Abstract

ICT procurement is a challenging and complex process. Many organizations are investing large amounts of money in their search for competitive advantages and profit, for example US enterprises alone spend more than $ 250 billion annually for procuring software products and services [Getto et al., 2002]. Unfortunately, many procurement projects run into problems like missed deadlines, budget overruns and poor quality [Aftenposten], [Landauer, 1995], [Gibbs, 1994], [May, 1998]. With analyses showing that around two-third of all IT projects faces such problems as the ones mentioned above [BCS, 2004], the potential for improvements is obvious.

The procurement phase is one of the last phases where inexpensive thoughts about software systems have not been transformed into expensive-to-change form; this discipline has not been given much attention. As a result, ICT procurement projects are challenging. To reduce the risks involved in the procurement phase, organizations can benefit from guidance in how to procure software intensive systems. Several available standards and procedures offer some guidance [SPICE], [IEEE 1062], [ISO/IEC 12207, 2002], [Hansen et al., 1999]. But are these standards applicable for all kind of organizations?

Some investigation intended to improve the acquisition of software intensive systems has been conducted by other researchers [Goldenson et al., 2000], but they focused on large-scale governmental procurements. Since the largest number of the procurements is made by small and medium sized organizations, additional research is needed. To elicit these needs, this report presents a three-step investigation conducted to identify problems and challenges experienced by small and medium sized organizations procuring software intensive systems. Archival research is carried out to see if the available procurement guidelines are applicable for small and medium sized organizations. Data has been collected through questionnaires and interviews with the organizations' employees responsible for software procurements.

The quantitative data has been analyzed using statistical methods, in an attempt to identify the main weaknesses in the current procurement procedures. In addition, the qualitative data are analyzed to complement the findings made from the quantitative data.

Results indicate that the organizations who participated in the survey seldom follow a predefined procedure when they execute software procurements. However, organizations that do have a defined, formalized procurement procedure are significantly more satisfied with their procurements. In addition, risk management is seldom integrated in software procurements despite the fact that the organizations to some extent consider software procurement as a risky activity.

Recommendations derived from the survey results are offered to increase the organization's ability to procure and use software intensive systems.

Preface

This master thesis is part of the 10th and final semester at the Master of Science program in computer science at Norges Teknisk-Naturvitenskapelige Universitet (NTNU). This report is initiated as a result of an ongoing lifecycle software project (LCSP) at the research unit of Det Norske Veritas (DNV).

I wish to thank my project advisors, Dr. Lars Bratthall at DNV and Prof. Tor Stålhane at NTNU. This project would not have been possible without their guidance and help. In addition I would like to thank Endre Angelvik and the other employees at DNV Research who has given me inputs and help during the project. I would also like to thank the participants of the conducted survey and interviews.

Table of Contents

Table of Contents

List of Figures

List of Tables

1 Introduction

In today's society the use of software-intensive systems has become incorporated in all sorts of organizations and processes. The software systems' range of application is expanding rapidly and new solutions arise daily. Many organizations are totally dependent on state-of-the-art software systems to gain competitive advantage in their line of business. As a result, developing and supplying software systems have become a large-scale business. In Norway alone, the software industry presented a total turnover at 24 billion NOK in 2003 [ikt]. This is more than the total turnover within the fishing industry in Norway which historically have been one of the economical cornerstones for the country.

But somewhere between the detection of the need for software systems and the implementation of the final system, risks that can increase the total cost of ownership are introduced. According to Landauer [Landauer, 1995] it does not appear to be any correlation between organizational investment in IT and organizational success. Even though there exist methods and standards for the whole software system acquisition process [ISO/IEC12207, 2002], [Dorling et al., 1999], large budget overruns and poor quality is often the outcome of the projects [Aftenposten], [PROBE], [Landauer, 1995].

In the past, the complex discipline of ICT *procurement* seems to have received far less attention then software systems *development*. To remedy these problems, Det Norske Veritas (DNV) executes a project with the following objective: *Develop a public set of guidelines for stepwise improvement of an organization's ability to procure and use software-intensive systems, with focus on total cost of ownership.* This project only includes larger organization with highly experienced ICT-procurers. Since DNV wishes to embrace organizations of all sizes, this master thesis was initiated.

The main research objective of this master thesis is to investigate what risks and suitable mitigating actions related to the procurement of software-intensive systems are known among *smaller and less experienced organizations*. Therefore, we present an empirical analyses of information gathered from several organizations in Norway. The information is obtained through surveys and interviews. The research methods employed are described in Chapter 3.

The purpose of this study is to formulate a roadmap to guide organizations from being non-aware to becoming an aware software procurer. The objective of this project is that the increase of knowledge will ease the procurement process for the organizations. The intended audience is everyone involved in the process of ICT procurement in small and medium sized organizations, i.e. up to 250 employees [Congrex], and researcher in software engineering.

The rest of this report is organized as follows. Chapter 2 presents a prestudy of software procurement and risk management. In addition some of the available standards are described in more detail. The method used to gather the data is described in Chapter 3, and the results are presented in Chapter 4. In Chapter 5 the results are analyzed and assertions based on this study are presented. Finally, in Chapter 6 the project is evaluated and discussed.

2 Background

2.1 Introduction

To be able to perform a thorough and adequate analysis of the procurement processes within software procuring organizations, an investigation of prior work and research is necessary. The following section includes an overview of some of the research and briefly describes the process steps involved in the procurement of software. In addition, we have included risk management related to procurement, due to the fact that several procurement projects don't seem to take this seriously enough. In Section 2.3, some of the most common standards and practices are described.

2.2 Prestudy

2.2.1 Software procurement

Software procurement is a complex task, because it involves multiple stakeholders such as users, management, owners and suppliers. These stakeholders often have non-corresponding requirements, or at least different point of views. It is therefore essential that every stakeholder is included throughout the procurement phase. To add to the complexity, procurement is a fairly fast process, but with long-term impact as seen in ongoing studies at DNV [not yet published]. The lifetime of a software system may be five, 10 or even 20 years, and this indicates the importance of a well-conducted procurement.

