Development of a Model for Risk Assessment of Projects at SKF

A Benchmarking Study of Portfolio Management

Johan Olsson

DISSERTATION

International Project Management
CHALMERS UNIVERSITY OF TECHNOLOGY
NORTHUMBRIA UNIVERSITY
Göteborg, Sweden 2006

Dissertation for the joint degree

MSc in International Project Management
Teknologie magisterexamen i International Project Management

Development of a Model for Risk Assessment of Projects at SKF
A Benchmarking Study of Portfolio Management

Johan Olsson

International Project Management
CHALMERS UNIVERSITY OF TECHNOLOGY
NORTHUMBRIA UNIVERSITY
Göteborg, Sweden 2006

Abstract

Abstract. The concept of risk and uncertainty is a hot topic in today's industries and risk management methodologies are constantly being developed and improved. As product development work more and more is conducted in project form, the need for project portfolio management processes has emerged in many companies. Selecting projects for a portfolio of industrial product development projects involves evaluation of project ideas and business cases, a decision in which risk assessment is crucial. This benchmarking study presents the area of risk assessment as to outline the fundaments of what to assess and what approaches to take. Further, various uses of tools and methods for project risk assessment found through benchmarking are presented, complemented by suggestions from literature and research. Further, an analysis of the current processes at SKF is presented and suggestions of improvements made. The benchmarking showed that SKF already mainly used proper tools; however some improvements could be made. Overall, the study showed that it is important to establish a common view on risk. Literature showed that risk assessment consists of three phases: identification, analysis and evaluation, where the first two are conducted on project level and the last by portfolio management. Identification aims to list a wide coverage of all possible risks. Analysis aims to estimate risk exposure, plan responses and prioritise the risk list. Evaluation is the incorporation of the presented material in the project selection decision. Depending on the nature of the projects, the level of response planning possible is different and portfolios may consequently approach risk evaluation differently.

Keywords. Risk assessment, risk identification, risk analysis, risk evaluation, risk response, portfolio management, project management.

Table of contents

Figures

Appendices

1 Introduction

This chapter presents the problem that has given rise to this research. The background of the problem is initially described and the purpose of the study stated. Delimitations for the study are further made. Finally, a disposition of this thesis is presented.

1.1 Background

SKF was established in 1907 by Sven Wingquist. Today, the SKF Group is the leading global supplier of products, customer solutions and services in the business of rolling bearings and seals. The main competences include technical support, maintenance services, condition monitoring and training. The SKF business is organised into three divisions: industrial, automotive, and service. The divisions each serve a global market within their respective customer segment. SKF has about 100 manufacturing sites globally distributed and its own sales companies in about 70 countries. In 2004, SKF had 39,867 employees and had a turnover 44,826 MSEK (*About SKF*, 2005).

The product development work at SKF is mainly organised in project form. There are different types of product development at SKF, for example *customer order*, *new market offer (NMO)* and *technology & competence development*. There are many similarities, but also some differences between the types, which will be further explored in this study.

In order to achieve efficient project work, the Group Project Model (GPM) was developed at SKF. This model is a framework for how all project work is to be conducted. The model includes guidelines and templates for project planning and evaluation and also guidelines for team leadership and efficient teamwork. Responsible for the SKF project model is the GPM Support Office, Dag Mannheimer, who was also supervising this thesis. During the last few years, SKF has started to implement a portfolio view on product development projects. This has brought along a formal grouping of projects into portfolios and the assignment of a portfolio manager for each portfolio. As ideas arise for creating a new project, the decision must be made which project ideas to accept and which to reject, sometimes referred to as the go/kill decision (e.g. Cooper, 2001; Cooper, Edgett & Kleinschmidt, 2001), a term that will be used in this study. This is a fundamental decision in portfolio management; the selected projects add to the portfolio and must therefore match all requirements. Alongside the project model, various frameworks for portfolio management are being developed. At this point there is no common framework but several different, developed by the responsible for the different portfolios based on their perspective and to suit their specific needs.

1.2 Problem discussion

New project ideas are evaluated on several different criteria in the selection process. There is always a certain level of risk of not reaching the set goals or objectives. A thorough assessment of risks is an important task in the new project selection process.

There is currently no common process for risk assessment at SKF; risk assessment is conducted differently in different portfolios. Also, the processes are largely dependent on feeling and there is an interest within the organisation to find out how the risk assessment process can be improved in order to incorporate risk better in selection decisions. Risk assessment deals with forecasts and possible outcomes at an early stage in the project, often when little knowledge is available. The lack of concrete "failure proof methods" has created an interest among a number of portfolio managers at SKF of how other companies assess risks; the interesting question is: "are there better methods than those currently used at SKF?"

1.3 Purpose

The main purpose of this thesis is to provide a foundation for a continued development or improvement of SKF's risk assessment process in project portfolio management, based on theoretical and empirical research. The empirical work is based on benchmarked organisations.

The main research question is formulated as "how can portfolio management at SKF improve risk assessment of projects in the portfolio management process". In order to narrow down on the purpose, the problem is broken down into three sub-questions:

1. *How are the current risk assessment processes at SKF designed?* What are their roles in the project selection process? The specific aim is to give a description of the present project selection process.

2. *Which methods and tools for project risk assessment exist?* Which are the alternative methods and which are used by others for risk assessment of projects from a portfolio management and project selection perspective? The specific aim is to present a summary of common tools and methods.
3. *How can the current risk assessment processes be improved?* What is best practise of risk assessment of projects from a portfolio management perspective? How is this best introduced into the current portfolio management process? The specific aim is to evaluate the presented tools and methods, discuss possible processes and tools and finally suggest improvements.

Another outcome of this paper will be a documentation of the study in a different format. This aims to be a useful basis for further development and will present the results as explanations of definitions, guidelines for risk assessment and suggestions for improvements including further developed reasoning. This documentation will not be enclosed in this study.

1.4 Delimitations

This study focuses on SKF. Companies with similar structure and product development may utilize some of the material; however the results may not generally be applicable to other companies.

The study is performed from a portfolio management perspective and will thus focus on this application of risk assessment. Further, focus is on product development projects and there is no guarantee that the results are applicable to other types of projects.

Portfolio management is an area under development at SKF and today's processes may be changed in a near future. Further, implementation of improvements requires rather extensive testing and evaluation. As a result of these two factors, the suggested improvements will not be completely specified but function more as a basis for further development. As explained in a *risk management standard* developed by the UK risk management organisations the Association of Insurance and Risk Managers (AIRMIC), the National Forum for Risk Management in the Public Sector (ALARM) and the Institute of Risk Management (IRM), it is very important to establish a common terminology, process, organizational structure and objective for risk management (AIRMIC, ALARM & IRM, 2002).

Risk and opportunity are strongly related; as there is risk management, there is also opportunity management. However, the focus of this study is on risk, however many of the principles may be utilized for opportunities as well.

2 Theoretical frame of reference

This chapter presents the theoretical frame of reference for the research. Main concepts are initially presented in order to clarify the area of study. The concept of risk assessment is then defined, explained and broken down into three phases. Finally, methods and tools for each of the three phases are presented.

2.1 Main concepts

Some fundamental definitions are presented that create the cornerstones of this research. These concepts are underlying the following theories and empirical research and must thus be clarified.

2.1.1 Project

In order to put all projects in one perspective, a common definition is needed. Project Management Institute (PMI) defines a "project" as "a temporary endeavour undertaken to create a unique product, service or result" (PMBOK, 2004, p. 5). More detailed, some literature defines a project as a sequence of unique, complex and connected activities having one goal or purpose and that must be completed within a specified, limited time, within budget, and according to certain resource specifications (e.g. Archibald, 1992; Charvat, 2003; Wysocki & McGary, 2003). The latter more specified definition will be used in this study.

By the above definition of a project, all projects have a goal that is meant to be achieved. A distinction is often useful between the goal reached within the project and the goal reached as a result of the accomplished project. The project goal can be defined as the results that the project is meant to achieve (Wenell, 2005b). Examples of project goals are deliverables, functionality, documentation and maximum production cost (Wenell, 2005b), or a product, a capability to perform a service or an outcome and documentation (PMBOK, 2004). The term "end effects" is defined by Wenell Management AB (Wenell, 2005b) as describing why a specific project should be run. It is the responsibility of the project orderer but the project leader and the project team must be aware of it. Common end effects are business goals such as market share and sales volumes, customer benefits such as access to information and satisfied need or society benefits such as reduced environmental harm and health figures (Wenell, 2005b). This distinction is visualised as in Figure 2.1.

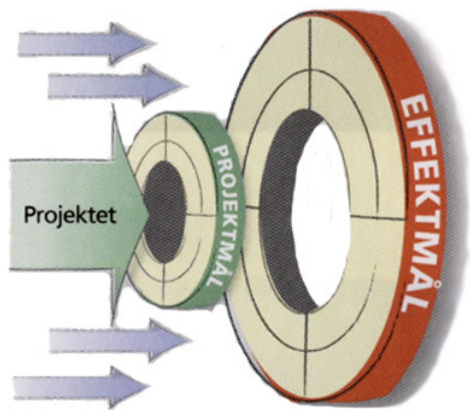


Figure 2.1. Project goals and end effects (Wenell, 2005b, p. 36).

2.1.2 Project portfolio

The term *portfolio* has long been used within financial investments of different kinds. Organisations that run projects invest similarly and must thus have a plan for their projects and consider them as a portfolio of investments (e.g. Cooper, Edgett & Kleinschmidt, 2001; Wysocki & McGary, 2003).

A simple definition of the term *project portfolio* is made by Wysocki and McGary (2003, p. 353): "a portfolio is a collection of projects that share the same common link to one another". A more detailed definition is made by Turner and Müller (2003, p. 7):

> *A portfolio of projects is an organisation, (temporary or permanent) in which a group of projects are managed together to coordinate interfaces and prioritise resources between them and thereby reduce uncertainty.*

Considerable confusion is prevalent in literature regarding the use of the terms *portfolio*, *multi-project* and *program*. These terms are often used interchangeably although a distinction between them has gradually evolved in research literature. Pellegrinelli (1997) uses the concept "a multi-project organisation" to denote that fact that several project managers utilize the same resources and the concept "multi-project management" to denote the balancing of these resources, costs, and interests as for instance stake holders. He further states that the concept *program* is a far more wide-stretched area concept where, on top of the issues from multi-project management, the technical and planning aspects play the most important role. Henceforth, the term *project portfolio* will refer to the definition by Turner and Müller (2003), as distinguished above.

2.1.3 Portfolio management

The theorist and economist Henry Markowitz is usually considered to have established the field of modern portfolio theory (referred to in Wysocki & McGary, 2003). In the 1990's, his theories were extended from the investment portfolio to the project portfolio. Hence, from merely focusing on investments, the concept has been broadened, such as in the definition by Wysocki and McGary (2003):

> *Project portfolio management includes establishing the investment strategy of the portfolio, determining what types of projects can be incorporated in the portfolio, evaluating and prioritising proposed projects, constructing a balanced portfolio that will achieve the investment objectives, monitoring the performance of the portfolio, and adjusting the contents of the portfolio in order to achieve the desired results.*

Cooper, Edgett and Kleinschmidt (2001) summarises three goals for portfolio management: maximising the value of the portfolio, achieving a balanced portfolio, and the need to build strategy in the portfolio. These goals are based on the results of case studies. Maximising value was the first goal for most companies studied, where the value was maximised against one or more business objectives, e.g. profitability, strategy and acceptable risk, using tools such as financial methods and scoring models. Achieving a balanced portfolio means balancing aspects such as long and short term projects, risk and reward, domestic and foreign investment, and across technological area. The need to build strategy in the portfolio is based on the other two goals, e.g. the value maximisation is meaningless unless the value is measured in terms of company goal, and the ideal portfolio balance ultimately likewise comes down to strategy. Most companies studied by Cooper, Edgett and Kleinschmidt stressed that all active projects must be aligned with the organisation's strategy (Cooper, Edgett & Kleinschmidt, 2001).

Among the many methods and tools for managing project portfolios and selection projects are financial models, such as Net Present Value (NPV), Internal Rate of Return (IRR), Expected Commercial Value (ECV) and Productivity Index (PI) (Cooper, Edgett & Kleinschmidt, 2001), and Options

Pricing Theory (OPT) (Doctor, Newton & Pearson, 2001). These models have advantages being rigorous and boiling down to a few key numbers, however over reliance on strictly financial data possibly containing errors or false estimates may lead to wrong portfolio decisions (Cooper, Edgett & Kleinschmidt, 2001). Cooper, Edgett and Kleinschmidt write that other characteristics, such as having a unique and superior product, targeting an attractive market or leveraging internal company strengths, may favourably be used as guidelines for product success.

2.1.4 Risk and uncertainty

Before exploring risks in projects, the concepts of risk must be clarified. "Risk and uncertainty describe the possibility of different potential outcomes" (Schuyler, 2001, p. 6). The two concepts of risk and uncertainty are frequently used in daily business life as well as in research literature, sometimes interchangeably; however a distinction should be made for better understanding.

Sometimes, such as by PMI in PMBOK (2004) and by the UK Office of Government Commerce in PRINCE2 (OGC, 2002), risk and uncertainty are an equality. They define risk as uncertainty of outcome that can be both positive and negative. Thus, the chance of winning in a lottery is a positive risk and the chance of being hit by a car in traffic is a negative risk.

Schuyler (2001) found that *uncertainty* refers to the variability in some value and *risk* is the, usually unfavourable, potential impact of the outcome. A similar simple definition from the insurance industry is that *risk* is the product of loss and likelihood; the likelihood that an event will occur and the expected loss, i.e. the consequences, thereof (Kendrick, 2003).

Olsson (2005) clarifies how *risk* and *opportunity* derive from *uncertainty* by the illustration in Figure 2.2. Until put in a context, as for example during risk assessment, *risks* and *opportunities* are *uncertainties*.

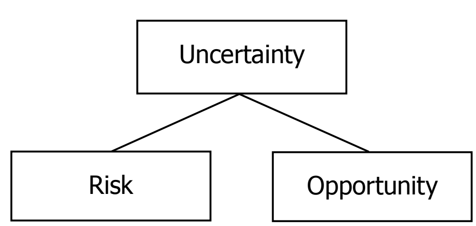


Figure 2.2. Risk and opportunity derive from uncertainty (Olsson, 2005, p. 6).

In this study, the above definition made by Olsson (2005) will be used, where the two aspects of *uncertainty* is *risk* and *opportunity*, as the term positive risk may sometimes be confusing.

2.1.5 Risks in projects

There are many theories on, and definitions of, risks in projects, whereof some are presented here. Risk is and important area within project management and most literature on the subject agree that risk is present in all projects, e.g. "project risk has its origin in the uncertainty that is present in all projects" (PMBOK, 2004, p. 255). PMBOK further stress that organisations should be committed to addressing risk management proactively and consistently during the project to be successful. Similarly by Nelson and Eubanks, "a well planned and executed risk analysis activity should be part of any significant product development project" (2005, p. 430).

Risks related to a project can be categorised in two groups: internal and external (PMBOK, 2004), also known as project risks and project environment risks (Steinkeller, 2001). Examples of external risks are market risks, regulation, inflation and social impacts whereas internal risks can be management, schedule, cost, design, changes in technology and licenses (PMBOK, 2004).

