5 Risk response action

Module 5 is the process of finding responses for the events that threatens the objectives, assess and decide which response will be the best one. A response will have to be made for each identified risk (Rᵢ), even if it is the response of acceptance. The responses can result in a change of any of the variables T₀, C₀, Q₀, T’, C’, Q’, t, c and q or a change in the SEDₙ. 
If more possible responses are identified for the risk the responds needs to be assessed and compared through scenario making and decision trees, where cost, impact and probability will be taken in to account for deciding on a response(s), since more than more precaution might be necessary or give a better result. 
When all risk got the responses they need they will be documented in the risk register and then continue to the next module.

4.6 M6 Implement, monitor and control

Module 6 has many functions. First of it will implement the responses, that should reduce the risks, that where agreed upon. But before it implementation actually are conducted the impact of the responses will have to be analysed for determining if they where the right responses and if the responses are enough, so basically it means that the 4. module of the model will have to be conducted again. 
If one or more of the variables T₀, C₀, Q₀, t, c or q have been changed due to a risk response module 1 should be conducted again so the project and the objectives will be defined properly, and to get an idea if the changes actually are possible. 
When changes are made through risk responses it might give birth to new risks or it means that some risks will be eliminated, which further means the identified risk no longer are sufficient, so a repeat of the module 2 will give an updated list of risks (Rᵢ).
When new risks have been found and when the old risks has new probability and/or impact, or completely eliminated, new quantification in module 3 will have to be conducted. That will lead to a new SED which again will lead to module 4 the risk assessment and further to module 5 identification of risk response action.
The repeating of the model will be conducted until no new risks can be identified and no new responses can be developed or improved, and all changes must be documented in the risk register. After that the responses will be implanted.

The other function the sixth module has is the monitoring and controlling of the risk. This module will be based on the information documented in the risk register. The monitoring and controlling will be about whether the implemented responses are working, the identified risks evolve or change or if there is any change in the assumptions, which might influence the objectives or the risks, or even create new risks.
That makes the model a continually process, which will be conducted again and again through the entire project. Some decided meeting for discussing the risks should be pre-selected in the project life cycle, so there will be a continually structured assessment update for the project and the risks in the project. The model must also be revisited for a new assessment if the conditions for the objectives and the risks are discovered to have changed.
Even when the project are done the process of risk management are not finished. The project and the risks involved in it will have to be evaluated and documented in the risk register. In that way experience from this project will be useful in the next project.

4.7 Discussion of the model

The model is for very general use, but that is because all projects are unique, thus it is actually impossible to make a generic model that will fit every project. So each project needs to have a tailor-made method for dealing with risks, but the generic model gives a good basis that can be used in each of the type of project. Further discussion for what are important for each type of project risks will be in the following chapters.

The need for project risk management is there, but still there a lack of proper project risk
management in many projects. The factors for not committing enough resources and money into implementing project risk management are:

- **Cost effectiveness**: Project risk management takes up resources and the project are on a budget, so the organisation have appraised and decided that the money are to be used on another way.
- **Trouble seeing the benefits**: The organisation might see the point in project risk management. Sometimes it may also the case that a project will not benefit from it but most often they will.
- **Lack of expertise or familiarity in the techniques**: If there is no one that know the techniques for project risk management or does not know enough of it, the analysis will just be insufficient and be a waste of money.
- **Lack of time**: It where assessed that there simply where not enough time to do a risk analysis.
- **Human/organisational resistance**: The organisation or a significant person(s) in the organisation does not think a risk analysis is worth it, perhaps for the reason listed above, and are resisting it.

### 4.8 Industrial projects

The industrial projects are based on craftsmanship and therefore the work made does not differ much from project to project. That means that the risk involving the actual work on the product will be mostly generic risks, that will have generic responses for handling the risks also, in the form of employee training, equipment and procedures, which have been developed through experience and research.

But even so the industrial projects still often exceeds the deadline or the budget, the most common risks for delays are:

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65 Lyon
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• **External risks**: Factors involving the client, including finance, payment for completed work and change and disputes in the demand and the contract. It might also be change in regulations.

• **Organisational risks**: Owner interference and slow decision making and unrealistic contract duration imposed by the owner. Miscommunication and disputes between all the involving parties in the project. Consultant factors that includes long waiting times.

• **Environmental risks**: Factors involving weather conditions, site conditions and problems with neighbours.

• **Resource risks**: Material factors that includes the quality and shortage.

With the above risks as the ones most attention should be paid to, not meaning other factors should be neglected. In accordance to the generic model it means that the project definition should be detailed with communication plan, OBS, WBS, procurement plan and feasibility study, with focus on owner and customer involvement. That way module 1 in the generic model will get a higher chance of getting a complete analysis of the project’s objective. Further it will provide better risk identification in module 2, and along with the knowledge of which risk is most common, that module can be conducted satisfactory.