Procurement and acquisition are both terms used in published material to describe the activities and tasks involved when providing software, and they are often used without differentiation. At Webster [Webster] both terms are interpreted quite similarly; as to get possession of something. But there are researchers that use the two terms with two different meanings. They use acquisition as the name of the overall process, while procurement includes only the purchase of the software [Hansen et. al., 1999]. In this report, there will be no differentiation between the two terms, as they both will be applied to the overall process of providing software.

2.2.1.1 The procurement cycle

The procurement of software can be regarded as a never-ending cyclical process [buyIT]. During the monitoring and evaluation of operational systems, i.e. installed, accepted and running systems, the detection of the need for new software appears. An example of such a procurement cycle is shown in Figure 1.

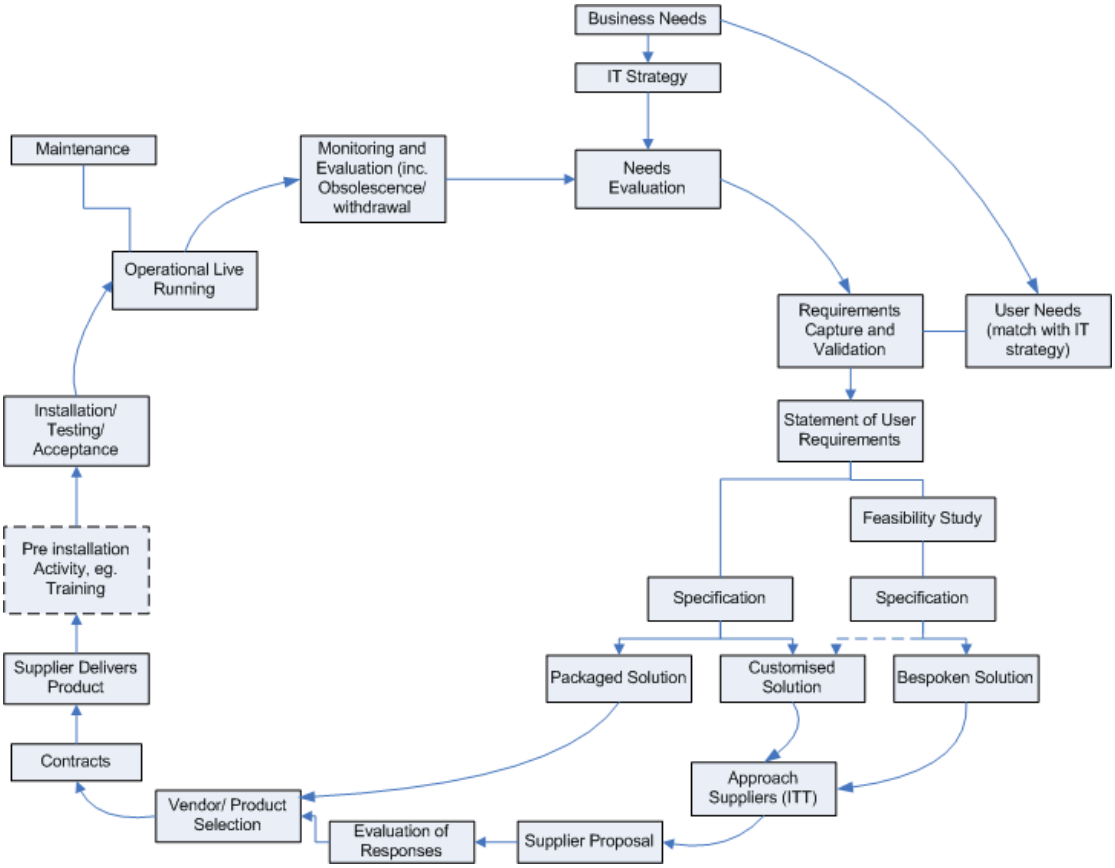


Figure 1: The procurement cycle [buyIT, 1995]

This cycle can be contracted into a six step procurement-process as shown in Figure 2. There are several approaches that can be used to detail the procurement process [IEEE 1062], but the one shown in Figure 2 gives an appropriate overview of the activities involved.

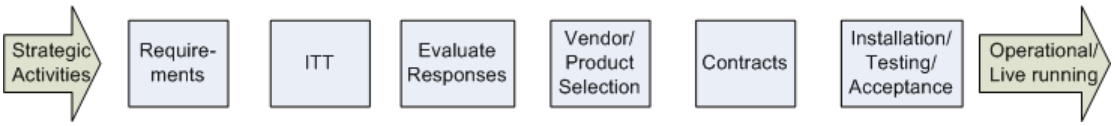


Figure 2: The procurement process [buyIT, 1995]

As shown in Figure 1, the initial factor in the procurement process is the detection of needs. The needs can be detected either by the management, the users or as a demand from the customers. If these needs match the overall business strategy and the information system strategy of the organization, a requirement phase can begin. The information system strategy should define the technical architecture and standards that system suppliers should support. This maximizes the chance of easy system integration in the future.

2.2.1.2 The requirement phase

The purpose of the requirement phase is to define a set of requirements for the intended software system. These requirements are meant to ensure that the final system will meet the needs detected in the previous phase by describing the required functionality. In addition, the list of requirements will be used in the assessment and selection of potential products. This can be done by including both "mandatory" and "desirable" requirements and give them weights based on their importance for the organization. The requirements should be as unambiguous and detailed as possible to prevent potential misunderstandings and conflicts [IEEE 830-1998].

2.2.1.3 Invitation to Tender

When the list of requirements is completed, the next phase of the procurement process is to send out an Invitation to Tender (ITT), which involves the dispatch of the requirements to potential suppliers. The suppliers invited to participate in the tender competition can be selected through pre-qualification, market shares or reputation. The purpose of this phase is to get response from as many potential suppliers as possible, and ensure fair competition between them.