There are numerous theories on what project aspects risk fundamentally derives from. According to Pfleeger (2000), risks can be distinguished from other project events by three indicators: *a loss associated with the event*, the event must create a situation where something negative happens to the project; *the likelihood that the event will occur*, one must have some idea of the probability that the event will occur; *the degree to which we can change the outcome*, for each risk, it must be determined what can be done to minimise or avoid the impact of that event.

Risk and maturity are two often related concepts. For example, Ross (2004) suggests that projects "may be characterised in terms of their level of maturity and their volumetric (or value) uncertainty" (p. 2). These two factors represent essentially the difference between the two terms; maturity representing risk and volumetric (or value) uncertainty naturally representing uncertainty.

Marmgren and Ragnarsson (2001) state that, the degree of complexity of a project depends on the level of uncertainty regarding what to do and how to do it. They further present and discuss four common risk factors for projects: *size*, *novelty*, *the surroundings* and *dependencies*. *Size* simply means the project size. Without saying that larger projects are harder to manage, the larger the size the more pieces and areas of competence there are that need to fit. This insecurity is manageable in theory, as experience from earlier projects can be used to predict the problems. *Novelty* mainly deals with the technical innovation, i.e. if the development is on well-known ground or not. There are four levels of *novelty*: (0) utilization of existing knowledge, (1) refinement of existing knowledge, (2) development of known knowledge, and (3) creation of knowledge. *The surroundings* change constantly which in turn may change the goal of a project; the goal set at an early stage may soon have become irrelevant. *Dependencies* can be divided in two groups. *Product dependencies* are when the project involves development of several parts that constitute integrated parts of a main product. If one part is changed, the whole project is affected. *Project dependencies* are when different activities are interlinked or integrated, i.e. when one group's work affects another's.

2.1.6 Risk response

The concept *risk response* is sometimes included in risk assessment and must thus be clarified. When developing action plans for identified and analysed risks, there are a number of possible options, usually referred to as risk responses. Different sets of risk responses can be found in literature, whereof some are often overlapping. However, to maximise understanding, some overlapping is usually considered acceptable. Bartlett (2002) lists four possible responses and states that mitigation of the identified risks is clearly the most important aspect of risk assessment:

- *Mitigate*: the risk can be lessen in severity, either by reducing possibility of occurrence or reducing impact.
- *Accept*: the risk can be accepted, either by choice or if the risk is unavoidable and unchangeable. This may be complemented by a contingency plan.
- *Avoid*: the risk can be avoided by finding a work-around or making a change to the project's direction
- *Insure against*: this does not prevent the risk from occurring but provides compensation if it impacts.

In PRINCE2, a somewhat different set of risk responses are presented (OGC, 2002):

- *Prevention*: terminate the risk, either by doing differently or by putting in place countermeasures.
- *Reduction*: treat the risk; take action to control it in some way.
- *Transference*: pass management of the risk to a third party, e.g. via an insurance policy.
- *Acceptance*: tolerate the risk, either if nothing can be done or if the impact is acceptable
- *Contingency*: plan actions to come in force when the risk occurs.

This study will use the term risk response as defined above, and the specific set of responses used will be developed later on.

2.2 Risk assessment

Also the concept of risk assessment has several different definitions. The word “assess” means “to estimate the size or quality of” (The Concise Oxford Dictionary, 1998). Often, risk assessment involves the acquisition of the risk information used for evaluation. Risk assessment is the process of identifying potential risks, quantifying their likelihood of occurrence and assessing their likely impact on the project (Field & Keller, 2004; Wideman 1992, 2005). It includes review, examination and judgement whether or not the identified risks are acceptable in the proposed actions (Field & Keller, 2004; Wideman, 2005).

As risk and opportunity derive from uncertainty, consequently risk management and opportunity management derive from uncertainty management (Olsson, 2001). However, in this study, the simplified term risk assessment will be used exclusively, however include uncertainty assessment.

Putting risk assessment in a context, it is often seen as an early phase in risk management and includes risk analysis. PMI divides risk management in six sub-processes: risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning and risk monitoring and control (PMBOK, 2004). Pfleeger (2000) divides the area of risk management into risk assessment and risk control. He further divides risk assessment into three parts: risk identification, risk analysis and risk prioritisation, as shown in Figure 2.3.

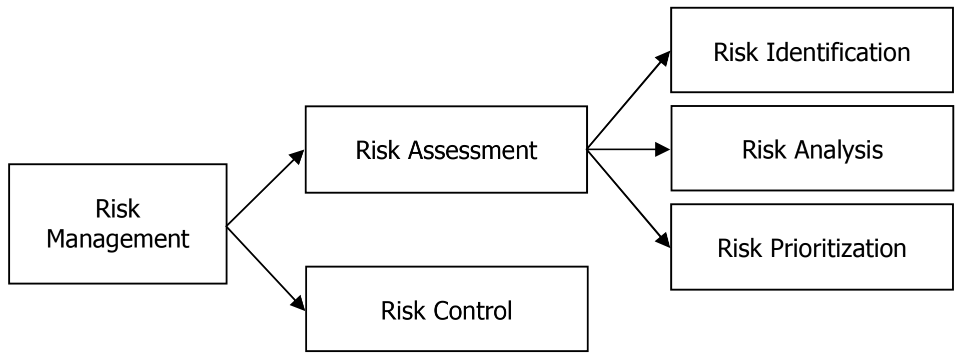


Figure 2.3. Risk assessment as a part of risk management (Pfleeger, 2000, p. 267).

Wideman (1992) simply divides risk assessment in four processes: *identify, analyse, respond* and *document*, as shown in Figure 2.4.

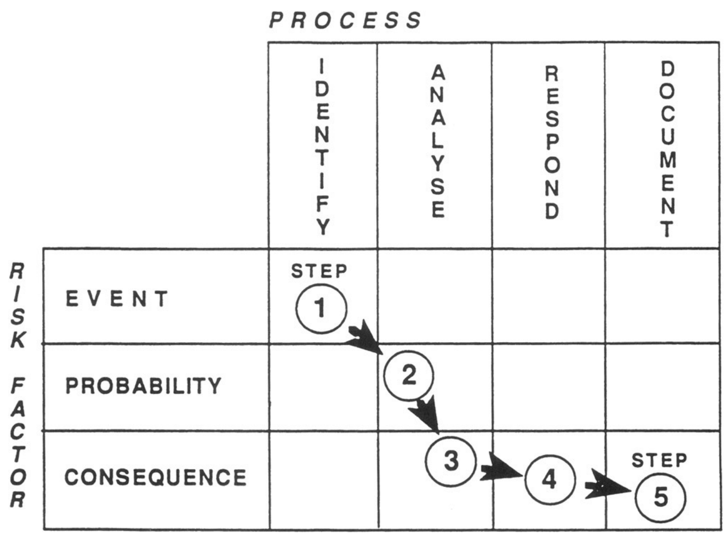


Figure 2.4. A simple risk assessment (Wideman, 1992).

Chapman (1997) names the phase succeeding risk analysis *risk evaluation*. The key deliverables of the *risk evaluation* is a diagnosis of any and all important issues found and a comparative analysis of the implications of the responses to these issues, looking however from a project rather than portfolio perspective. He also explains that looping back to earlier phases may be necessary to improve the quality and reliability of the risk assessment.

In this study, risk assessment will be divided in three phases. First are the two common phases presented above, however with risk analysis covering prioritization and risk response planning:

1. *Risk identification*, where uncertainties and risks are identified. The deliverable of this phase is a risk list.
2. *Risk analysis*, where the identified risks are described, qualitative or quantitative and the exposure of each risk is defined. Risks should be prioritized and risk responses planned.

These phases are well covered by Chapman and Wards "minimalist first pass approach" (2000a), created as a simplified method in comparison to their more ambitious approaches (Chapman & Ward, 2000b, 2004). As the focus of this study is on project selection from a portfolio perspective, the third phase will be such as defined by Chapman (1997) above, however looking from a portfolio rather than single project perspective:

3. *Risk evaluation*, where the risk analysis is used as a basis of decision. The evaluation deals with the way risk is taken into account in the project selection decision making.

2.3 Methods and tools for risk assessment

There are a number of different methods and tools to use in the risk assessment process. This chapter aims to outline the most common, with a sufficient level of detail for discussion later on. The tools are presented in order of the three phases of risk assessment: *risk identification*, *risk analysis* and *risk evaluation*. One method however, the *Successive Principle*, is covering both risk identification and risk analysis and is listed first.

The Successive Principle

This method, sometimes known as the Lichtenberg analysis or MOSR (Method of Successive Refinement) has proven particularly appropriate for calculation of a reliable total sum when uncertainties and lack of information prevail (Lichtenberg, 1989). As outlined by Lichtenberg (2000), there is a sequence of activities. First, the *base case* must be defined, i.e. a standardisation of the context of the project must be agreed. This can be compared with using today's price level in a cost estimate. Second, a brainstorming workshop is held to identify the *general issues*, i.e. general sources of potential uncertainty that thus cause variation from the *base case*. Next, the actual successive procedure begins by dividing the project into a small number of important independent activities, i.e. the first blocks in the WBS (Work Breakdown Structure). For each of these, a three-point estimate is made on a factor of choice, such as duration or cost. From these estimates, the mean value and the standard deviation are calculated based on normal distribution theory. The base case is then adjusted by taking the *general issues* into account, added as overall correction factors also presented as three-point estimates. The *grand total* is calculated as the sum of the activities' mean and the overall correction factors' mean. Also the overall standard deviation is calculated. The activity with the highest standard deviation is worth the most attention and is subdivided to the next step in the WBS and the process repeated. For each subdivision, the prior values are revised using the new, more detailed, figures. The idea is to specify all parts of the project in such detail that the collective overall project has reached an acceptably low level without spending too much time. The "20-80 rule" is generally relied upon, i.e. 20% of the elements account for 80% of the total (Lichtenberg, 2000). The *Successive Principle* stresses the bringing up of soft or fuzzy issues, such as the efficiency of management (Lichtenberg, 1989). A basis for successful assessment is efficient workshops; groups must be multidisciplinary and led by an educated facilitator (Lichtenberg, 2000).

2.3.1 Methods for risk identification

Risk assessment begins with identification of risk factors. The deliverable of the risk identification is list of all risks related to the project. There are fundamentally two alternative ways of risk identification; brainstorming and checklists being the extremes. However, several methods and tools for structuring and assisting the brainstorming exist that create a range of alternatives. The presentation will start with *brainstorming*, continue with some workshop assistance tools and end with *checklists*.

Brainstorming

Brainstorming is a simple yet effective way to help people think creatively in a group setting without feeling inhibited or being criticised by the others (Wideman, 1992). The group should include members with as relevant and broad knowledge of the circumstances of the situation as possible. As ideas are generated, the group members further build upon them with new ideas. No criticism or disapproval is allowed during the brainstorming session as the intent is to encourage as many ideas as possible, however imaginative or wild they may appear. The technique is improved by a variety in the participants' backgrounds and experiences and is very effective in finding creative solutions to potential problems (Wideman, 1992).

Risk identification matrixes

To assist the risk identification session, Lichtenberg (2000) suggest the use of a matrix. The matrix is or should be designed to provide a systematic and rough classification, see Table 2.5.

	Technical and commercial issues	Social and organisational issues
External issues		
Project-related issues		
Internal issues		

Table 2.5. Example of matrix (Lichtenberg, 2000, p. 63).

Risks should be identified for each of the cells in the matrix. The matrix format provides understanding of risk in the wider context, e.g. technical risks addressed within the project as well as for the company as a whole. Such matrixes can be changed and more columns added for greater clarity, e.g. people issues, commercial issues and technical issues (Lichtenberg, 2000).

Focus areas

Bartlett (2002) suggests that focus areas should be devised to the project to which the team members easily can relate, e.g. product design, product testing and project resources. Within each of these areas there are risk drivers, i.e. potential trigger points for risks. The wide scope must however not be forgotten; consideration should also be given to external focus areas such as the market conditions and legislation. Examples of focus areas and risk drivers are provided in Table 2.6. The focus areas and risk drivers should be identified in a workshop, where the team members can reach consensus. The workshop group should include the core project team as well as other interested parties, such as sponsor, stakeholders, sales, procurement, finance and human resource.

Focus area	Risk driver
Application design	Functional specification
Application coding	Version control Documentation Coding quality Resources
Integration testing	Test method Documentation
Systems testing	System performance Documentation
User acceptance	Test scripts User resources

Focus area	Risk driver
Business operations	User preparation User buy-in Quality standard
Business organisation	Sponsorship Re-structuring Cost reductions Office rationalisations Globalisation
Legislation	Regulatory requirements Health and safety

Table 2.6. Sample of internal and external focus areas and risk drivers for a software development project (Bartlett, 2002, pp. 22-23).

The use of focus areas is an approach similar to the use of headings, suggested by Lichtenberg (2000) and PMI (PMBOK, 2004). Headings can be project-related issues such as project organisation and contract issues, organisational issues such as financing organisation and consultants, and environmental issues such as general economic trends, rules and regulations. A drawback of using headings is that areas without headings remaining unidentified (Lichtenberg, 2000). PMI suggest using headings according to the risk breakdown structure presented in Figure 2.7.

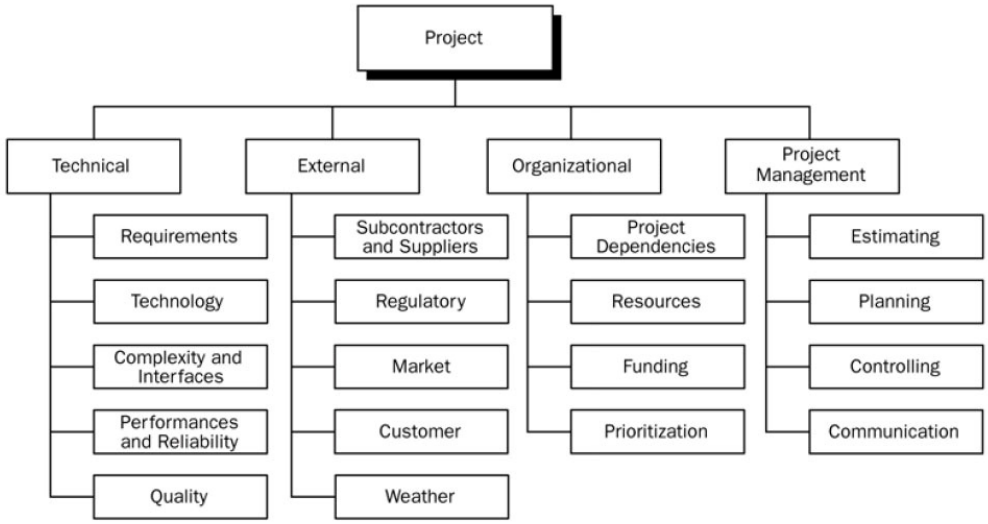


Figure 2.7. Risk breakdown structure (PMBOK, 2004, p. 244).

Checklists

A checklist is a list of risk factors that is gone through during the risk identification workshop. The risk factors are commonly presented in a yes/no format, the risks present in the project receiving a yes answer (Cooper, 2001). Checklists can be developed based on experience from earlier projects or generic issues; the aim is to cover all risk areas and there is a possibility of highlighting known, common risks. PRINCE2 provides a list of various categories that they say make a useful start point for risk identification (OGC, 2002), the full list is presented in Appendix 3.