For responses for the most likely risks will still be created in module 5. To deal with those risks the responses could include contracting, where clauses for limiting liquidated damage are included and offering incentives for early completion. Further it should limit the customer’s interference after the contract has been signed. Also secure resource quality and deliverance from the supplier through contracting and supplier research. Further response could be managerial improvement, with training in human resources, information systems, scheduling and communication.

For re-evaluating the risks in systematic ways, it should be done after completion of preselected work packages, which marks some kind of milestone in the project, and then would be a natural time for evaluation.
4.9 Manufacturing projects

The manufacturing projects are more flexible than the industrial projects, since it is custom made products, even though the company still got its base in an industry, which gives it a certain degree of the standard of processes. That means that the organisation can benefit from standardising the processes in order to reduce the operational risks, which will reduce the risks of poor quality, higher costs and overdue of the time schedule. For reducing waste and improving quality there are tools like six sigma, LEAN and TQM.

If the end product are being assembled by components or subsystems, that are produced on different locations, that can be one of the biggest challenges in a project. It could either be that the organisation got different factories for producing different parts of the product, or it could be that the project are a joint venture, both scenarios gives the risks of miscommunication, bad logistics, incompatible lead times and possibly poor leadership. To deal with that it requires good WBS, OBS, CPM and communication plan, so those organisational and operational risks can be identified and responses can be made against them.

In the case of a research and development project, the phases of concept and design in the project life cycles will be longer, since it mostly will not be a single customer demand and the specific product requirement that will be given. So the research involves acquiring the marked demand, and designing a product from what the marked wants, which then requires more attention identifying risks and response to risks in those phases. Research and development projects means that the organisation goes in to a relatively new area so there will be a degree of uncertainty and further it is influenced by the development of the industry and the economics and the competition, and the further risk in the research and development projects could be:

- External risk: Intellectual rights, licenses, approvals, patenting.
- Resource risks: Technology, qualified employees (expertise and innovation skills).
- Financial risks: Can a profit be made on the new product.

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67 Yong-zhong
For standardised measurement of manufacturing maturity and risk for a given technological solution, manufacturing readiness level (MRL) can be applied. Manufacturing readiness is the capability of manufacturing, production and quality assurance that satisfies the projects needs on time.\textsuperscript{68} There are ten manufacturing readiness levels:

1. Manufacturing feasibility assessed: The lowest level of manufacturing readiness. Basic manufacturing principles are being defined and observed.
2. Manufacturing concepts defined.
3. Manufacturing concepts developed
4. Capability to produce the technology in a laboratory environment.
5. Capability to produce prototype components in a production relevant environment
6. Capability to produce a prototype system or subsystem in a production relevant environment
7. Capability to produce systems, subsystems or components in a production representative environment
8. Pilot line capability demonstrated; Ready to begin Low Rate Initial Production
9. Low rate production demonstrated; Capability in place to begin Full Rate Production
10. Full Rate Production demonstrated and lean production practices in place: The highest level of maturity. The production is a full rate and meets all the engineering, quality, reliability, performance, procedures, tests and units costs requirements.

The MRL is to ensure the continually maturity and readiness of manufacturing through the subjects of technology, design, material, costs, quality, personnel, facilities and management and it should be appropriate with the phase of the project life cycle. Since the MRL is a measurement of the maturity and readiness, and then also the shortcomings of the manufacturing, it can help with identifying the risks and along with a plan of maturity it can help controlling the risks.\textsuperscript{69}

\textsuperscript{68} MRA Deskbook p. 10 - 14
\textsuperscript{69} MRA Deskbook p. 16 - 18
4.10 Management projects

The projects that in some way conduct a change in the organisations structure, management or processes are often an internal project with possible aid from external consultants. The end-product from the projects are basically intangible and the goal is not clearly defined, which means that measuring the quality can be more difficult, since there are no physical attributes to assess, on the other hand there also might not be any risks on the safety.

The management change projects do not just end after the changes have been implemented. The project does also involve data collection about the changes, corrective action for what does not work about the changes and then implement the changes. When collecting data for assessing the changes made, the risk of people’s unwillingness for change should be taken into account, the changes needs to have time to be implemented proper and so the employees can get used to them, which must include in the time objective.

When the project are a internal project, and the organisation by that are its own employer, there is the risks that exceeding the objectives of cost and time are being considered lesser concerns, which it should not be. The quality measurement can be made of improved effectiveness of processes from the change, improved product quality from the change, better safety or perhaps something as fuzzy as employee satisfaction.