2.2.1.4 Evaluation of vendor responses

As soon as the suppliers reply to the ITT, the evaluation of the responses begins. In this phase a preliminary selection of the suppliers is performed. Any supplier failing to meet the mandatory requirements defined in the previous phases is eliminated. In addition, the suppliers are evaluated according to pre-defined requirements, and given scores based on how well they meet them. There are several ways to perform this action, and the organization need to find a method that suits them [Ochs et al., 2001], [ISO/IEC 9126]. The outcome of the evaluation is a list of candidate suppliers that will move on to the final selection phase.

2.2.1.5 Vendor/product selection

The next phase is the selection phase. Suppliers that made it through the previous phase will now have their proposals investigated in detail. The purpose of this phase is to select the best suited supplier to deliver the required system. In this phase the organization should investigate if it has confidence in the supplier's ability to meet contractual requirements; both functional and non-functional. This could include activities like demonstration and installation of pilot systems.

2.2.1.6 Contract negotiation

Based on the pre-defined requirements and selection criteria, a selection of products and suppliers is made. The next activity is the contract negotiation, where the supplier(s) and the procurer discuss and agree upon the details regarding the delivery. The contract should be a legally enforceable agreement and include guarantees and criteria in accordance with the requirements defined in the initial phase.

2.2.1.7 Installation, testing and acceptance phase

When the contract is consent, the next phase for the procurer will be the 'installation, testing & acceptance' - phase. The purpose of this phase is to give the procurer the possibility to test the system before final acceptance. Criteria for acceptance should be defined in the requirement phase and agreed upon in the contract. It is also common that the procurer wants to withhold part of the payment until the acceptance criteria are met in full. This request is, however, most likely in conflict with the suppliers urge for a quick payment. When the procurer is satisfied with the delivered system, the procurement project is signed-off.

The procured system should now be up and running. Often new requirements or needs for adjustments occur, when the system has been installed. Dependent on the maintenance of the system and the quality of the original requirements, the system will hopefully be operational for some time. The supplier could also be responsible for keeping the system compatible with defined standards. Most likely new needs will arise sometime in the future, and the procurement process starts all over again.

2.2.1.8 Additional thoughts and related work

The previous sections have described the software procurement cycle in accordance with a general procedure [buyIT]. There are, however, several aspects with this procedure that are not included, but still present in real life procurement projects. The biggest problem among the software procuring organizations may be the lack of defined, formalized procurement procedures. PROBE is a European initiative for benchmarking and defining best practice in IT acquisition. According to this organization, a significant part of the organizations in Europe have no formal acquisition processes [PROBE]. This lack of resource allocation and interest in the planning of the procurement process can explain some of the unsuccessful projects. But there are also organizations with established processes that fail in their software procurement projects. It is therefore tempting to say that either today's standards are not good enough, or there are risks related to the procurement process that the organizations are not aware of.

Judah Mogilensky [Mogilensky, 1990] wrote several years ago about the divergence between the software procurement process in theory and the software procurement process in practice. Even though Mogilensky's paper deals with Government software procurements, many of the issues he points out related to the early phases of the procurement cycle are applicable in scaled-down procurement projects as well. This applies especially to the problems with the requirements.

One of the challenges/problems that have also been emphasized among other researchers is the activities done during the requirement phase. The description of the requirement phase given in Section 2.2.1.2 is an "ideal world"-scenario. In reality, the work done in this phase is not as easy as it seems, and the final system may suffer heavily due to bad/wrong requirements.

One common problem is the lack of domain-knowledge, both internally and externally. This may result in the procuring organization defining requirements that are not applicable and not in accordance with the needs to the organization. "In worst case, the solution space defined by the requirements includes solutions outside the

total space of feasible solutions, and has no overlap at all with the set of solutions actually preferred by users." [Mogilensky, 1990] This scenario is shown in Figure 3. The other possibility is that the supplier doesn't have enough knowledge to interpret the requirements correctly [Snir et al., 1999]. Both these scenarios will affect the final result.

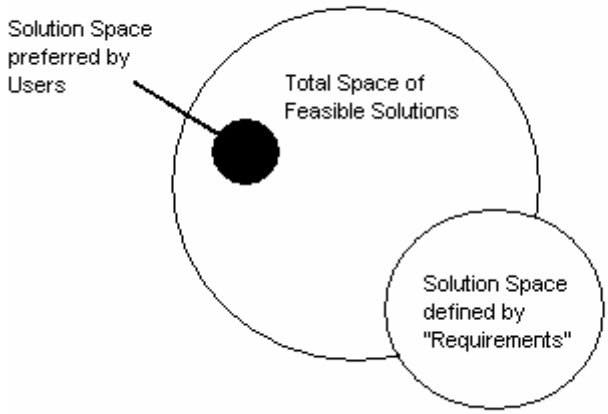


Figure 3: Overlap among different solution spaces [Mogilensky, 1990]

To remedy the problems described above, additional methods have been suggested. One solution is the procuring organization describing the task/service the needed system is supposed to execute instead of the usual requirements [Mogilensky, 1990]. This may prevent the definition of requirements that are not applicable/correct for the needed system. Based on the description presented, the supplier will have to establish the requirements that are needed to fulfill the request. This method gives the supplier more room to decide the technical solutions of the system. This can be propitious, as the procuring organization may lack technical knowledge and thereby hinder the development of a well functioning system. But it is essential that the supplying organization's goal is corresponding with the procurer; to make a system as good for the procurer as possible. Otherwise, the result may be of bad quality as the supplier may take the easy way out and produce a system full of "shortcuts". It is therefore essential to have concise acceptance criteria regarding the performance of the delivered system. The procuring organization should also perform some quality assurance on the requirements/needs defined.

Markensten & Artman [Markensten et al., 2004] conducted a case study which examines the use of external usability consultants in order to redesign a website. In this paper, Markensten and Artman claim that: "Procuring organizations today lack methods or processes to transform their often abstract organizational requirements to a systems specification for procurement." Further, they claim that the use of usability activities may ease the interconnection between organizational and systems requirements, and thereby result in a more successful procurement.

Another challenge/problem is the alteration of the organizations' needs during the procurement process. The initial requirements/needs defined in the early stages of the procurement process may not be applicable/correct in a later stage. This can, to some

extent, be solved by a tight relationship between the supplier and procurer. In addition there should be some kind of change clause included in the contract to enable re-definition of the requirements/needs.