If the technical development is similar to that of earlier projects, a checklist may be used with problems that are likely to occur (Pfleeger, 2000). Pfleeger further writes that for development work with new characteristics, the checklist can be augmented with an analysis of each of the activities in the development cycle (Pfleeger, 2000). As checklists are even more specific and detailed than focus areas and headings, the risk of leaving unaddressed areas out is also larger.

2.3.2 Methods for risk analysis

The phase succeeding risk identification is risk analysis. Analysis includes description, analysis and quantification of all identified risks, where quantification can be both qualitative and quantitative to describe the exposure. One basic concept, which is feasible whatever method chosen, is *risk prioritisation*. *Prioritisation* aims to order the risks after importance in order to optimise the use of risk management resources (Pfleeger, 2000). Risks can be ordered differently; Severity of impact is probably the best criterion to help decide the risk priority, even though other factors may also be important (Bartlett, 2002). However, both probability and impact are usually considered.

Mini Risk

This method has many names: *Mini Risk* (Wenell, 2005b), *Hazard analysis* (Nelson & Eubanks, 2005) and *Jonsson analysis* (Hamilton, 1996), described with only minor differences. The method is based on probability and impact, as stated by Bartlett: "[risk] evaluation is primarily concerned with assessing the probability of the risk occurring and its impact on the project. These are the elements that are highly subjective" (2002, p. 43). The method is beneficially used prior to any significant development effort to provide an early view of the "project's landscape" (Nelson & Eubanks, 2005, p. 431).

The definition presented here is of *Hazard analysis* by Nelson and Eubanks (2005). It is a top-down approach that identifies the general problem areas to be handled. The risk assessment team identifies hazards, i.e. risks, which the product might produce. Among the identified hazards must include deficiencies in safety (injuries) and could include deficiencies in performance (insufficient throughput) or customer dissatisfaction (Product produces too much noise). Each identified hazard is listed and rated by severity (*S*), which is the degree of damaged caused, and occurrence (*O*), which is the chance that the cause will occur, both ranging from 1-5. From this, the risk index (*RI*) is calculated as the product of severity and occurrence, in this study referred to as risk exposure. Finally, a mitigation strategy for each hazard is defined and potential causes for the hazards are discussed. An example of a *hazard analysis* worksheet is provided in Table 2.8.

ID	Potential Hazard	Cause(s)	S	O	RI	Mitigation

Table 2.8. Hazard analysis worksheet (Nelson & Eubanks, 2005, p. 432).

Bartlett (2002) suggests using percentage rather than values ranging from 1-5 or 1-3 for probability of occurrence in order to reduce the margin of error. He similarly suggests the use of monetary units rather than values for impact, as the impact ultimately comes down to money. Additionally, he suggests expressing impact as percentage of the project budget as a way to put a focus on risk in relation to the project as a whole (Bartlett, 2002).

An advantage of *Hazard analysis* is the simplicity compared to more sophisticated probabilistic methods. An output presented as a 1-5 value does not imply a high level of detail; the method is designed for rather rough estimates, thus suitable for early estimates. As stated by Bartlett (2002), even if there is data or experience from occurrence in a similar situation, the calculation of probability can only be a rough estimate. However, in for example a study by Roetheli and Pesenti (1986) it was found that estimates of technological success in research and development projects made by an ad hoc group of managers and specialists were surprisingly correct.

Decision tree analysis

When dealing with subsequent decision points with probability estimates, decision tree analysis provides a good overview and structure and has been described and utilized by many theorists (e.g. Doctor, Newton & Pearson, 2001; Jackson *et al.*, 1999; Schuyler, 2001; Walls, 2004). The tree diagram is the decision model and at the same time serves as a template for calculating the expected values. The tree structure describes the logic of a complex decision. An illustration of a chance node is given in Figure 2.9. Each branch represents an alternative with their respective probabilities of occurrence indicated.

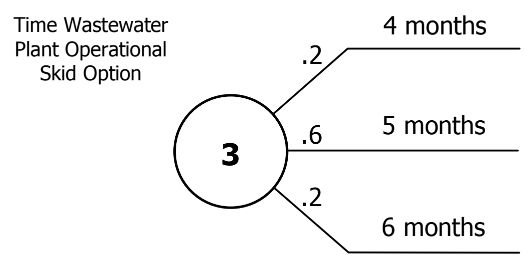


Figure 2.9. Chance node (Schuyler, 2001, p. 62).

From large trees with this structure, the *expected value* can be calculated, i.e. the mean, which is the best single-point estimate of an outcome. The *expected value* is simply the sum of each branch's outcome multiplied by its probability.

Monte Carlo simulation

For a more detailed probabilistic view on risk, *Monte Carlo* simulation is an often used statistical technique. *Monte Carlo* simulation provides a structured approach to sensitivity analysis that explicitly incorporates uncertainty into models (Cooper, Edgett & Kleinschmidt, 2001). When incorporating uncertainty into models such as financial forecasts and time schedules, the statistical calculations tend to become rather complicated or impractical as the number of activities increase (Cooper, Edgett & Kleinschmidt, 2001; Schuyler, 2001). Instead of calculating, *Monte Carlo* simulation uses a random sampling process to approximate expected values. Based on a number of estimated outcomes and their respective probability of occurrence, a *Monte Carlo* simulation runs a large number of random possible what-if scenarios in an iterative loop in order to present the probability. The collected result makes up the systems total distribution. For this reason, *Monte Carlo* simulation is appealing as it is not a black-box solution, i.e. it is easily understood (Schuyler, 2001). It is common to use a simplified version with three-point estimates as input, i.e. expected, best-case and worst-case (Schuyler, 2001). Exemplified in terms of project duration, these estimates represent the expected duration, the shortest possible duration and the longest possible duration. *Monte Carlo* simulation can either be performed using commercial software products for risk analysis or, often simplified, in ordinary spreadsheet software.

2.3.3 Risk evaluation

The final phase in risk assessment is risk evaluation. This is where the identified and analysed risks are evaluated as part of the project selection decision.

There are several approaches when making a project selection decision. Studies studied project selection methods used at companies and found a number of methods (Cooper, Edgett & Kleinschmidt, 1999). In a later study, five methods proved to be preferred, listed in order of popularity (Cooper, 2001):

1. *Financial or economic methods:* These are extremely popular, however the businesses studied that had the poorest performing portfolios relied extensively on such methods. Estimates for financial figures such as expected sales, production costs and investment outlays are made and used as a basis for the project selection decision.
2. *Business strategy:* This method uses strategy as a basis for allocating money across different types of projects. Based on strategies' priorities, money is distributed into envelopes or buckets. Projects are then ranked within their respective bucket. The project selection decision is based on the rankings.

3. *Bubble diagrams or portfolio maps:* Projects are plotted on an X-Y diagram, like bubbles or balloons. Projects are categorised by the quadrant they are in, as seen in example in Figure 2.10. The project selection decision is based on how the project fits in the portfolio for a set of diagrams of choice. Bubble diagrams are also suggested by Cooper, Edgett and Kleinschmidt (2001) for new product development project evaluation and by Ghasemzadeh and Archer (2000) who suggest plotting risk on one axis for optimal portfolio selection.
4. *Scoring models:* Projects are scored on a number of criteria, for example low-medium-high, 1-5 or 0-10. These ratings are then added to achieve a project score, which is used in the project selection decision.
5. *Checklists:* Projects are evaluated on a set of yes/no questions. Each project must receive for example all or a certain number of yes answers to pass. The number of yes answers is here used in the project selection decision.

These methods do not focus on risk assessment as presented, but can to various degrees be adjusted to incorporate and focus on risk. They nevertheless show some possible approaches that may be feasible.

Risk radar chart

Bartlett (2002) suggests the use of risk radar charts, as presented in Figure 2.10, to give a steering committee a quick feel for the risk level in different areas. He claims that the model is particularly effective when used in comparison, month to month

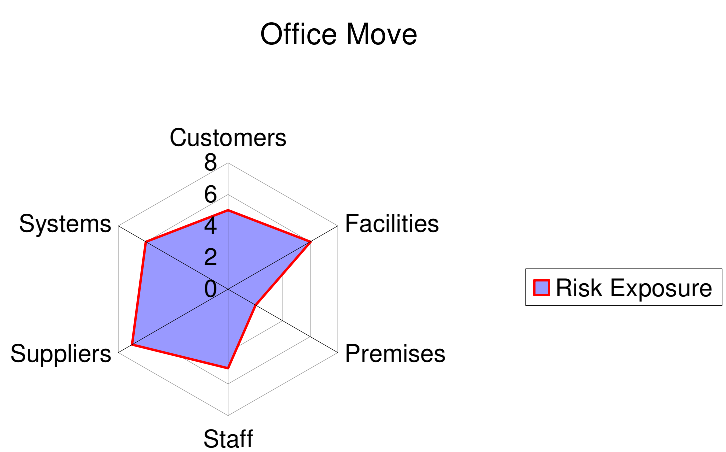


Figure 2.10. Risk radar chart (Bartlett, 2002, p. 94).

Risk/Benefit Grid

Wysocki and McGary (2003) and PMI (PMBOK, 2004) suggest displaying risk in a grid using probability of technical success probability of business success as the axes, as seen in Figure 2.11.

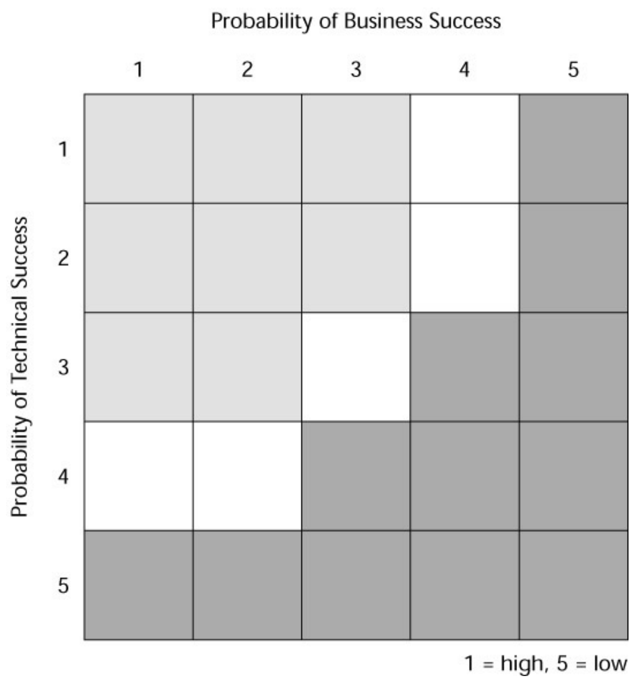


Figure 2.11. Risk/Benefit grid (Wysocki & McGary, 2003).

Hence, in this model two risks are assessed, technical risk and commercial risk, which can be multiplied for the probability of project success. A project selection should be based on the following suggestions: fund projects that fall within the lightly shaded area, consider those in the non-shaded area and refer those in the darkly shaded area back to the proposing instance. However, the authors leave the option of funding high-risk projects if a compelling reason exists.

Product maturity grid

Lewis and Wong (2005) suggested that the projects should be evaluated based on their maturity of risk assessment. Each risk category is graded depending on the level of risk response agreed and planned. The risk categories suggested are:

- *Market and customer risk (M):* the project is not feasible to implement due to lack of market. This is a showstopper for the project and the team is required to produce a response action plan and a contingency plan.

- *Project timing risk (T):* the project cannot be completed within the time frame specified. This is a showstopper for the project and the team is required to produce a response action plan and a contingency plan.
- *Project resources risk (R):* the project team does not have all the necessary resources to implement this project, including human resources and funding. This is a showstopper for the project and management is required to allocate the necessary resources. The project team is required to prepare a proposal to manage the situation.
- *Project scope risk (S):* The project scope, product functions, and features are not feasible to execute because new technology is not yet ready or staff lacks the know-how to operate it. This is a showstopper for the project and the team is required to prepare a response action plan and contingency plan.
- *Acceptable risks (D):* The project team has identified the potential risks but found they are not critical or are acceptable. These risks do not affect project implementation but do require continued monitoring and assessing to see if their attributes change as the project proceeds.

The risk categories are then be translated into the product maturity grid, shown in Figure 2.12. The shaded areas represent major risk factors for which management attention is required (Lewis & Wong, 2005).

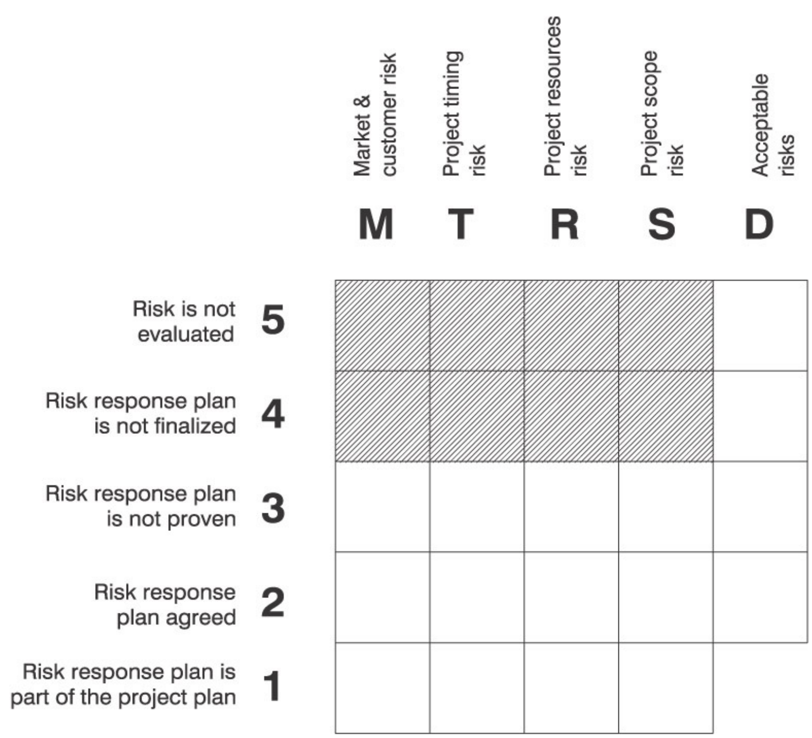


Figure 2.12. Product maturity grid (Lewis & Wong, 2005).

The resulting grid can be used for the project selection decision as it presents an overview of the risk assessment maturity of the project. In this study, the grid will be called risk response maturity, as the focus is on project risk assessment rather than on the product.

3 Method

This chapter first presents the methods used for the theoretical study. After that, a description of the method for the empirical study is given, where participants for the benchmarking study were chosen from different organisations of interest. The benchmarked companies are then briefly described and an instrument and a procedure for collecting empirical data are thereafter designed. Finally, a method for coding and analysing the gathered data is chosen.

3.1 Theoretical study

The literature research was conducted early in the study process to give a solid basis of existing theories in the area of portfolio management, risk analysis and risk assessment. As the empirical study proceeded, the theoretical framework was complemented and revised.

The main sources for information were databases of academic and business articles and books, whereof some were found through internet based libraries.