The IT projects are projects that got lowest success rate, and many have tried to define the reasons for lack of success in IT projects. Organisational risks are the kind that often hinders the IT projects, with such as the lack of support, user involvement and commitment from the managers. Other significant reasons are the objectives and goal of the project are unrealistic or ill defined that leads to misunderstandings. In resource risk there are the insufficient/inappropriate staffing and/or project manager and that the technology is not sufficient for the project.70

To conduct management projects the need for knowing the state of the organisation is great, which

70 Al-Ahmad
means that complete WBS and OBS of the organisation, as it currently is, are important, and
depending on the nature of the project and the change that is to be made, the communication plan,
procurement plan and quality plan, of the organisation’s processes and production, are important to.
With the defined current state of the organisation and the projects goals and objectives, the risk
identification of the project will be better.

4.11 Scientific projects

As the special cases the scientific projects are the generic model might not fit. The reason for that is
the objectives for the scientific projects are difficult to define, and that the model are build on
defined objectives and the SED. Especially the quality objective are difficult to define because of
the uncertainty of the outcome, so the same amount of uncertainty will be around the quality of the
outcome. Also the time and cost objectives are difficult to define because of the uncertain outcome,
which may mean that the time schedule and budget have to be more flexible. Instead regular
management reviews and reassessment of the value of the project must be made, to determine how
the funding and time limits further should be.\footnote{Lock (PM) p. 7}

The risks identification and risk assessment method can be the same as the other types of projects,
but the objectives, course and conditions of the project might change through the project life cycle,
which might make new risks occur and change the probability and/or impact for already identified
risks. That makes the need for often reassessment of the project risks for preventive response
opportunities.
5. Conclusion

The present thesis has processed the topic project risk analysis with attention on risk identification and risk assessment in regard with different types of projects. This conclusion will summaries and explain what have been discovered in the thesis. The underlying theory in the thesis is based on existing theory about risk identification, risk quantification, risk assessment, project types and risk types for showing the overall idea of risk analysis and the applied level of framework.

Regarding the risk type there are two ways to distinctive risks. The first way is by its nature that is used to define the risk and where it might occur, and are used for understanding and assessing the project. Defining the risk by nature gives six different categories to explain risks, the six categories of risk are external, financial, environmental, organisational, resource and operational. The second way to define risk is by the impact on the project, which is safety or one of the objectives that are time, cost and quality. It is used for quantifying the risks and thus for assessing the project and the risk.

Figure 12 – Interaction between risks and the objectives

The project types are being categorised also by the nature of the work and by the product or service it is providing. That ends up in four general types of projects that is industrial, manufacturing, management and scientific research projects. Each of the project types has its own characteristics and certain risks that are most likely to have an influence on the objectives. In table 4 is an overview of the different types of projects with their characteristics and the risks that has the most likely influence on the project.
Table 4 – Projects characteristics and common risks

<table>
<thead>
<tr>
<th>Project</th>
<th>Characteristics</th>
<th>Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>• Large amount of capital</td>
<td>• Problem with client</td>
</tr>
<tr>
<td></td>
<td>• More contractors</td>
<td>• Owner interference</td>
</tr>
<tr>
<td></td>
<td>• Craftsmanship</td>
<td>• Weather and location conditions</td>
</tr>
<tr>
<td></td>
<td>• Fixed location</td>
<td>• Material and resource quality and shortage</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>• Assembled on home base</td>
<td>• Product rights/patents</td>
</tr>
<tr>
<td></td>
<td>• Customer specified</td>
<td>• Employee qualifications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Technology and process maturity</td>
</tr>
<tr>
<td>Management</td>
<td>• Often internal</td>
<td>• Lack of support</td>
</tr>
<tr>
<td></td>
<td>• Intangible product</td>
<td>• Lack of user involvement</td>
</tr>
<tr>
<td></td>
<td>• High failure rate</td>
<td>• Management commitment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ill defined objectives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Insufficient staffing and technology</td>
</tr>
<tr>
<td>Scientific</td>
<td>• Unclear goals</td>
<td>• Unclear objectives</td>
</tr>
<tr>
<td></td>
<td>• Intangible product</td>
<td>• Unclear project life cycle</td>
</tr>
<tr>
<td></td>
<td>• Expansion of human knowledge</td>
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</table>

Regarding the identification of risks, in order to be able to conduct proper risk identification the groundwork needs to be done first. That be the defining the organisation, work structure, procedures, processes and the surroundings. With the project defined it is a help for the risk identification techniques for determining the where, what and when of the risks.

For assessing the risks the impact on the objectives needs to be measurable, which is the necessity for quantification. The quantification is done through simulation modelling of the risks impact on the project with a numerical value for each of the objectives. The simulated risk quantification is
assessed relatively by the objectives that have been set through the SED and a tolerated excess of
the objectives that are described as SEDt. Though risks that have an impact on the safety are being
assess separately, where a tolerated level of slack are not acceptable, the safety needs a responsibly
level.

In all it can be combined to the basic generic model that have been described in this thesis. The
model can be used for a basis for risk analysis for all the project types. But since no project are
identical, with potentially many different kinds of sub-project types within the four categories of
project types it is possible that some projects will need to have more individual methods for risk
analysis.
6. References

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