There is a standard available to guide the procuring organization during the establishment of the requirements [IEEE 830-1998]. By following this standard, the procuring organization may find it easier to define unambiguous and concise requirements/needs. In addition, other researchers have published related work, intended to help both the buyer and supplier during the establishment and interpretation of the requirements [Finkelstein et al., 1996], [Rickman, 2001]. Rickman claims that there has been a change away from a "technology at any cost"-mentality. With shrinking budgets the new mentality is "what is the most value I can get for the money I have available". This mentality-change introduces a need for a new process for requirements understanding, Rickman continues. "Systems lifecycles are longer and the system needs to be procured based on the total ownership costs, not just the development costs […] Requirements cannot be analyzed in a vacuum – the requirements need to be understood in relation to existing components, COTS and reducing total ownership costs" Rickman claims. To meet this new challenge, Rickman introduces a 21 step process. It is outside the scope of this paper to detail this process, but it is shown in flowchart form in Figure 4. This process may be a bit too comprehensive and resource demanding in smaller procurements, but it could be used as guidance.

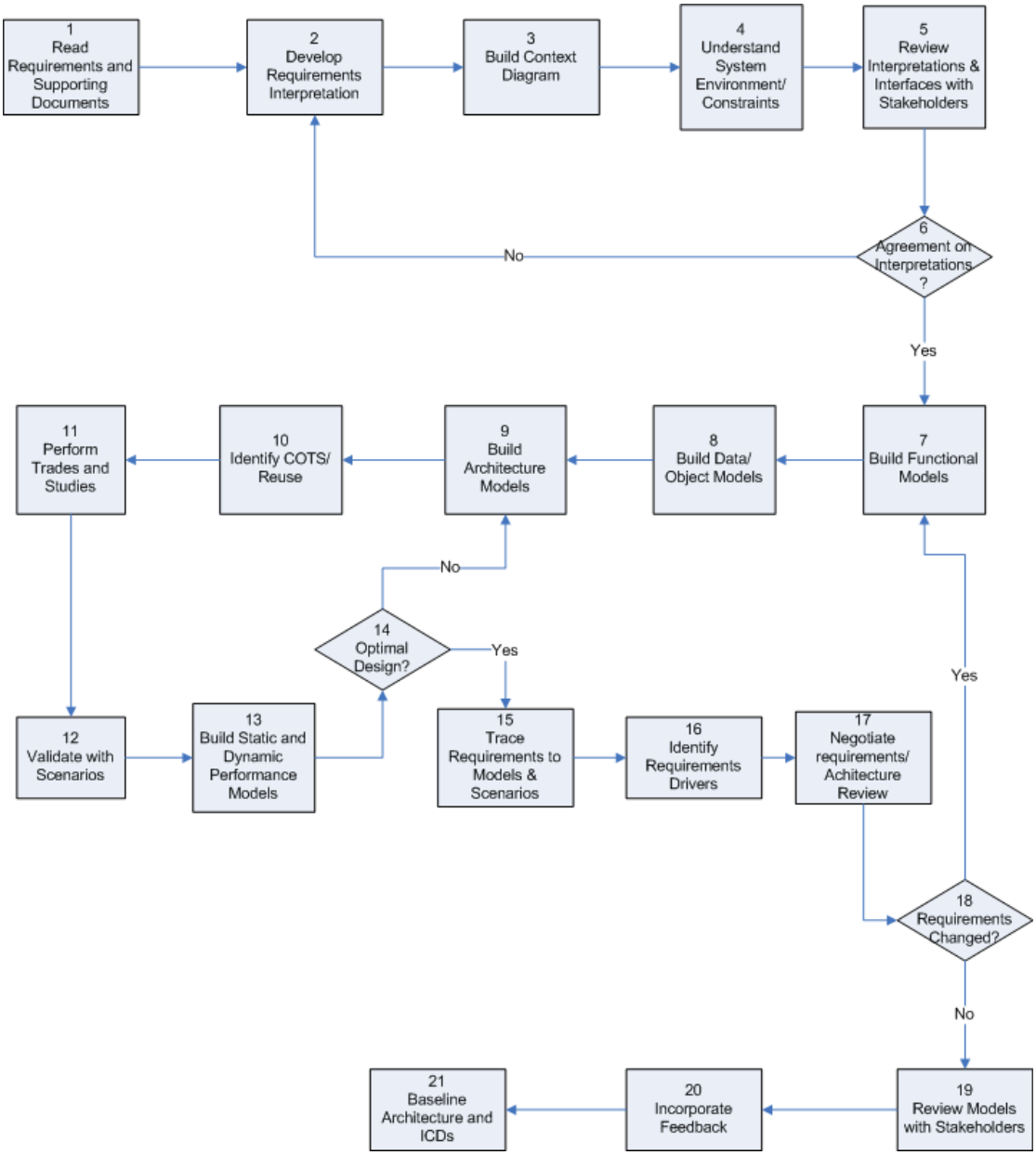


Figure 4: Requirements Understanding Process Flowchart [Rickman, 2001]

During the invitation to tender (ITT) phase (see Figure 2), there are some pitfalls the procurer should be aware of. As mentioned in Section 2.2.1.3, open competition between potential suppliers is essential. There are several ways of advertising the invitation to tender; public announcements, use of external consultants or interest groups etc. "Each potential supplier should be provided with the same information about the system to be procured, and the same functionality should be demanded from each supplier" [Hansen et al., 1999]. It is also an idea to inform the potential suppliers about the evaluation policy and criteria.

The evaluation and selection of suppliers/products is a difficult and often time-consuming task. To be able to do this thoroughly, the person(s) performing the evaluation/selection needs competence and knowledge about the technologies available on the market in addition to organizations' business needs and available

resources. This often results in the need for representatives from several units of the organization in the evaluation/selection team.