The most used journal collections were *Proquest* (http://www.proquest.com/) and *Science Direct* (http://www.sciencedirect.com/). For books, the search engine at *Books24x7* (http://www.books24x7.com/) was used as well as ordinary libraries. Typical search terms used were: *project portfolio management*, *risk analysis*, *risk assessment*, *project risk management*, *project selection* and *product development project*.

3.2 Empirical study - interviews

The primary data collection in this study will be qualitative, since it aims for a more extensive understanding of the organisations' processes. This refers to the data collection within SKF as well as the benchmarked organisations. The explorative nature of the research project with little information available beforehand makes qualitative research favourable (van der Velde, Jansen & Anderson, 2004). The interviews will be based on a list of points, drawn up beforehand, to enable some comparability. The interviews were divided in two categories: *interviews at SKF* and *benchmarking interviews*.

All benchmarking interviews will be recorded and transcribed for analysis. Using a recordable media has the advantage of capturing all that is being said including the tone of voice without losing concentration, as when taking notes. The drawback is that some people may be inhibited when being recorded (Seely, 2002).

3.2.1 Participants

For the interviews at SKF, interviewees were chosen based on two criteria: (1) responsibility for a project portfolio or a portfolio management process and (2) an interest in improving the risk assessment process. The latter criterion improved the quality of the interviews, as interest was likely to be there throughout the process. Three interviewees from different portfolios were chosen: *new market offer projects*, *technology & competence development projects* and *customer order projects*.

For the benchmarking interviews, companies were chosen that were thought to have processes of interest for this study. Each company was selected after a discussion with a representative to briefly map their level of risk assessment work. The selection was limited to companies willing to share their processes. In order to find contact persons at external organisations willing to participate, three directions were possible: contacts of SKF's, contacts of academic supervisor Lisbeth Hedelin's and contacts initiated by the author. Also, a network meeting at Wenell Management AB with participants dealing with portfolio management issues at various companies was attended where new contacts were made. From each of the following companies, one interviewee was chosen: Bombardier Transportation, Ericsson AB, Skanska Sweden AB and Volvo 3P. Also, an additional interview was conducted with an experienced management consultant at Wenell Management AB, who has specialised in project risk management. This was in order to gain a good overview of best-practices. Each company represented is described under their heading below.

Ericsson AB

Ericsson is a world leading global provider of telecommunications equipment and related services. Over 1,000 networks in 140 countries are using their equipment and 40 percent of all mobile telephone calls are made through their systems. The company was founded in 1876 and its headquarters is located in Stockholm, Sweden (*Ericsson in brief*, 2005). The interviewee from Ericsson works within the department for Wideband Products at Lindholmen in Gothenburg, Sweden. The discussed division had 2 portfolios of a handful of projects each.

Volvo 3P

Volvo Group is one of the worlds leading manufacturers of trucks, buses and construction equipment, aerospace components and services, and drive systems for marine and industrial applications. Volvo was founded in 1927 and has today 81,000 employees and production in 25 countries. A number of business units provide additional manufacturing, development or logistical support. Volvo 3P is one such, and 3P represents *purchasing*, *product planning*, *product development* and *product range management* (*Volvo Group*, 2005). The interviewee from Volvo 3P works for Volvo Trucks within Economic Support at Renault V.I. in Lyon, France. Volvo Trucks has many smaller projects that do not undergo the full process, but has some 100 projects with a budget of €5,000,000 or higher.

Bombardier Transportation

The Canadian registered Bombardier develops and provides rail transportation equipment, air craft and provides financial services. Bombardier Transportation is the global leader in the rail equipment manufacturing and servicing industry. Among their products are passenger rail vehicles and total transit systems. (*Transportation*, 2005). The interviewee from Bombardier Transportation works within the intercity train division in Västerås, Sweden. This Mainland and Metros division has 6 portfolios of about 15 projects each.

Skanska Sweden AB

Skanska is one of the world's leading companies for construction-related services and project development. Skanska Sweden AB is the Swedish division that develop, build and maintain the physical environment. Skanska was founded in 1887 and its headquarters is located in Solna, Sweden (*Om Skanska*, 2005). The interviewee was responsible for the implementation of a new risk management process for development projects.

Wenell Management AB

Wenell Management is Scandinavia's oldest established project management firm. The company has 17 consultants and offer support, education and services within the field of project management (*Wenell*, 2005a). The interviewee from Wenell Management AB works at the office in Stockholm, Sweden. He has been facilitating consultant for approximately 200 projects within different lines of business during his eleven years at Wenell.

3.2.2 Interview guide

All interviews in this study were semi-structured in order to get answers to the desired questions yet leave freedom for the interviewees to express their own viewpoints on the topic that may not have been uncovered otherwise (Saunders, Lewis & Thornhill, 2003). All questions were open-ended to leave further freedom and possibility for discussion of certain points of interest.

The interviews at SKF were performed in two steps. The initial set of interviews aimed to present an overview of the current portfolio management processes in the organisation, i.e. its contents, its structure and how it is implemented. This information would also clarify the organisation's view on project risks at portfolio level. The main purpose of the introductory interviews was to find the appropriate focus of the continuous literature study as well as for the benchmarking. The more in-depth interviews aimed to further narrow down on the focus as more theoretical research has been conducted. Based on the theoretical research and the conducted interviews, issues for discussion were chosen that are of a special interest.

The benchmarking interviews aimed to describe the risk assessment processes implemented in these organisations. The purpose is, by adopting a best-practice perspective, to find risk assessment processes that can contribute to the development of a process for SKF. Focus will be on narrowing down on the core issues of the process, at the same time revealing details that may be of interest for SKF. The interview guide is presented in Appendix 1. The interview with a consultant aimed to describe his experiences of best risk assessment practice and its results are presented and analysed together with the benchmarking interviews. The interview guide for this interview is presented in Appendix 2.

3.2.3 Procedure

All interviews at SKF were performed in person at SKF. Notes were taken during the interviews in order to present a summary of the information revealed. The initial interviews at SKF were of about 45 minutes and the more in-depth interviews of about 60.

The benchmarking interviews were conducted in person in calm environments at the respective company. The duration of these interviews varied from 50 to 80 minutes. All benchmarking interviews were recorded.

At one time, technical malfunction prevented recording and a complementary interview were conducted and recorded via telephone.

3.3 Data coding and analysis

The interviews at SKF were summarised in a description of the present situation. All benchmarking interview recordings were transcribed in the original language. The excerpts from the non-English interviews presented in the results section were translated, but not the transcripts in full. The transcripts were then coded using categorisation. The categories were taken from the interview guide. Some additional categories were also created for issues of interest not covered by the guide. The presentation of the results was structured based on the interview guide, with examples of answers given to each question. The examples will be chosen to present the full range of answers from all companies, at the same time showing similarities and trends. The answers were presented anonymously as a matter of confidentiality.

The discussion contains analysis of the theoretical and empirical findings as well as reasoning on possible structures and improvements that can be made. As the study aims to suggest improvements by evaluating the findings and discuss possibilities, the reasoning and discussion will be rather highly emphasised.

4 Results

This chapter presents the results derived from the interviews. First, the present situation is presented through the results from interviews at SKF. Second, the benchmarking results are presented.

4.1 Present situation at SKF

The GPM contains a classification of projects as either A, B or C projects depending on size or complexity, A being the largest. The classification gives the level of project management required. The model further includes risk management guidelines with four parts (SKF, 2005b):

- *Risk & opportunities – Mini Risk*, where all possible risks are to be identified and analysed, brainstorming being suggested.
- *Risk areas – checklists*, where a checklist is provided for use after brainstorming.
- *Extended risk management*, where the use of a project risk management specialist or impartial project audit is suggested if the project shows a need for more extensive risk management. Included here is also Software supported risk management.
- *Software supported risk management*, where the softwares *PROAct* (*Noweco*, 2005) and *@RISK* (*Palisade Europe*, 2005) are suggested and supplied.

Three portfolios at SKF were studied: *New market offers (NMO)* within the industrial division, *technology & competence development* within the industrial division and a *customer order* portfolio within the automotive division. The portfolios had somewhat different processes as there was no standardised common process within SKF. There were guidelines available, although currently under development. The processes are presented first by their commonalities followed by their individual characteristics.

The *NMO* and the *technology & competence development* portfolios used the same basis for their portfolio processes. The process was currently being revised, and in order to implement the new process, all existing projects were analysed according to the new process criteria, as were all new projects.

There was a structure of business gates, starting with BG0, where projects were reviewed by a business gate committee. When starting a project, an idea was taken from an idea bank to the pre-study phase. This is BG0, and decision maker was the segment manager. The start-up approval was based on the estimated value or importance of the idea and the availability of a sponsor, project manager and resources. Each project started at the pre-study phase. The main deliverables of the pre-study, presented by the sponsor or project manager at BG1, were: a summary of business case and charter, business case and charter, business case evaluation, risk assessment, strategic offer map, proposed project organisation and a free presentation. These deliverables were usually made rather brief at this early stage and are refined during the next phase, the preparation phase and once again presented at BG2.

Risk assessment was incorporated partly through presented *Mini Risk* results, partly through a business case evaluation filled in by the project manager or the sponsor. The business case evaluation was a scoring model, where a certain number of project characteristics were graded under six headings: customer and market match, value for SKF (Total Value Added [TVA]), speed (year for break even), organisational feasibility, strategic alignment and probability of technical success. In total, a project was scored on 20 factors. An overall risk level scoring was finally made, ranging 1-5, taking each of these factors into account. The discussion during this scoring was stressed as a crucial ingredient in the risk assessment. A low score on a factor implied high risk, as was the grades formulated, e.g. low customer need implies the risk of investing the money in a project with a low customer and market match, thus not gaining maximum value. The scores were then grouped and plotted in several bubble diagrams, whereof value for SKF versus risk was one.

4.1.1 NMO portfolio

NMO projects aim to develop and launch a new offer for more than one customer. The offer can be existing products, modified products, new developments, complex solutions, services or a combination of the above (SKF, 2005a). The projects were hence categorised by market segment rather than technology. The segmentation aimed to create groups with comparable projects, since different characteristics of markets not always allow for fair comparisons; for example oil industry related projects usually have high levels of risk and large investments whereas projects developing car application fans usually deal with relatively low risks and investments. All segments had an assigned segment manager, with only a few exceptions. The portfolio contained about 80 projects, divided into 25 segments.

On top of the bubble diagram, a polar diagram was created from the business case evaluation, similar to Bartlett's radar chart (2002). The diagram had six axes, one for each category in the business case evaluation. Again, low values implied high risk and thus, a large hexagon in the diagram implied low risk. The risks analysed in the *Mini Risk* were categorised and summarised into four risk areas, each scored with low, medium or high:

- Technical
- Commercial
- Organisational
- Project Related

These risk areas were presented in a form for summary of business case and charter together with a polar diagram

According to SKF working standards, project managers or sponsors must always develop and submit the required project documentation. In order to evaluate the prevalence of this documentation, all project managers within the portfolio were recently asked by portfolio management to submit the business case or other similar documentation. Only one third of the 80 projects submitted their business case, Project Profitability Calculation (PPC) or business case evaluation.

4.1.2 Technology & competence development portfolio

There were three types of projects: research projects, *technology & competence development* projects and product development projects, whereof product development projects were often managed by the *NMO* portfolio management. There were about 50 research projects and 100 *technology & competence development* projects. The project classifications from GPM were used and portfolio management covered class A and B projects, whereas most class C projects were managed by local management, which was often the sponsor or resource owner.

The project selection from the business cases was conducted by a portfolio board, comprising professionals with expertise from six different areas. The board contributed with experience and expertise.

4.1.3 Customer order portfolio

This process belongs to a portfolio of automotive related projects within the automotive division at SKF. The automotive division has a strong focus on quality and is implementing Six Sigma. Historically, warranty costs and liabilities are imminent threats that need to be dealt with. The automotive industry pushes liability requirements hard, sometimes up to three years. Generally in the industry, recall costs are at least 1.7-1.8% of total turnover, a figure that is slightly lower at SKF. A common problem is the focus on business opportunity rather than the accompanying risks. As SKF as a supplier climb higher in the value chain, moving from just supply of bearings to solutions involving software development, the processes need to be adjusted. “All divisions climb the value chain. The question is if they know what it entails?” Many of the costs in the product development can be traced to design decisions made early on in the development.

A problem with the current risk assessment is having the right participants in the risk identification brainstorming sessions, regarding nationality and competence among other things. Improved risk assessment is mainly desired by two reasons: to be able to stop projects, thus save money and to be able to choose the proper methods for risk management

4.2 Benchmarking interview results

The results are structured according to the interview guide for benchmarking interviews, presented in Appendix 1. Presented first are some thoughts on the concept of risk, second is a brief overview of the portfolio management process and finally is a more in-depth description of the risk assessment process. For each issue from the guide, examples or a summary of answers will be presented. The results from the interview with the consultant were integrated with the benchmarking results.

4.2.1 The concept of risk

These issues aim to present the studied organisations' fundamental definitions of risk and also the level of attention they pay to risk in their project selection decisions.

The organisation's view on risk

It was important to accept and highlight the presence of risks in a project in order to really understand a projects potential and develop reliable forecasts. "It is a lot about bringing the risks to the surface and accepting that you have risks; if you cannot do the first part, accepting that there are a lot of risks, you will never know what there is to win because you can turn a risk into an opportunity. And you will never know what will happen in the end if you don't accept that risks are present in the project."

Risk analysis had not always been paid much attention, but "it is something we have started too look at. You can say that hitherto it [the selection decision] has been about feeling". However the focus has recently changed: "it [the risk analysis process] is something we are looking at".

Risk analysis was a lot about utilizing the existing knowledge; "to a large extent, the knowledge of the risks exists within the company". The processes for doing this seemed to be an area of continuous development, however.

Risk and uncertainty

The distinction between risk and uncertainty was not always clearly made. However, one definition was that "risk and opportunity come from a common point, uncertainty. And a risk or opportunity is uncertainty put in a context."

Also, tools dealing with three-point estimates, such as *Monte Carlo* simulation, deal with uncertainty and the companies using such tools had the distinction clear. Further, it was said to be beneficial when analyzing uncertainty to look at both risk and opportunity using the same methods: "if you run statistical exercises, it will come automatically, because you don't just look at expected and worst-case, but also best-case. And best-case is always an improvement."

4.2.2 Portfolio management model

These issues aim to give a presentation of the studied organisations' portfolio management processes, in which the risk assessment process was incorporated.

The role of portfolio management was to view the portfolio of projects as a whole, not see to each project individually, that is assigned to project management. "On a portfolio level, you basically neglect the project goals, only the end effects are important. But at the same time you have to do risk analysis on the project goals /…/ to see if there is a chance that they are reached. You can't just look at the effects not having the deliveries."

At many companies, portfolio management was said to be paid too little attention, "[it] is nothing new, but nobody bothers to take it in. In many cases, people don't see the benefits of making a single project work. Then to see the benefits of the sum of all projects working…"

Overview of the portfolio management process

At one company, the portfolio management process was under development. "It is something I am looking at right now actually. And it is basically connected to our strategic work /…/ these are our strategies and this is our portfolio of development projects. And to try and map those and see, do these projects really fulfil the strategies?" "We look at the whole of all projects."

Specific portfolio managers were not always assigned. Usually, "it is the management team that is responsible" and manages the portfolio. However, projects were generally regularly monitored by portfolio management, a process starting with a project selection decision. For example, at one company a portfolio management software tool was just about to be implemented where project managers regularly submit information about their projects in a specific template. The portfolio management could then aggregate this information to get an overview of the project portfolio and for example get comparative diagrams and distribution charts.

Another example was project audits at the business gates with a decision board evaluating each project. In this case, the projects were funded phase by phase, i.e. each gate review was a decision of funding for the next phase. The projects were to present their status and progress according to a standardised template, used to achieve comparability between projects.

Who made the selection decisions?

It was said that selection decisions should be made by a specially assigned portfolio management; "when talking about portfolio, it should be the same individuals, whether it is one person or a group handling everything in the portfolio". This was important in order to get an adequate overview of the portfolio.

The selection decisions were sometimes made on different levels depending on the importance, size or value of the project. "It is the management team that makes the decisions", but "if you run small projects /…/ there is no need to lift it up to the management level".

A hierarchy of reviews for project selection was also used in some cases. "We have a directors review, which is the first step /…/ then there is the divisional review, then it is group review, and if the volume of the project is big enough, financially, there is a corporate review."

What role did risk play in the selection process?

The importance of risk in the project selection decision was hard to pinpoint. However, it was usually clearly subordinated commercial expectations, for example "when you have fifty potential business opportunities /…/ and they are otherwise similar. If you can present that these are more risky than the others, then you probably shouldn't select those primarily." Usually, risk assessment was required not just for results comparison, but to show that a thorough assessment had been conducted; "management will not accept if we do something and have no risks. They will say that this is a joke, come back in a month with a risk analysis."

Sources for information in developing this model (authors/theorists/companies)

Two of the companies had used consulting agencies in the process development, one of them for a risk assessment process and the other for a whole portfolio management process. Both these solutions included implemented software tools. Another company had processes and tools developed through academic research during a doctor's thesis, where some where designed in collaboration with a foreign university.

4.2.3 Risk assessment

These issues aim to give a presentation of the studied organisations' risk assessment processes. After a general description of risk assessment process and its role in the project selection, the three phases are presented separately: identification, analysis and evaluation.

Overview of the risk assessment process

All companies had a specified risk assessment procedure, however at different levels of detail. In all cases, some tools and methods were specified.

In order to adjust the level of risk assessment work, one company initially categorised projects based on their level of complexity. The level of complexity was based on the two factors customer and technology, both ranging from well-known to unknown. The lowest level was a well-known customer and existing technology as "for example in a repeat order /…/ with the exact same product to the exact same customer". The highest level was likewise an unknown customer and unknown technology, i.e. "a complete development project where the customer is unfamiliar".

Who took part in the risk assessment?

The participants in the risk assessment process varied somewhat, but a common view was that the group should be inter-disciplinary. The project group, if assigned at that early stage, had to work "with several departments, like purchasing, engineering, product development and so on". Often, the workshops were led by an educated facilitator. The facilitator not only maximised the efficiency of the workshops, but also contributed with experience from earlier risk analyses.

How were risks identified?

Possible risks were usually identified in workshops through brainstorming. There was however not always a formally structured process for the brainstorming, but merely a creative group discussion. In one case, it was desired that the brainstorming group members had prepared risk factors before the workshop. The deliverable for these workshops was a risk list, containing all identified risks that could affect the outcome. In one case, this workshop dealt only with project risks, whereas end effect risks were taken out for the finance and marketing department to analyse.

An alternative example was a semi-intelligent question database functioning as a risk funnel early in the idea phase. The database had been developed through study of historical hazardous projects and "analysing what factors were present in those projects that affected the final result", i.e. the trigger factors for project failure. A database of questions was then developed where the questions were chosen based on preceding answers. By answering the questions, the presence of these trigger factors was analysed.

An alternative example was just about to be implemented. It was a standardised template where the project manager enters a value, 1, 3 or 5, for the degree to which a given risk factor is present. The risk factors were in this case the technical risk, the difficulty to implement, the difficulty to find competent resources, the degree of operational change, the number of inter-project dependences and the number of involved internal and external units. These risks were then summed up to a total risk value for the project. "I think it is too many, in one way. I feel that they are of different importance, but this is just a draft."

In order to analyse the uncertainties in duration, budget or resources, *Monte Carlo* simulation was in one case used (through the *Microsoft Project* add-in *@Risk*). A simulation was then run for example on the complete project schedule to find out what the situation really looks like. This could help identify risk factors otherwise overlooked. For example, "if the critical path is not where you thought it would be, issues can be interesting other than those you thought. And the ordinary way to plan with critical path is somewhat dangerous. It is very easy just to put on a filter and then move all that is not critical out of sight, and then you think that you have control of everything. But it is only critical given that each activity last the time you have guessed, and that's just guesses. And if it doesn't last that time, totally different things are critical, but then you have filtered them out of the view and that is rather dangerous."

Another alternative was a method for uncertainty analysis called *Project control Glahn Lichtenberg* (*PGL*), based on the *Successive Principle*. The method included a software tool that was used during a workshop, led by an educated facilitator. The method focused on one factor of choice, usually time or budget. The choice of factor was considered rather obvious as the knowledge was thought to exist within the organisation. This factor was then successively analysed using three-point estimates starting with a handful of subgroups, usually the first blocks in the WBS. The values were inserted in the software tool which, based on simple statistical calculations, returned if the level of uncertainty was acceptable. If not, the subgroup must be broken down into its subgroups, and the process repeated until all uncertainties were identified and mapped. For smaller projects, this method was simplified and a spreadsheet-based version of the software was used.

Experience from earlier projects was only formally incorporated in one case. This company had developed a database for risk identification, the "risk and opportunity database". "As soon as a tender is initiated, the risk manager starts a new project in the risk database, where all risks and opportunities are recorded. It is a working document from the very start of the tender." As a new project was started, the project manager must search through the database for projects with similarities, thus try and find risk factors that had otherwise possibly been overlooked. For example, the project manager could search for risk factors identified for a certain supplier and further track previously taken actions and their effects. It was considered very important to find the patterns, "a risk in one project can be very small, but if it appears everywhere, it can be hazardous".

How were risks analysed?

Generally, the tool *Mini Risk* or similar was used for risk assessment. The risks were then measured using a five point scale for probability of occurrence and impact. The *Mini Risk* also included creation of action plans for the risks. The company using the *PGL* method measured uncertainty using three-point estimates and standard deviation, all in the units used for the estimates.

The level of measurement should be adjusted to the number of decisions that are to be made; "from a portfolio perspective, if you are to evaluate fifty projects traffic lights is about what you can handle, but if you are to evaluate four projects in a portfolio you can go into another level of detail".

A difference between analysing specific risk factors and analysing uncertainties in estimates was pinpointed in one case. "The ordinary *Mini Risk* is very good if you just want a general overview of the situation, but is doesn't tell very much of the chances of completing the project in time, or within budget." Uncertainty analysis such as *Monte Carlo* analysis presents the expected outcome in the units used for the estimates and, thus was one solution.

How were risks evaluated?

Risk evaluation was the least described phase of risk assessment. The common view was that evaluation dealt with a large amount of feeling and few formal processes were mentioned.

In the case where *PGL* and *Mini Risk* were used, the results from both were used as a basis for decision, whereas the highest scored risks from the *Mini Risk* were brought to the project for risk management. In one case, the *Mini Risk* was used merely as a risk prioritisation rather than a basis for decision.

One company put the total risk value summed from the standardised risk factor rating against a total project value calculated from other factors. These two were displayed in a risk-value bubble diagram for all projects and was used as the basis for decision.

5 Discussion

The discussion connects theory with empirical findings and also contains thoughts and suggestions made by the author. Initially, main issues found in the study are presented. This is followed by a more detailed discussion of a number of issues. The risk assessment process at SKF will then be evaluated and discussed phase by phase.

5.1 Main issues

The fundamental terms risk and uncertainty are first discussed. After that follows a discussion on what to assess, i.e. how to approach risk assessment. Finally, important best practise findings for the three phases of risk assessment are discussed: *identification*, *analysis* and *evaluation*.

5.1.1 Risk and uncertainty

The distinction between risk and uncertainty made by Olsson (2005) gives that uncertainties may be either risks or opportunities, as risk and opportunity are two sides of the same coin. This was supported by the empirical findings, as most of the benchmarked companies had clearly distinguished the two, whereas a few had not.

To further develop and clarify the difference between risk and uncertainty (Kendrick, 2003; OGC, 2002; Olsson, 2005; PMBOK, 2004; Schuyler, 2001), the visualisation in Figure 5.1 was created. A specific event or outcome has an expected case which is the most likely value. When possible and feasible, a best and a worst case can be specified to enhance the image and understanding. The span in between is the uncertainty, with risk and opportunity as the two sides. The best and the worst case may not always be the utmost limits, but the likely limits, however yet enhancing the description of the uncertainty. Also note that the expected case may not necessarily be in the middle of the variation span.

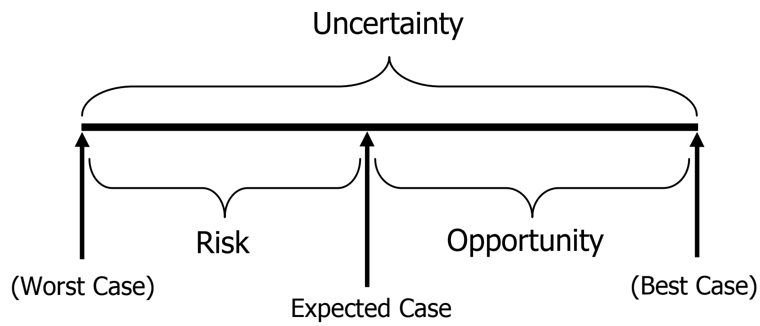


Figure 5.1. Risk, opportunity and uncertainty.

The visualisation further shows a useful distinction between assessments of the two aspects risk and uncertainty. This was utilized by the companies where the *PGL*, based on the *Successive Principle* (Lichtenberg, 2000), and sensitivity analysis were used and where *Monte Carlo* simulation (Schuyler, 2001) was suggested. Other companies either did not make the differentiation or did but did not specifically identify and analyse uncertainties.

Uncertainties are beneficially considered separately. When a project is evaluated on a number of criteria, all estimates and values each have uncertainties. Hence, uncertainties exist and should be considered in all aspects of project evaluation. Uncertainty analysis shows how much is known about the project and the areas where the uncertainty is largest, as in the *PGL* and *Monte Carlo* simulation used at two of the companies. The uncertainty in expected outcome is important as it shows the quality of the forecast; large uncertainties may be a risk in itself, meaning that the knowledge of the projects is low.

Risk assessment methods are for example *Mini Risk* (Bartlett, 2002; Hamilton, 1996; Nelson & Eubanks, 2005; Wenell, 2005b), the standardised charts and various ways of incorporating experience that were used at the benchmarked companies. Such methods aim to find specific risk outcomes, such as reduced performance due to low raw material quality. Clearly expressed outcomes are discussed that may be easier for the team to relate to, which was noted during the benchmarking. As stated by one of the benchmarked companies, experience may exist from specific incidents in earlier projects that may occur again, thus being easily addressed as risks. This was seen as many of the benchmarked companies stressed the importance of a multi-disciplinary and experienced workshop group.

Putting the two concepts against each other, uncertainty and risk analysis could however come to the same conclusion; *Mini Risk* could address many of the reasons for a delayed task and a project duration simulation could address several specific impacts that would delay a task, both summing the likely outcome. However, as the focus and starting points are rather different, they each have advantages and should both be used, separately to avoid confusion. As stated by one of the interviewees, *Mini Risk* is a good way to create an overview, but does not tell much of the chances of finishing on time. Risk analysis and uncertainty analysis are here both included in the term risk assessment.

5.1.2 What to assess

Before analysing specific tools and methods, risk assessment will be discussed from a more generic point of view, i.e. what is to be assessed. The three phases of risk assessment will then be discussed successively.

Several of the benchmarked companies meant that risk identification must not become a burden, but rather be seen as a creative a part of the process where insight is gained about the project. Hence, the risk identification method must be time efficient, easy and understandable. There is evidently a risk in overdoing risk assessment that must be overcome. One of the companies had an initial screening process in order to categorise projects after complexity. The level of risk assessment work was then adjusted to the complexity of the project, in order not for simple projects to spend too much resources on risk assessment.

In order to approach the risk evaluation needs, a rough outline of risk assessment is presented in Figure 5.2, based on the work conducted during the three phases of risk assessment (Chapman, 1997; Pfleeger, 2000; PMBOK, 2004; Wideman, 1992). Risks are first identified out of all existing risks. During the analysis, risk responses are planned for as many risks as possible, aiming to reduce risk exposure to an acceptable limit. Risks for which sufficient responses cannot be planned remain critical. Finally, portfolio management evaluates the results of risk analysis.

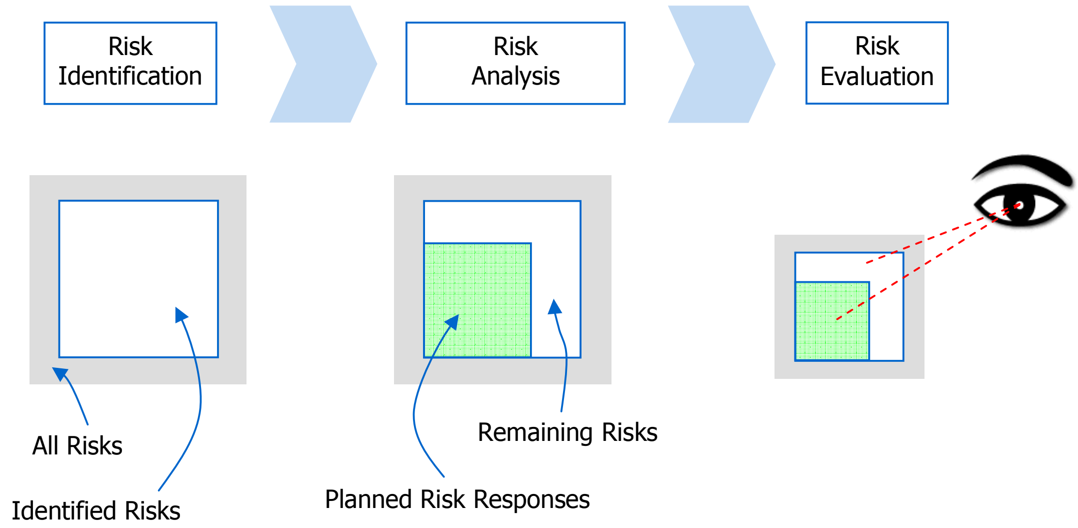


Figure 5.2. A rough outline of the risk assessment process.