Before the evaluation and selection starts, a set of evaluation attributes with weights must be defined. These evaluation attributes depend on the product needed and the organization buying it. The ISO/IEC standard 9126 provides a set of attributes for evaluating the quality of software systems, which might be suitable [ISO/IEC 9126]. Based on the requirements/needs defined earlier in the procurement process, a set of minimum technical requirements should be established. Every proposal must satisfy these requirements to enter the final evaluation. In the final evaluation phase, the procurer should put a figure/amount on the factors that separates the proposals. By doing this, the best candidate should appear in the end. Rapcsák et al. [Rapcsák et al., 2000] describes two case studies for evaluating tenders in information technology in public procurements. Even though public procurements often cover a larger scope than procurements made by private organizations, many of the aspects are similar in both cases. Therefore, the decision model described by Rapcsák et al. should be of interest for procurers in small and medium sized organizations as well.

Both Alves et al. [Alves et al. 2002] and Ochs et al. [Ochs et al., 2001] give guidance to the evaluation and selection of customer-of-the-shelf (COTS) products. Scown [Scown, 1998] criticizes how the acquisition-decisions are made. He claims that the accountants involved in the procurement process have limited awareness of the relevant human factors issues, and only base their decisions on financial aspects like return on investment (ROI) and total cost of ownership (TCO). This may result in the procurement of systems that don't meet the procurers' needs. To remedy this, Scown claims that more focus should be put on human factors like usability. By having knowledge of human factors, the calculation of TCO becomes easier.

The use of TCO in the evaluation of software systems has come more into focus the last years. TCO includes all the expenses related to procuring, owning, maintaining and phasing out a software system. Verhoef [Verhoef, 2005] describes a method to quantify the value of investments in software systems. This method can, according to Verhoef, be used to provide insight into the standard economic indicators: net present value, internal rate of return, return on investment, its risk-adjusted variants, the payback period, break even points, cost-benefit analysis over time, J-curves, and comparisons of different risk scenarios. Verhoef claims that these factors are important in IT-investment management.

Verhoef has also written a paper were he present a quantitative approach for IT portfolio management [Verhoef, 2002]. In this paper, Verhoef gives guidance on how to assess proposal from business units, risk calculations, cost comparisons and estimates of TCO of entire IT portfolios. The approach presented by Verhoef can be applied by organizations on CMM level 1 (See Section 2.3). Knell et al. [Knell et al., 2002] also focus on the portfolio approach to IT procurements. They suggest that IT capability should be viewed as a portfolio to be optimized. This approach can only be achieved in stages, and the authors describe a framework which illustrates how an organization can evolve to become a better IT procurer. This evolution is characterized by five levels describing the maturity as IT procurer.

The procuring organization should also make an effort to investigate the feasibility of the proposals from the suppliers. There are several methods that can be used to execute this investigation; get references, use prototyping, close collaboration with the supplier, use external evaluator and so on. The procurer should use one or more of these methods, depending on the resources and availability. It is also possible to reference to the ISO/IEC 15504 standard [ISO/IEC 15504] on software process assessment during this activity to perform a thorough investigation of the supplier.

The purpose of the contracting phase is to form a legally enforceable agreement and include guarantees and criteria in accordance with the requirements defined in the initial phase. This activity is important for the outcome of the project, both technical and economical. In reality, the processes previous to the contracting are more or less controlled by the procurer. When the contract is entered, the control of the project is to some extent transferred to the supplier.

A software procurement project involves a lot of short- and long-term risks. When the procurer and the supplier enter the contract negotiation, both parts are interested in taking the smallest risk possible. Nevertheless, the contract should tend to a fair risk sharing and protect both parts. The procurer may include incentives in the contract, to motivate the supplier to take a greater share of the risk [Lichtenstein, 2004]. This can be done by contractual provisions like pricing, milestones, maintenance provisions and effectiveness-based payments. It is outside the scope of this paper to detail the contractual provisions, but more about them can be found in [Lichtenstein, 2004] and [Banker et al., 1992].

There are several other problems/risks related to software procurement. One question that the procuring organization should consider is: “Are we ready for a change in the existing system/procurement of a new system?” The introduction of a new system may demand a lot of resources and hard work. If the cost of a procurement project is higher than the gain, there is no use in effectuating the project. More about risks and how to handle them is covered in the next section.

2.2.2 Risk management

Since there is a significant part of the software procurement projects that run into trouble [Aftenposten], [PROBE], [Landauer, 1995], [May, 1998] it is quite safe to assume that some risks unknown to many people will be present during the process. If the people involved in procurement was aware of these risks, suitable mitigating actions could be initiated. The result could be fewer budget overruns and more well-performing systems delivered at time.

A risk is according to D. Cooper et al. [Cooper et al., 2005, p3]: "exposure to the consequences of uncertainty. In a project context, it is the chance of something happening that will have an impact upon the project's objectives. It includes the possibility of loss or gain, or variation from a desired or planned outcome, as a consequence of the uncertainty associated with following a particular course of action."

In the experience of DNV, most non-trivial ICT procurements are performed in the form of a project, though some frame agreement regulating hourly costs may exist. To achieve a good project outcome each time, managing the risks involved in the execution of the project is essential [Ropponen et al., 2000], [Powell et al., 1996], [Mayrand et al., 1996]. To be able to do this, risk management plans and procedures are helpful tools. This is an ongoing task throughout the whole project, and has to be monitored continuously. D. Cooper et al.[Cooper et al., 2005] proposes some key activities to manage project and procurement risks effectively:

- "identifying, analyzing and assessing risks early and systematically, and developing plans for handling them;
- allocating responsibility to the party best placed to manage risks, which may involve implementing new practices, procedures or systems or negotiating suitable contractual arrangements; and
- ensuring that the costs incurred in reducing risks are commensurate with the importance of the project and the risks involved."

These key activities are easier, cheaper and faster to conduct if risk management plans are developed prior to the project start. Failing to develop risk management plans may result in reduced value for the outcome of the project as well as potentially harder implementation due to the consequences of unforeseen risks. In addition, it is essential that the need and importance for risk management is understood and supported by all stakeholders involved in the project. Only then can risk management be integrated into the procurement project and hopefully ease the way to a successful outcome.

There are many published approaches to project risk management [Addison et al., 2002], [BS IEC 62198:2001]. This report will use the same approach as D. Cooper et al. [Copper et al., 2005] which is consistent with the AS/NZS 4360 standard [AS/NZS4360]. An overview of Cooper et al.'s approach is shown in Figure 5.

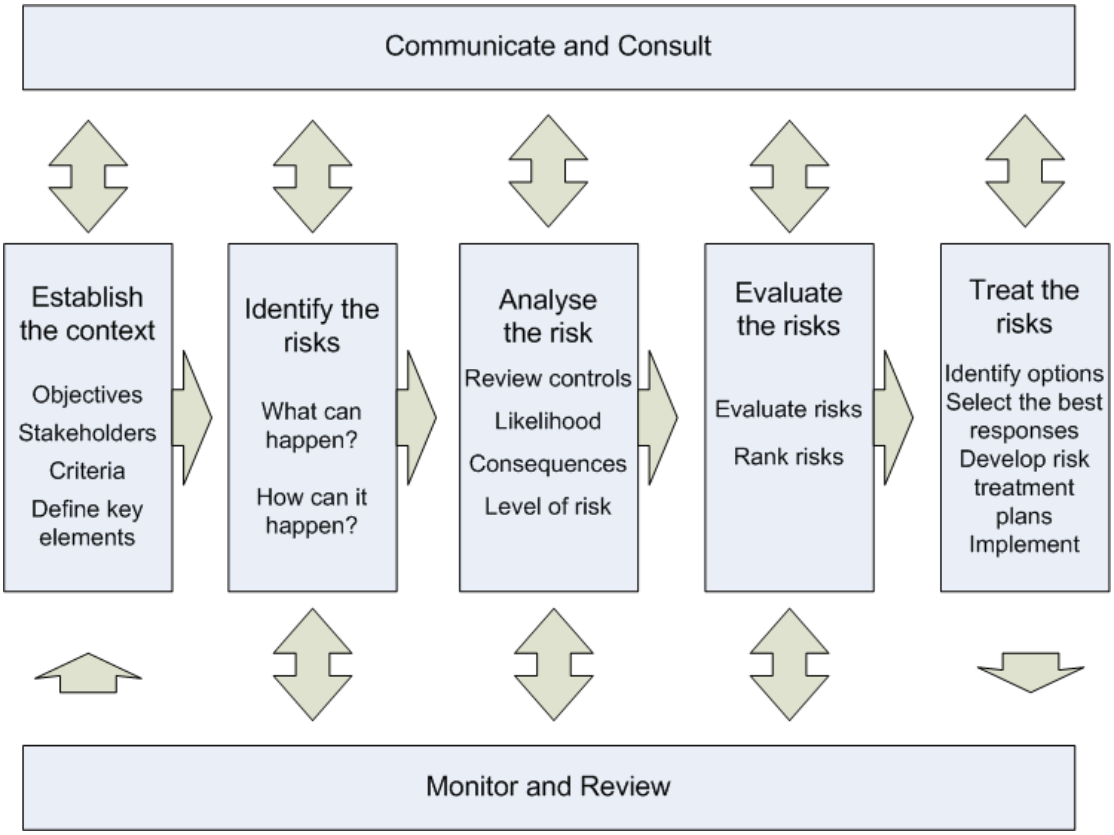


Figure 5: The project risk management process [D. Cooper et al., 2005]

In the following sections each step in the project risk management process is detailed.

2.2.2.1 Establish the context

The first step in the project risk management process is to establish the context for the rest of the process. The purpose of this step is to gather the information needed to establish a structure for the execution of the following steps in the process. The input to this activity is documentation describing the purpose and scope of the project. This is, among others, project execution strategy and engineering designs.

This step has, as shown in Figure 5, four sub-elements; Objectives and criteria, Stakeholder identification and analysis, Project criteria and Key elements. Some of these tasks correspond fully or partially to tasks included in some of the procurement process phases (See Section 2.2.1). Table 1 below indicates these correspondences. This correspondence emphasizes the importance of the integration of risk management in the overall procurement project. Otherwise redundant work may occur, and the effectiveness of the organization will decrease.

Risk management process task	**Procurement process phase**
Objectives and criteria	Requirement phase, Information system strategy
Stakeholder identification and analysis	Requirement phase
Project criteria	Requirement phase, Information system strategy
Key elements	Requirement phase

Table 1: Corresponding activities

As mentioned above, the information gathered in this part of the process is essential in later steps, so adequate attention and allocation of resources is important. Otherwise the chances for a project failure will increase.

Identification and analysis of the stakeholders is included in the context establishment. This is done to get an overview of all parties in the project, and also to be able to evaluate their needs in relation to the requirements. Failing to perform this part of the risk management can result in the acceptance of inadequate systems not fulfilling all needs, and additional costs.

When the requirements and the needs of the key stakeholders are identified, a set of criteria for the project can be composed. These criteria are used in the qualitative risk assessment later in the risk management process.

Even small projects become quite complex when you start to go into the details. It is therefore practical to divide the project into smaller subprojects/activities to reduce the possibility of missing crucial information. These subprojects/activities create a good basis for the definition of the key elements later used in the risk identification. Each key element treats a specific topic, and makes it easier to go into depth on the

project details. It is, however, important to avoid too fine-grained decomposing which can result in too much guidance of the risk identification and thereby bias the result. Another issue that arises with decomposition is the challenges related to the interface between the components. This could result in additional work and risks, so the decomposition should be done with care.

2.2.2.2 Identify the risks

The next step in the risk management process is to identify the risks. This process must be extensive and thorough, so that as many risks as possible are identified. Risks that are not record during this phase will not be assessed in the following phase, and they might threaten the success of the project later on. During the risk identification, the key elements defined in the first step of the process ease the systematical examination of the project.