Taking this reasoning one step further, the risk categorisation during the analysis phase will be investigated. As found during the benchmarking, some companies analysed internal and external risks separately. This separation was mainly motivated by project managers not having enough knowledge of external matters, thus often letting internal matters outweigh external. This relates to the definition of project goal and end effects (Wenell, 2005b), which in turn enables a distinction between project risks and end effect risks; project risks are the risks involved in the accomplishment of the project goal and end effect risks are the risks involved in the reach of the end effects given that the project goal is reached. Integrating these two theories gives that not all the project risks ought to be dealt with within the project. Examples are risks related to project dependencies or uncertainties in market forecasts for a *technology & competence development* project. For the distinction to be useful, these theories are extended and a category is created called *risks that ought to be dealt with within the project*, visualised as those enclosed by the broken lines in Figure 5.3. The category may not cover all risk up to the project goal; some risks may require too much resources to deal with or are better dealt with elsewhere in the organisation. The responsibility of analysing and further on managing these risks lies within the project group, not saying that they should be neglected by portfolio management. These risks may be relevant to present in a risk response maturity grid, as presented by Lewis and Wong (2005).

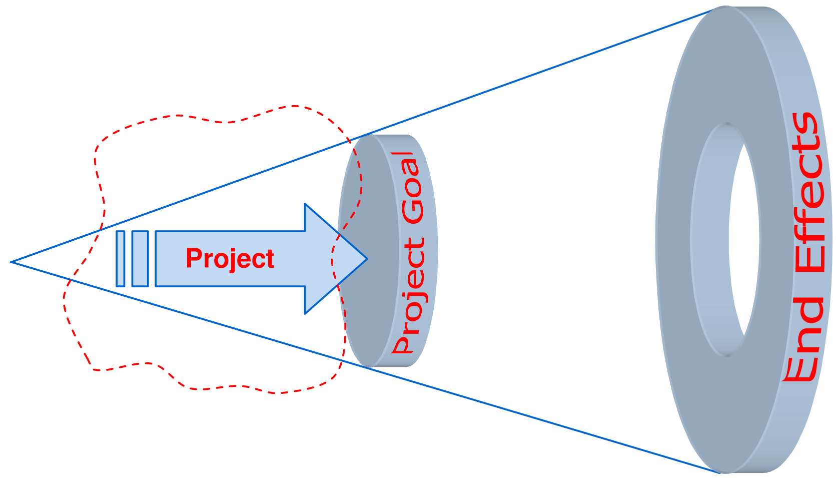


Figure 5.3. Risks that ought to be dealt with within the project.

Also a second category is created: *remaining risks* are those that either ought not to be dealt with within the project or that cannot be dealt with within the project. This category naturally includes the end effect risks, as those by definition are not part of the project goal. Note that this category may cover some project risks, as enclosed by the broken line in Figure 5.4. The overlap covers risks that require too much resources to deal with within the project.

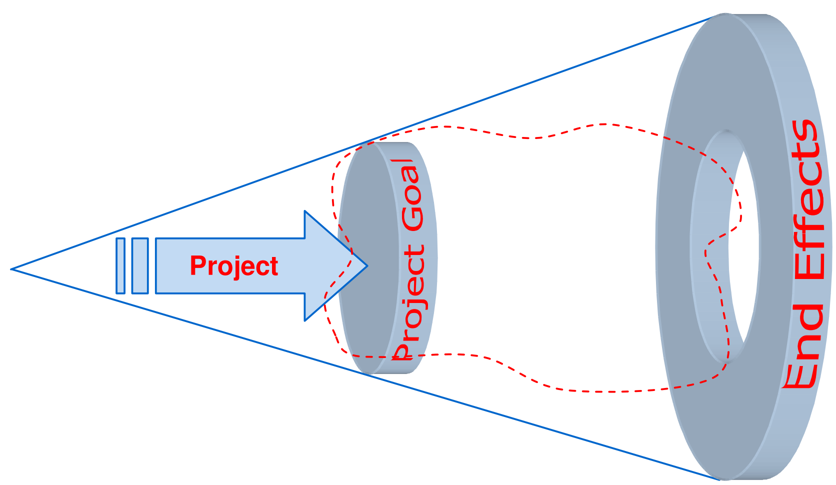


Figure 5.4. Remaining risks.

One of the benchmarked companies had removed business related issues from the project team's risk identification and analysis. This is one example of how some risks are not dealt with within the project and therefore assessed separately. This categorisation of risks into *risks that ought to be dealt with within the project* and *remaining risks* partly aims to increase the understanding of risk assessment, partly has implications in risk evaluation that will be discussed further on. However, tools for the three phases will first be analysed and discussed.

Risk identification

The empirical results show that risks are best identified through brainstorming workshops. Theory on brainstorming suggests that a brainstorming should not have any restrictions or frames for the ideas (Wideman, 1992). However, the benchmarking showed that some assistance may be beneficial; among the supporting tools used at the companies were standardised forms, a risk database and a suggested matrix or checklist for use afterwards. Three important ingredients of successful risk identification were found during the benchmarking:

- *Participants*: multi-disciplinary groups including management and sponsor are a key factor of efficient risk identification, as stressed by most of the benchmarked companies. Such groups not only identify more risks factors, but also establish more understanding for the projects from sponsor and management. This is supported by for example Lichtenberg (2000) and Wideman (1992).
- *Facilitator*: as practised by two of the companies and suggested by one, the use of an experienced facilitator improves the quality of the workshop and helps to better utilize the positive effects of brainstorming. Facilitators with experience from risk identification also help assure that all risk areas are covered and that common risks that have appeared in other projects are addressed. This is supported by for example Lichtenberg (2000).
- *Method of verifying identification coverage*: in order to verify that all risk areas are covered, different tools can be used, some during the brainstorming and some afterwards. In order to assure a wide coverage during the workshop either a matrix, as suggested by one of the interviewees and supported by Lichtenberg (2000), or focus areas or headings (Bartlett, 2002; PMBOK, 2004) can be used. The difference is in level of structure. Focus areas provide more structure and help, thus increases the risk for a too narrow identification. A matrix, on the other hand, provides less help but encourages a wider perspective. Whatever method is chosen, a checklist can be used afterwards to check whether a set of known important issues have been covered (Cooper, 2001; OGC, 2002; Pfleeger, 2000).

Risk analysis

Methods for risk analysis are dealt with first, followed by methods for uncertainty analysis.

Mini Risk (Bartlett, 2002; Hamilton, 1996; Nelson & Eubanks, 2005; Wenell, 2005b) was by far the most popular method for risk analysis among the benchmarked companies. The interviewees at the benchmarked companies using such methods explained benefits as quickness and ease of use. There are different ways of quantifying or measuring risk, whereof mainly scores were used at the benchmarked companies due to the ease of use. Using monetary measures was briefly mentioned as having advantages being more tangible, however more exacting. Scores, e.g. 1-5 or low-high, have the advantage of enabling comparability between risks of different nature (Bartlett, 2002; Hamilton, 1996; Nelson & Eubanks, 2005). However, it provides low comparability between projects unless a standardised scale is used. The somewhat more demanding but more tangible use of monetary values were not used at any of the companies more than for occasional quantification of a few risks. Monetary values, or possibly expressed as percentage of the whole project, provides improved comparability between projects, and facilitates better understanding and communication. This is supported by Bartlett's suggestions of using percentages of the whole (2002).

These companies all prioritised the risks, as suggested by Pfleeger (2000), and created a top priority risk list to focus on. This list was in two cases used both for risk evaluation and further on risk control or risk management during the project. The planning of risk responses (Bartlett, 2002; OCG, 2002) together with risk prioritisation (Pfleeger, 2000), both included in risk analysis, creates an iterative loop (Chapman, 1997). An extension of these theories gives that as risks are prioritised, risk responses should be created for the most important risks with the purpose of reducing the risk probability or impact. New estimates must be made for the expected effect of the risk response, thus the resulting risk score after the risk response. This may change the top priority risk list, thus open for new risk responses to be created. After working through many of risks, the overall risk level has probably been significantly lowered and the knowledge of the risks increased. The risk value after planned risk responses may tell more about the actual risk level, as some identified risks may easily be dealt with, thus are not really hazardous when identified and responded to. Hence, risk response planning is a fundamental issue in risk analysis.

Uncertainty analysis may deal with uncertainty in project estimates, as at the companies using *PGL* and *Monte Carlo* simulation of project WBS. On the other hand, all forecasts have uncertainties (Lichtenberg, 2000), and the end effects should also be analysed. Applied to the made distinction between *risks that ought to be dealt with within the project* and *remaining risks*, WBS analysis and simulation fall in to the first category. As at some of the benchmarked companies, uncertainty in forecast was measured, either by a score, an interval or a distribution. This addresses the importance of evaluating the uncertainty in end effects forecast which, integrated with the figure created from Wenell (2005b), can be visualised as in Figure 5.5 to distinguish the uncertainty in forecasts from specific risk factors.

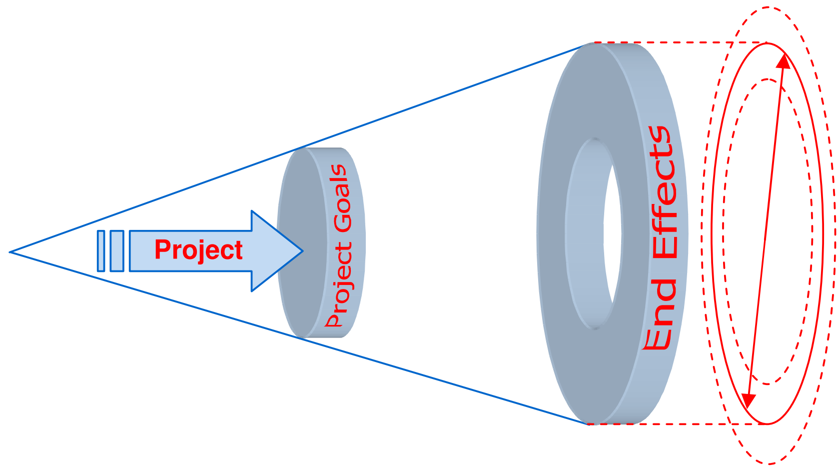


Figure 5.5. Uncertainty in project end effects forecast.

There are a number of methods for uncertainty analysis presented, that each has advantages and disadvantages. *Monte Carlo* simulation is a powerful method of uncertainty analysis as presented in theory (Cooper, Edgett & Kleinschmidt, 2001; Schuyler, 2001) and as suggested by one of the interviewees. Even though rather large amounts of inputs are required, the output is simple and visual. Specifying all sub-groups of a project requires a high detail of planning, which may not be feasible for smaller projects or early on in the project. The *Successive Principle*, as presented by Lichtenberg (2000) having similarities with the *PGL* used at one of the companies, effectively narrows down on the most critical area, the core of uncertainty. This way, the method is a more time efficient way of receiving a good estimate of the individual parts as well as the total. Common for the above methods is that they require rather extensive input. They may thus not be feasible for smaller or uncomplicated projects. Also, these methods may be more feasible for project related matters rather than end effect matters, such as market share and expected cascading possibilities. None of the benchmarked companies presented a method for uncertainty analysis of end effects forecast. One of the interviewees described the sensitivity analysis performed which, although it does not analyse uncertainty, shows the forecast's robustness to variation.

Risk evaluation

The empirical findings show that comparability between projects is not always desired; the main part of the interviewees stressed that all projects are very different and that achieving strict comparability was impossible. However, the area of risk evaluation was rather briefly described by the interviewees. A common view suggested that free scope must be allowed for feeling in the evaluation. Before discussing tools and methods for evaluation, three different approaches in risk evaluation that have crystallised during the study will be discussed:

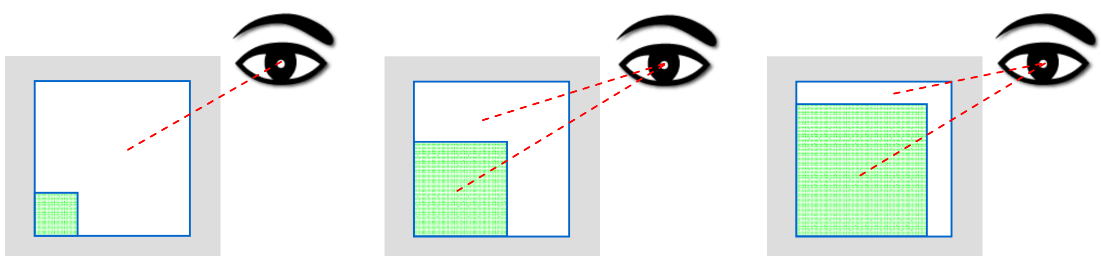
1. *The risk level of the project is being evaluated*. Risk exposure can be plotted against the project's importance or value, e.g. strategically, financially or proprietary; one of the benchmarked companies presented bubble diagrams where risk was plotted against reward as a main factor in the evaluation. This approach was proven popular in the study made by Cooper (2001). Plotting several projects in the same chart is tempting, however should be done with care; it must be considered when evaluating such diagrams that even if the measures of reward may be strictly comparable the risk level may not, as discussed earlier (Bartlett, 2002; Hamilton, 1996; Nelson & Eubanks, 2005). The selection decision is based on the relation between risk and reward (Cooper, 2001).
2. *The uncertainty of the project is being evaluated*. As stated by Schuyler (2001), Lichtenberg (2000) and the companies using *PGL* and suggesting *Monte Carlo* simulation, uncertainty gives a better picture of the actual project. The selection decision is positive if the uncertainty of the project is within an acceptable limit, e.g. if the uncertainty of the duration causes acceptable deviation from the target.
3. *The risks are being reduced to an acceptable level*. This focus is on the risk responses for the identified risks, which was called action plans at the benchmarked companies, and is an integration and extension of the theories of risk analysis as an iterative loop (Chapman, 1997; Pfleeger, 2000) and the categorisation of *risks that ought to be dealt with within the project*. If action plans, which avoid or reduce the impact of the risk to an acceptable level, exist for all risks, they can be incorporated in the project, e.g. financially in the project budget or as duration in the project schedule. This relates to evaluating the risk response maturity, based on the theory presented by Lewis and Wong (2005). The selection decision is based on to which extent all risks, thus also the total risk level, are acceptable.

These three approaches significantly affect the way the decision is made. The first two approaches imply that the results from the risk or uncertainty analysis are compared between projects in one way or another. The third approach however shows the extent to which risks are eliminated, i.e. how thorough the conducted risk assessment work is. Combinations of the three methods may be possible, however requires more feeling and complexity of judgment in the evaluation. The three methods may each be favourable, however in different situations or portfolios.

5.1.3 Different portfolio – different risk assessment

From the earlier discussion follows that the evaluation material may be approached differently depending on the nature of the portfolio's projects and portfolio management needs. Hence, the development of a risk assessment process for project selection should start from a portfolio perspective.

Extending the evaluation phase as presented in Figure 5.2, different evaluation foci can be visualised for comparison as in Figure 5.6a-c. Some projects (a) allow for little risk response planning and evaluation should have a holistic focus on risk exposure. Other (b) allow for some risk responses to be planned and evaluation should focus on the risk response planning as well as the risk exposure. Finally, in some projects (c) most risks can be planned risk responses far. Risks that remain critical should each be evaluated individually, and focus should then be on the risk response planning.



a *b* *c*

Figure 5.6a-c. Different levels of risk response planning.

These three examples show how evaluation may focus and what issues may be brought up during the evaluation session.

5.2 Current risk assessment at SKF

The current project model included risk assessment with *Mini Risk* and the portfolio management processes all included various types of risk assessment. The processes for portfolio management were undergoing development and improvements continuously were made, and it was mentioned that a common view on risk and risk assessment would be beneficial.