As shown in Figure 5, the purpose of the identification step is to answer two questions; what can happen and how it can happen. To deal with these questions, several sources of information are needed. It is an advantage if the people involved in the risk management have experience from previous, similar projects. Historical data from these projects can be used as a basis during the risk identification. If the organization doesn't have this kind of information internally, they could try to find it in books, papers or project completion reports, and execute a theoretical analysis of the project.

Cooper et al. [Cooper et. al., 2005] lists available tools and techniques for the risk identification. This list includes, among others:

- brainstorming;
- checklists;
- interviews and focus group discussions; and
- surveys and questionnaires.

The brainstorming technique suites new or non-standard procurement activities best, since innovative and creative thinking is cultivated. In projects that are similar to previous conducted projects and well-known for the organization, the use of checklists might be more suitable. This technique is quicker and less resource-demanding then the brainstorming approach. Contract negotiation is a subtask of the procurement process where a checklist approach might be suitable.

The weakness of the checklist approach becomes apparent when the organization executes non-standard or unique projects. In these projects, a checklist may constrain the innovative and creative thinking and the possibility of overlooking some risks increases.

The use of interviews, surveys and questionnaires can sometimes be appropriate to get additional information. These techniques are more time-demanding then brainstorming, but can be used to go more in-depth in specific areas.

Another possible approach to the risk identification is the use of a hazard and operability study (Hazop). A Hazop is "a structured approached that systematically

analysis every part of a process to identify how hazards, operability problems and deviations from design intent may arise." [Cooper et al., 2005] This technique is often used when projecting processing plants, but may also be applicable in projects like software procurement or complex processes/procedures. The Hazop can either be used as a complete risk analysis of a process or as a prestudy in certain areas. The outcome of a Hazop study is a list of detailed hazards, their consequences and sometimes proposed rectification actions. A detailed description of the method is outside the scope of this project.

To be able to treat the risks, the cause and effect relationship must be determined in addition to the identification. This includes the investigation of the factors or incidents that must be present for the risk to occur. Hazop covers this, but the organization should also include this investigation when they use other risk identification techniques.

Independent of what technique used to identify the risks, a routine for documenting them should be present within the organization. This documentation is necessary to keep control over, and see the relationship between, the risks identified. The documentation should include a description and relevant information regarding the risk. One possible template is presented in Figure 6.

Project: **Element:** **Risk:** **Manager (risk owner)**			**Reference:**
Description and mechanisms:			
Key assumptions:			
Sources of information:			
List of attachment:			
Compiler:	**Date:**	**Reviewer:**	**Date:**

Figure 6: Risk description work sheet [D. Cooper et al., 2005]

The work and documentation performed in this step of the risk management process should result in a comprehensive list of risks present, and serve as a basis for the remaining activities of the process.

2.2.2.3 Analyze the risks

When all the risks are identified, an assessment of the risks is performed. This assessment can be done qualitative, semi-quantitative or quantitative. The qualitative approach uses nominal or descriptive scales for the assessment, while the quantitative approach is based on numerical ratio scales. The choice of method depends on the complexity of the project and experience among the people involved in the assessment. Qualitative analysis is easy to use, but might not provide sufficient features during comparison of process/project elements. The quantitative analysis requires more info and advanced skills to perform, and is applicable in more thorough assessments. Only the qualitative analysis is described in this report.

The qualitative process includes two tasks; an initial risk analysis, and a risk evaluation. The purpose of the risk analysis is to determine how often the risk may occur and the consequences of the occurrence, while the risk evaluation determines the significance of the risks.

One of the activities that are conducted during the risk analysis phase is the establishment of a priority-setting matrix. This matrix is used in the priority rating of the risks later on. The priority-setting matrix can be of different sizes, depending on the desired scaling. One example of such a matrix is shown in Figure 7 below. This matrix combines the likelihood and consequences scales, and defines the significance of a risk. The organization can, with these matrixes, determine their rating policy. As shown in the matrix below, this organization is most concerned about the catastrophic risks, independent of the likelihood. Prior to the establishment of such matrixes, a consistent definition of the likelihood and consequences scales must be present. These scales depend on the type of organization and project, and different scale definitions/descriptions have to be established each time.

	Consequence				
Likelihood	*Insignificant*	*Minor*	*Moderate*	*Major*	*Catastrophic*
Almost certain	Medium	Medium	High	High	High
Likely	Low	Medium	Medium	High	High
Possible	Low	Medium	Medium	Medium	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

Figure 7: Priority-setting matrix [D. Cooper et al., 2005]

When every risk is given a rating according to the matrix, an initial view of the significance of the risks is created. This rating is then reviewed and evaluated in the next step of the risk management process.

2.2.2.4 Evaluate the risks

The purpose of the risk evaluation step is to establish a final register of the risks, including rating, treatment actions and the name of the responsible person. An example of such a risk register is shown in Figure 8 below. This process evaluates the analysis done in the previous step. Ratings are adjusted in accordance with the organization's priorities and requirements. This step also prevents that errors made in the initial ranking will affect the final product.

E	Element	Group	R	Risk	Existing controls	C	L	Agreed priority	Inherent risk	Action sheet	Responsibility

Figure 8: Risk register

The first column (E) contains a reference number to the risk's related key element. This key element is briefly described in the next column. The Group column is used to group similar risks, and thereby ease later work. In the next column the unique risk identification number is inserted, and the risk is described in the Risk column. Then the existing controls are described. Consequence and likelihood rating achieved in the previous step is put in column C and L. In addition, the priority rating from Figure 7 is placed in the next column. Some risks may involve inherent risks if they occur. The inherent level of risk states the level that would exist if something unforeseen happens with the controls applied. This information is included in the Inherent risk column. In the last step of the risk management process, treatment plans are developed, and cross-references to this plan is placed in the Action sheet column. In the last column of the risk register, the name of the person responsible for managing the risk is stated.

Procurers often face fixed budgets in software procurement projects. With this limitation, the risk prioritizing becomes an important task. Based on the resources available, the procurer needs to use the priority-setting matrix shown in Figure 7 to identify the risks with the highest rating.