A classification of projects is part of the project model. All projects are classified as either A, B or C projects, where class A projects are just a few large projects, class B are regular projects and class C are small projects. The guiding factors and project characteristics are:

- *Business importance*.
- *Impact of uncertainties*, such as recall and warranty costs, long term commitments, legal suites, loss making business etc.
- *Total need of resources, measured in man-hours*.
- *The need for coordination*.

This classification aims to secure that the appropriate project format and control is applied to the individual projects as well as to facilitate the project portfolio structure. It should be notes that the classification does not reflect the priority of the project (SKF, 2005a). The classification is not optimised for risk assessment classification, but additions to the criteria may enable the use of this well established classification also for risk assessment purposes.

Mini Risk has been and is being used extensively within SKF as the main risk analysis method. The risks analysed were evaluated in the project selection decision.

Bubble diagrams

In the *NMO* and *technology & competence development* processes, bubble diagrams were used for evaluation. The diagrams were based on the business case evaluation form, with grades ranging from 1-5. In one diagram, the y-axis was titled v*alue for SKF* and calculated as the mean of *accumulated TVA* and *certainty of PPC estimations*. Placing the *value for SKF* on the y-axis thus involves putting an uncertainty factor on the y-axis. Risk, which was on the x-axis, should more naturally include this uncertainty. Further, *accumulated TVA* is affected by *customer need*, *customer value* and *market size,* among other factors. Hence, viewing risk as the interpreted negative side of uncertainty gives that the higher the risk, the wider the uncertainty span, as shown in Figure 5.7.

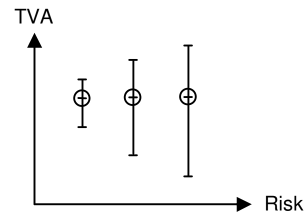


Figure 5.7. Problem with bubble diagrams.

This shows limited functionality of the diagram. Risk is built into the y-axis and is not an independent variable on the x-axis. This problem arises when risks are closely linked to reward, e.g. when reward is TVA and risks are mainly market risks. In this case, TVA may better be expressed with an uncertainty interval on the y-axis, plotted against an independent variable, such as strategic alignment. When risk and reward are not closely linked, such as in technological research projects where the risks are mainly technological, financial reward such as TVA can be plotted against risk.

5.3 Suggestions of improvements

In developing a portfolio management process, it should be established how risk is best incorporated in the selection decision and based on that specify what information is required from each project. A common view on risk and risk assessment, shared by projects and portfolio management, would provide a good framework in this development. An established common set of values would clarify the difference between risk and uncertainty, the different types of risk assessment and how the overall risk level of a project is best assessed.

The current risk assessment processes can be improved on a number of issues. A fundament for this, thus an improvement to be made initially, is to establish a common definition base for risk in order to achieve a better understanding and support further improvements (AIRMIC, ALARM & IRM, 2002). Also the suggested general process for risk assessment will be discussed.

As discussed earlier, there are different types of risks and uncertainties to evaluate. In order to assure a full coverage, these types must all be covered in the risk assessment process, regardless of the specific tools used.

5.3.1 Initial screening

Different projects may require different levels of risk assessment; for a very small project, a thorough risk assessment may involve a disproportional amount of work, whereas it may be necessary to understand a large and complex project.

In order to improve the initial screening, a checklist with yes/no questions, as presented by Cooper (2001) is one alternative offering a quick judgement of a number of characteristic factors. Focus is not on making the screening failure proof, but rather to enable for an initial overview in order to choose the right process; the project is allowed to change class later on if appropriate, as expressed by one of the benchmarked companies. However, as there are three project classes, a three level scoring of each factor is preferable. Marmgren and Ragnarsson (2001) named four factors that give the complexity of a project, whereof not all are covered in the current screening. Size is covered as the total need of resources but could preferably be complemented with budget. Novelty is included mainly in technical risk and should be paid more attention. Similarly, the surroundings are included in the mainly risk aspects and should also be stressed more. A suggestion of checklist factors is given in Table 5.8.

	Low	Medium	High
Business importance			
Risk of recall and/or warranty cost			
Budget			
Resources			
Project dependencies			
Product dependencies			
The surroundings			
Novelty			
Financial risk			
Technical risk			
Safety risk			

Table 5.8. Scoring model for initial screening.

The levels should classify a project with all scores low as class A, one or more medium as class B and one or more high as class C. The three levels for each issue should be quantified if possible, otherwise described as clearly as possible. This quantification must be calibrated to the projects in the portfolio so that the desired number of projects fall into each category.

5.3.2 Risk assessment

An overall common process of risk assessment should be established for a clear overview. The three successive phases will here be discussed individually.

Risk identification

The current processes at SKF include a brainstorming session; however, application of the best practise factors presented earlier, the quality of the work can be increased by a number of improvements:

- *Participants*: the importance of multi-disciplinary groups including management and sponsor must be stressed. Personnel from different departments, such as finance or marketing, must also be included. The time required from the participants will most likely be worth wile.
- *Facilitator*: an experienced facilitator should be considered. A facilitator could also contribute to the risk assessment process development by monitoring different sets of participants, thus finding a good balance between used resources and gained value. Further, methods for verification of identification coverage could also be better evaluated.
- *Method for verification of identification coverage*: A checklist should always be used to afterwards go through the identified risks. Where gaps exist, the brainstorming should continue. The checklist should be developed individually for each portfolio and the PRINCE2 checklist (OGC, 2002), presented in Appendix 3, could be used as a starting point. If the workshop group has a too narrow perspective, a list of focus groups can be used. If a facilitator is available, a matrix can be used for increased coverage, such as the suggested matrix in Table 5.9.

	Technical	Commercial	Resource	Other
Environment				
Organisation				
Project				

Table 5.9. Risk identification matrix.

Risk analysis

The currently used *Mini Risk*, with a scale ranging from 1-5, is rather efficient for ranking the risk factors. The main improvement that can be made is the risk response planning and the view of risk analysis as an iterative loop. The concept of risk responses and an iterative loop should be implemented in the process. As the highest ranked risks have been assigned risk responses, new risk scores should be produced taking the risk response into account. This gives a new set of highest ranked risks for analysis. As the iterative loop proceeds, as shown in Figure 5.10, the final risk list appears that will further on be evaluated. These remaining risks should be quantified in monetary values or as a percentage of the whole project to give a better view of the implications of the risks.

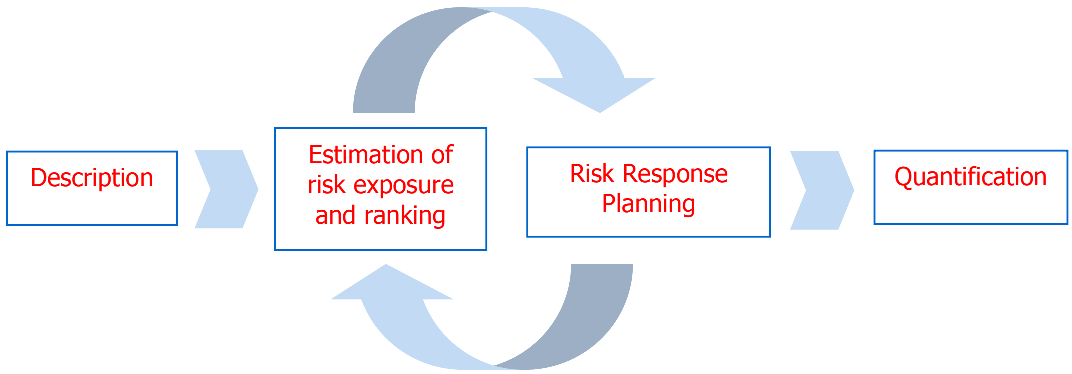


Figure 5.10. Risk analysis as an iterative process.

For class A projects, *Monte Carlo* simulation or the successive method should be used for a more detailed assessment of time and budget estimates.

Risk evaluation

As visualised in Figure 5.6a-c, the three portfolios have different foci and thus require different risk evaluation. However, portfolio management must always assure that all aspects of risk and uncertainty are evaluated, as shown in Figure 5.11, even though the foci will be different.

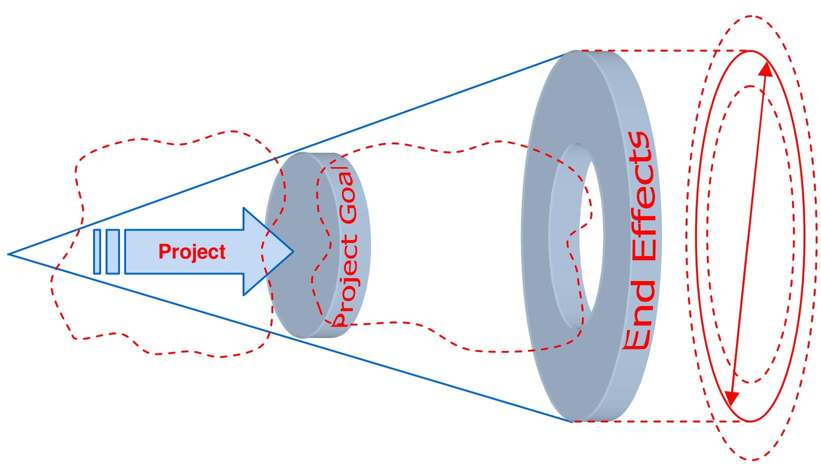


Figure 5.11. Risk and uncertainty in project goal and end effects.

Based on the difference in possible risk response planning visualised in Figure 5.6a-c, the categorisation of *risks that ought to be dealt with within the project* and *remaining risks*, and uncertainty in end effects visualised in Figure 5.5, exampled of three evaluation foci are given. Each portfolio should analyse what the characteristics are, if generalisations are feasible and finally what focus is appropriate. In all cases, the aim is to direct the discussion to the appropriate focus.

For projects where most risk responses can be planned for a small amount of the risks, a large group of remaining risks are left that are of interest, as shown in Figure 5.6a. It is here of interest to evaluate the overall risk level. Depending on the nature of the risks, as discussed earlier, risk can either be plotted against reward or included in plots as an uncertainty span. The highest ranked risks are of interest and should be evaluated. The large amount of remaining risks can be divided into subgroups or headings as to show where the highest risks can be found, thus direct discussion.

For projects where risk responses can be planned for a large part of the risks, they are highly interesting, as shown in Figure 5.6c, and maturity of response planning should be evaluated. The most critical remaining risks are very important as they are a threat to project success. As they are relatively few, they can be evaluated individually.

For projects where risk responses can be planned for some of the risks and that thus fall in between the two earlier mentioned characteristics, as shown in Figure 5.6b, evaluation must consider both aspects; the maturity of response planning as well as the highest ranked remaining risks must both be evaluated in order for a full coverage.

In all cases, a business case evaluation should include at least a discussion of uncertainties in end effects forecasts. The focus adopted may be based either on the nature of the portfolio's projects or on the maturity of risk assessment, e.g. the degree to which project managers plan risk responses. The choice of focus may thus change with time and process improvement.

5.4 Limitations of current theory

Risk assessment theory well covers risk identification and risk analysis with an abundance of methods, tools and techniques. Risk evaluation on the other hand, is usually covered briefly and in generic terms. This may be explained by risk evaluation touching upon decision theory rather than conventional risk management theory, thus brings a whole new subject into risk management that not all theorists dig in to. It may also be explained by a widespread reliance on feeling in the evaluation phase.

5.5 Validity and reliability

The benchmarked companies' portfolios differed in some aspects from the portfolios at SKF. Projects were generally larger and had heavier and more detailed processes than feasible at SKF. Further, they were mostly of a *customer order* nature, which reduced the comparability. The least covered area was *technology & competence development*.

The lack of results regarding risk evaluation may depend on the choice of interviewees. Had interviewees been chosen with more experience from project selection rather than the earlier two phases of risk assessment, the quality of those answers would probably have been higher.

The interviews are subject to several types of bias, whereof most are caused by the interviewer. The use of a semi-structured interview guide with open ended questions for the benchmarking interviews may have reduced the validity.

6 Conclusion

This chapter will present conclusions derived from the analysis. A final reflection will deal with thoughts about the conducted research. Finally, suggestions of areas for further research will be given.

Risk management is an area of research that needs continued development. Many companies strive to improve their risk assessment processes by using simple tools and methods. Many of the available tools and methods are extensive and involve statistical models that require large amounts of input. These methods seem less feasible for implementation in rather immature processes.

6.1 Main conclusions

The initial step in the improvement at SKF should be to establish a common view on risk, fundamental definitions and terminology and a common overall risk assessment process.

Before setting the details, it may be beneficial to outline the process and its phases. Risk assessment consists of three phases: risk identification, risk analysis and risk evaluation, as presented in Figure 5.2.

There is a fundamental difference between risk and uncertainty, as presented in Figure 5.1, thus also between risk and uncertainty assessment. Based on the theory of project goal and end effects, as was visualised in Figure 5.3 and Figure 5.4, combined with the level of risk response planning possible, as was visualised in Figure 5.6a-c, risks can be classified in two groups:

- *Risk that ought to be dealt with within the project*. These risks can be reduced to an acceptable level by planned risk responses.
- *Remaining risks*. These risks either cannot sufficiently be dealt with within the project or should not.

A generalisation made from this classification suggests that portfolio management should approach risk evaluation differently depending on the nature of the portfolio. Where most risks *ought to be dealt with within the project*, such as in customer order projects, the maturity of response planning should be evaluated. Where few risks *ought to be dealt with within the project*, the overall risk level is of greater interest, as by plotting risk against another variable such as reward or strategic alignment.

Portfolio management should consider the portfolio's projects' characteristics when approaching risk evaluation, as was visualised in Figure 5.6a-c. This perspective further on gives suggested improvements of risk evaluation foci.

6.1.1 Suggested improvements

Before presenting suggestions for the three phases, it has been found that the level of detail of the risk assessment work beneficially can be adjusted by an initial screening. To the current project classification, into class A, B and C, should be added criteria for project complexity and thus address the risk assessment needs of a project better.

Risk identification should be based on a brainstorming workshop, assisted by either an *identification matrix* or *headings* and the coverage should be verified afterwards by a *checklist* containing known important issues. The deliverable is a risk list, possibly classified in a number of sub-groups according to the headings created.

Risk analysis should start with *Mini Risk*, where exposure is estimated, *risk responses planned* and the risks list *prioritised*. This phase may involve the largest improvements as the iterative risk response planning and prioritisation is introduced, as was visualised in Figure 5.9. During the analysis, depending on portfolio, risks that *ought to be dealt with within the project* should also be analysed according to *maturity of response planning*, whereas the most critical *remaining risks* should be listed. These most critical risks should be *quantified*, preferably in monetary values or as percentages of the total project. For projects that require more thorough risk assessment, given by the screening, a *Monte Carlo* simulation should be run assisted by an educated facilitator.

Based on the different levels of risk response planning possible, as seen in Figure 5.6a-c, portfolios may have different foci during risk evaluation. Fundamentally, focus is on either the remaining risks or the maturity of response planning. Depending on the nature of the risks, the overall risk level can be evaluated either by plotting risk against reward or by including risk as an uncertainty span.

The choice of focus may be based either on the nature of the portfolio's projects or the maturity of risk assessment in general, e.g. the degree to which project managers plan risk responses. Note further, that all suggested improvements should be evaluated during a trial period before launch. They should also be adjusted to all recent changes made to portfolio management processes.

6.2 Final reflection

The aim with this thesis was to study risk assessment from an overall perspective. Rather free scope was allowed for reasoning based on the theoretical and empirical findings. Most of the reasoning was been made in cooperation with supervisor at SKF with focus on creating improvements feasible for implementation. The study aimed not to present a full, detailed process for three main reasons: (1) there are very few comprehensive solutions available in theory and practise, (2) the work required for finalising a risk assessment process was considered too extensive, and (3) as legislation and standardisation constantly evolve, as presented in the suggestions for further studies, the process development is more of an continuously on-going activity; as a process is finalised, the requirements may have changed.

6.3 Suggestions for further studies

The best way to turn the made suggestions into practical tools is most likely to apply them on a set of projects and evaluate the results. This evaluation should focus on any noticeable quality changes between the proposed improvements and the current processes, as well as feasibility, i.e. if the methods are practical to use in daily work.

The initial screening process should be further developed and the checklist issues quantified. The best way to do this is probably an iterative process with quantification and testing on the current project portfolios. The quantifications may well vary between the different portfolios.

Incorporating experience from prior projects can be beneficial for the risk assessment results. Not only in order to help identify risks, but also to detect trends. Thus, a study of historical hazardous projects could be conducted in order to create a tool, such as a risk funnel or a checklist, highlighting and stressing these issues.

The area of *technology & competence development* should be further analysed. The empirical findings of this study were mainly from *customer order* oriented projects and there are evidently main differences between the two.

Project risk assessment processes may also be affected by wider-stretching systems that holistically quantify and measure threats affecting the ability of the organisation to reach its operational and strategic objectives. The outgrowths of the Sarbanes-Oxley Act of 2002 and similar legislation has created a need among many companies worldwide to maintain such systems of internal control. Enterprise Risk Management (ERM), as described by O'Donnell (2004), Berry and Phillips (1998) and the Committee of Sponsoring Organisations of the Treadway Commission (COSO, 2004), is one such system. A future implementation of ERM may affect the requirements for project risk assessment. Also, an ISO standardised "risk management terminology" has being developed, seemingly a first step towards a more complete standard (Knight, 2003).

7 References

About SKF (2005) Available at: http://www.skf.com/portal/skf/about/ (Accessed: 8 January 2006).

AIRMIC, ALARM & IRM (2002) *A risk management standard*. Available at: http://www.theirm.org/publications/documents/Risk_Management_Standard_030820.pdf (Accessed: 20 December 2005).

Archibald, R. D. (1992) *Managing high-technology programs and projects*. 2nd edn. New York: John Wiley & Sons Inc.

Bartlett, J. (2002) *Managing risk for projects and programmes*. Hampshire: Project Manager Today Publications.

Berry, A. Phillips, J. (1998) "Pulling it together", *Risk Management*, 45(9), pp. 53-58, *Proquest* [Online]. Available at: http://www.proquest.com/ (Accessed: 20 December 2005).

Chapman, C. (1997) "Project risk analysis and management – PRAM the generic process", *International Journal of Project Management*, 15(5), pp. 273-281, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 5 November 2005).

Chapman, C. & Ward, S. (2000a) "Estimation and evaluation of uncertainty: a minimalist first-pass approach", *International Journal of Project Management*, 18, pp. 369-383, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 7 November 2005).

Chapman, C. & Ward, S. (2000b) "Incorporating uncertainty in competitive bidding", *International Journal of Project Management*, 18, pp. 337-347, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 7 November 2005).

Chapman, C. & Ward, S. (2004) "Why risk efficiency is a key aspect of best practice projects", *International Journal of Project Management*, 22, pp. 619-632, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 9 November 2005).

Charvat, J. (2003) Project management methodologies: selecting implementing and supporting methodologies and processes for projects, Books24x7 [Online]. Available at: http://library.books24x7.com.proxy.lib.chalmers.se/book/id_5400/ (Accessed: 23 October 2005).

Cooper, R. G. (2001) Winning at new products: accelerating the process from idea to launch, Books24x7 [Online]. Available at: http://library.books24x7.com.proxy.lib.chalmers.se/book/id_7611/ (Accessed: 23 September 2005).

Cooper, R. G., Edgett, S. G. & Kleinschmidt, E. J. (1999) "New product portfolio management: practices and performance", *Journal of Product Innovation Management*, 16, pp. 333-351, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 14 October 2005).

Cooper, R. G., Edgett, S. G. & Kleinschmidt, E. J. (2001) *Portfolio management for new product development*. 2nd edn. Cambridge: Perseus Publishing.

COSO (2004) *Enterprise risk management – integrated framework - executive summary*, [Online] Available at: http://www.coso.org/publications.htm/ (Accessed: 20 December 2005).

Doctor, R. N., Newton, D.P. & Pearson, A (2001) "Managing ucertainty in research and development", *Technovation*, 21, pp. 79-90, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 9 November 2005).

Ericsson in brief (2005) Available at: http://www.ericsson.com/about/ (Accessed: 9 November 2005).

Field, M. & Keller, L. (2004) *Project Management*. London: Thomson Learning.

Ghasemzadeh, F., Archer, N. P. (2000) "Project portfolio selection through decision support", *Decision Support Systems*, 29, pp. 73-88, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 19 October 2005).

Hamilton, G. (1996) *Risk management 2000*. Lund: Studentlitteratur.

Jackson, J. A., Kloeber Jr., J. M., Ralston, B. E. & Deckro, R. F. (1999) "Selecting a portfolio of technologies: an application of decision analysis", *Decision Sciences*, 30(1), pp. 217-238, *Proquest* [Online]. Available at: http://www.proquest.com/ (Accessed: 8 October 2005).

Kendrick, T. (2003) Identifying and managing project risk: essential tools for failure-proofing your project, Books24x7 [Online]. Available at: http://library.books24x7.com.proxy.lib.chalmers.se/book/id_5591/ (Accessed: 2 September 2005).

Knight, K. (2003) "Risk management: an integral component of corporate governance and good management", *ISO Bulletin*, 10, [Online]. Available at: http://www.iso.org/iso/en/commcentre/isobulletin/articles/2003/pdf/riskmanagement03-10.pdf (Accessed: 19 December 2005).

Lewis, J. P. & Wong, L. (2005) *Accelerated project management: how to be the first to market*, Books24x7 [Online]. Available at: http://library.books24x7.com.proxy.lib.chalmers.se/book/id_7752/ (Accessed: 15 November 2005).

Lichtenberg, S. (1989) "New project management principles for the conception stage: outline of a new 'generation'", *International Journal of Project Management*, 7(1), pp. 46-51, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 8 November 2005).

Lichtenberg, S. (2000) *Proactive management of uncertainty using the Successive Principle*. Lyngby: Polyteknisk Press.

Marmgren, L. & Ragnarsson, M. (2001) *Organisering av projekt – Från ett mekaniskt till ett organiskt perspektiv*. Stockholm: Fakta Info Direkt Sweden AB.

Nelson, S. R. & Eubanks, F. (2005) "Risk tools for technical development: hazard analysis and FMEA", in Kahn, K. B. (ed.) *The PDMA handbook of new product development*. 2nd edn. New Jersey: John Wiley & Sons Inc., pp. 430-441.

Noweco (2005) Available at: http://www.noweco.com/emse.htm/ (Accessed: 14 November 2005).

O'Donnell, E. (2004) "Enterprise risk management: a systems-thinking framework for the event identification phase", *International Journal of Accounting Information Systems*, 6, pp. 177-195, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 20 December 2005).

OGC (2002) *Managing successful projects with PRINCE2*. 3rd edn. London: Stationery Office.

Olsson, R. (2001) *On the handling of uncertainties in large complex product development projects: a study of benefits and implications*, Licentiate thesis. Royal Institute of Technology.

Olsson, R. (2005) "From project to portfolio management – an approach to manage portfolio risks", PMI Risk Symposium 2005, Washington D.C. 1-5 May.

Om Skanska (2005) Available at: http://www.skanska.se/ (Accessed: 9 November 2005).

Palisade Europe (2005) Available at: http://www.palisade-europe.com/ (Accessed: 20 October 2005).

Pellegrinelli, S. (1997) "Programme management: organizing project-based change", *International Journal of Project Management*, 15 (3), pp. 141-149, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 12 September 2005).

Pfleeger, S. L. (2000) "Risky business: what we have yet to learn about risk management", *The Journal of Systems and Software*, 53, pp. 265-273, *Proquest* [Online]. Available at: http://www.proquest.com/ (Accessed: 18 October 2005).

PMBOK (2004) *A guide to the project management body of knowledge (PMBOK® guide)*. 3rd edn. Pennsylvania: Project Management Institute.

Roetheli, R. & Pesenti, P. (1986) "Portfolio method – a control tool in the multiproject organization", *Project Management*, 4(2), pp. 87-90, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 12 November 2005).

Ross, J. G. (2004) "Risk and uncertainty in portfolio characterisation", *Journal of Petroleum Science and Engineering*, 44, pp. 41-53, *Science Direct* [Online]. Available at: http://www.sciencedirect.com/ (Accessed: 7 September 2005).

Saunders, M., Lewis, P. & Thornhill, A. (2003) *Research methods for business students*. 3rd edn. Essex: Pearson Education Limited.

Schuyler, J. (2001) *Risk and decision analysis in projects*, 2nd edn, Project Management Institute, Pennsylvania.

Seely, J. (2002) *Writing reports (OSTA series)*, Books24x7 [Online]. Available at: http://library.books24x7.com.proxy.lib.chalmers.se/book/id_9388/ (Accessed: 4 September 2005).

SKF (2005a) *GPM overview*, GPM Support Office, The Learning Centre & SKF College.

SKF (2005b) *GPM project management toolbox section 1-7*, GPM Support Office, The Learning Centre & SKF College.

Steinkeller, H. (2001) *Riskstyrning avgör projektets framgång*. Available at: http://www.wenell.se/kunskapscenter/riskstyrning.pdf (Accessed: 15 November 2005).

The Concise Oxford Dictionary (1998) 9th edn. New York: Oxford University Press Inc.

Transportation (2005) Available at: http://www.bombardier.com/ (Accessed: 9 November 2005).

Turner, J. R. & Müller, R. (2003) "On the nature of the project as a temporary organization", *International Journal of Project Management*, 21, pp. 1-8, *Science Direct* [Online]. Available at http://www.sciencedirect.com/ (Accessed: 13 September 2005).

van der Velde, M., Jansen, P. & Anderson, N. (2004) *Guide to management research methods*. Oxford: Blackwell Publishing.

Volvo group (2005) Available at: http://www.volvo.com/group/global/en-gb/Volvo+Group/ (Accessed: 9 November 2005).

Walls, M. R. (2004) "Combining decision analysis and portfolio management to improve project selection in the exploration and production firm", *Journal of Petroleum Science and Engineering*, 44, pp. 55-65, *Science Direct* [Online]. Available at http://www.sciencedirect.com/ (Accessed: 20 December 2005).

Wenell (2005a) Available at: http://www.wenell.se/ (Accessed: 20 December 2005).

Wenell (2005b), *Praktisk projektledning*. Stockholm: Wenell Management AB.

Wideman, R. M. (ed.) (1992) *Project and program risk management: a guide to managing project risks and opportunities*, Books24x7 [Online]. Available at: http://library.books24x7.com.proxy.lib.chalmers.se/book/id_5607/ (Accessed: 15 November 2005).

Wideman, R. M. (2005) *Max's project management wisdom*. Available at: http://maxwideman.com/ (Accessed: 18 December 2005).

Wysocki, R. K. & McGary, R. (2003) *Effective project management*. 3rd edn. Books24x7 [Online]. Available at: http://library.books24x7.com.proxy.lib.chalmers.se/book/id_8124/ (Accessed: 15 October 2005).

Appendices

Appendix 1 Interview guide – Benchmarking

The concept of risk

- The organisation's view on risk
- Risk and uncertainty

Portfolio management model

- Overview of the portfolio management process
- Who makes the selection decisions?
- What role does risk play in the selection process?
- Sources for information in developing this model (authors/theorists/companies)

Risk assessment

- Overview of the risk assessment process
- How is risk assessment incorporated in the project selection process?
- How are risks identified?
- How are risks analysed?
- How are risks evaluated?
- Who takes part in the risk assessment?

Appendix 2 Interview guide – Consultant

Experience of successful portfolio management practice

- Project selection
- Decision makers – who must participate?

Experience of good risk assessment practice

- Where is risk assessment to be implemented
- Decision makers – who must participate?

Risk identification best-practice

- Checklists
- Question database as funnel
- Experience – what role does it play and how is it best incorporated?
- What-if scenarios

Risk measuring/valuing best-practice

- Diagrams
- Numbers
- Money
- What to do with the identified risks – penetrate deeper?

Suggestions of risk assessment tools

- Tools for initial overview
- Tools for detailed analysis

Creation of a basis for decision

- How are the results best presented?

Sources for information or best-practice (companies/authors)

Appendix 3 PRINCE2 Risk categories

Strategic/commercial risks

- Under-performance to specification
- Management will under-perform against expectations
- Collapse of contractors
- Insolvency of promoter
- Failure of suppliers to meet contractual commitments, this could be in terms of quality, quantity, timescales or their own exposure to risk
- Insufficient capital revenues
- Market fluctuations
- Fraud/theft
- Partnerships failing to deliver the desired outcome
- The situation being non-insurable (or cost of insurance outweights the benefit)
- Lack of availability of capital investment

Economic/financial/market

- Exchange rate fluctuation
- Interest rate instability
- Inflation
- Shortage of working capital
- Failure to meet projected revenue targets
- Market developments will adversely affect plans

Legal and regulatory

- New or changed legislation may invalidate assumptions upon which the activity is based
- Failure to obtain appropriate approval, e.g. planning, consent
- Unforeseen inclusion of contingent liabilities
- Loss of intellectual property rights
- Failure to achieve satisfactory contractual arrangements
- Unexpected regulatory controls or licensing requirements
- Changes in tax of tariff structure

Organisational/management/human factors

- Management incompetence
- Inadequate corporate policies
- Inadequate adoption of management practices
- Poor leadership
- Key personnel have inadequate authority to fulfil their roles
- Poor staff selection procedures
- Lack of clarity over roles and responsibilities
- Vested interests creating conflict and compromising the overall aims
- Individual or group interests given unwarranted priority
- Personal clashes
- Indecision or inappropriate decision making
- Lack of operational support
- Inadequate or inaccurate information
- Health and safety constraints

Political

- Change of government policy (national or international), e.g. approach to nationalisation
- Change of government
- War and disorder
- Adverse public opinion/media intervention

Environmental

- Natural disasters
- Storms, flooding, tempests
- Pollution incidents
- Transport problems, including aircraft/vehicle collisions

Technical/operational/infrastructure

- Inadequate design
- Professional negligence
- Human error/incompetence
- Infrastructure failure
- Operation lifetime lower than expected
- Residual value of assets lower than expected
- Increased dismantling/decommissioning costs
- Safety being compromised
- Performance failure
- Residual maintenance problems
- Scope “creep”
- Unclear expectations
- Breaches in security/information security
- Lack of inadequacy of business continuity