2.2.2.5 Treat the risks

The final step in the risk management process is to determine what mitigating actions should be carried out to reduce the risk exposure. This task is based on the list of risks identified and the priorities given them in the previous steps. In addition, the project plan and budget are included in the determination. Without the completion of this task, the previous steps have been wasted. The outcome of this step is a risk action plan which is the final result of the process.

There exist several strategies of risk treatment. The organizations overall risk management strategy will to some degree influence the determination of response to the individual risk identified. But a combination of the strategies will probably be used during the whole process. The risk management strategies are:

- risk prevention;
- impact mitigation;
- risk sharing;
- insurance; and
- risk retention.

The risk prevention approach is based on the elimination of the sources to the risk or reducing the likelihood of occurrence of the risk. This can be done in many ways, including selection of alternative approaches, improving design, training and skills enhancement and more. It is also possible to take a different course of action which is called risk avoidance.

The next strategy on the list above is impact mitigation. There are risks that will always be present, with likelihood impossible to erase completely. Impact mitigation, which minimizes the consequences of the occurrence, can be an applicable approach in these matters. This can be done by conducting quality assurance, contingency planning and other pre-defined actions.

Risk sharing is partially based on the principle that the responsibility of risks should be given to those best capable of controlling and managing them. In projects where some of the responsibility of the risks is allocated to parties outside the purchasing organization, risk sharing is used. This can be done through contracting or other agreements, and usually results in a cost for the purchasing organization. It is also crucial to ensure that the party taking some of the responsibility is able to manage it. Otherwise additional risks may appear during the execution of the project.

One particular risk sharing strategy is the use of insurance. According to Britannica Online, insurance is: “a system under which the insurer, for a consideration usually agreed upon in advance, promises to reimburse the insured or to render services to the insured in the event that certain accidental occurrences result in losses during a given period. It thus is a method of coping with risk.” [Britannica] This strategy transfers part of the burden of risk to another party. The insurance premium can be regarded as a measure of the cost of sharing the risk.

Sometimes the cost of dealing with a risk, one way or another, is higher then the cost of the consequences. Then the risk is retained, but still monitored. This could also be the case when dealing with risks that are impossible to avoid or transfer.

Regardless of the risk treatment strategy selected, Risk Action Plans should be developed and implemented in the organization. These plans will be included in the overall Risk Management Plan, which specifies the conduction of risk management in the project. The Risk Action Plan describes how the reduction of the identified risks should be conducted. Every risk classified as Extreme or High earlier in the process must be reduced. The reduction of the other risks is dependent on the resources available, but the Medium rated risks should at least be reviewed. It is often applicable to establish a Risk Action Plan summary. This is done by the person responsible for treating the risk, and the summary is used in the Risk Management Plan.

To obtain any benefits of the activities done in the previous steps, implementing the Risk Action Plan is important. This process has to be of the same quality and executed just as professional as the previous processes to gain full advantage. In addition, Figure 5 shows the need for monitoring and reviewing the risk management process, together with communication and reporting within the project.

2.2.2.6 Monitoring and review

The monitoring/review and the communication/reporting activities are running throughout the whole project. The monitoring/review task is crucial to be able to detect and manage new risks. In a dynamic project, the risk picture may change during the execution, and risks must be continuously monitored. This is also the foundation for updating the risk register. During the project, more information and knowledge is gained, and the initial risk assessment and evaluation may become obsolete. To prevent this, review of the risks is conducted. This action should be carried out at key milestones like major transition points and design review activities.

2.3 Best practice/Standards

There are some standards available that to some extent cover the procurement process. It is outside the scope of this paper to describe the standards in detail. Instead we give a brief introduction to some of the available standards and point out why they're not appropriate for this projects' intended audience; small and medium-sized organizations procuring software-intensive systems. This paper discusses seven standards:

- Capability Maturity Model Integration–Acquisition Module (CMMI-AM),
- Software Acquisition Capability Maturity Model (SA-CMM)
- SPICE (ISO 15504),
- Bootstrap 3.2,
- ISO 90003,
- IEEE 1062-1998,
- ISO/IEC 12207 amendment 2

CMMI-AM

This technical report is formulated by the Carnegie Mellon University and the Software Engineering Institute in USA. The Software Engineering Institute is a federally funded research and development center sponsored by the U.S. Department of Defense. The report contains "the acquisition practices that should be performed by government acquisition organizations acquiring systems and/or services. These practices can, however, also be used by non-government organizations to improve their acquisition practices" [CMMI-AM]. CMMI-AM is extracted from the Capability Maturity Model Integration (CMMI) framework, which is a set of models intended to provide guidance for improving an organization's processes [CMMI].

CMMI-AM doesn't contain any prescribed implementation approaches achieving acquisition best practices. As mentioned above, the report is based on the CMMI framework, with additions specific to the acquisition process.

One of the weaknesses to the CMMI modules is that they focus on very large U.S. Government acquisitions. The context of these acquisitions is quite different from the acquisitions made by smaller organizations. Brodman and Johnson claim that this is a common problem with the Capability Maturity Model [Brodman et al., 1994]. This claim is based on a survey conducted among smaller organizations and businesses in USA. Brodman and Johnson points out the requirements in the CMM are too hard to satisfy for smaller organizations due to limited resources and skills.

Based on the fact that the CMMI-AM is extracted from the CMMI framework, the findings made by Brodman and Johnson most likely hold for the CMMI-AM module as well. In addition, CMMI-AM doesn't give specific guidance on maturity for the acquiring organizations. As a result, the CMMI-AM needs adaption and down-scaling to be applicable for smaller organizations.

SA-CMM

Version 1.01 of the Software Acquisition Capability Maturity Model was a collaborative work of authors from government, industry, and the Software Engineering Institute. This resulted in a model that could be used in any environment. The current version, Version 1.03 is based on the previous ones and experience gained from using them.

The SA-CMM is "designed to be sufficiently generic for use by any government or industry organization, regardless of size, acquiring products." The SA-CMM provides a framework that can be used by organizations to improve the maturity of their internal acquisition processes. The architecture of the SA-CMM is presented in Figure 9. In the standard, each maturity level is detailed with defined goals, commitments, abilities, activities, measurements and verifications.

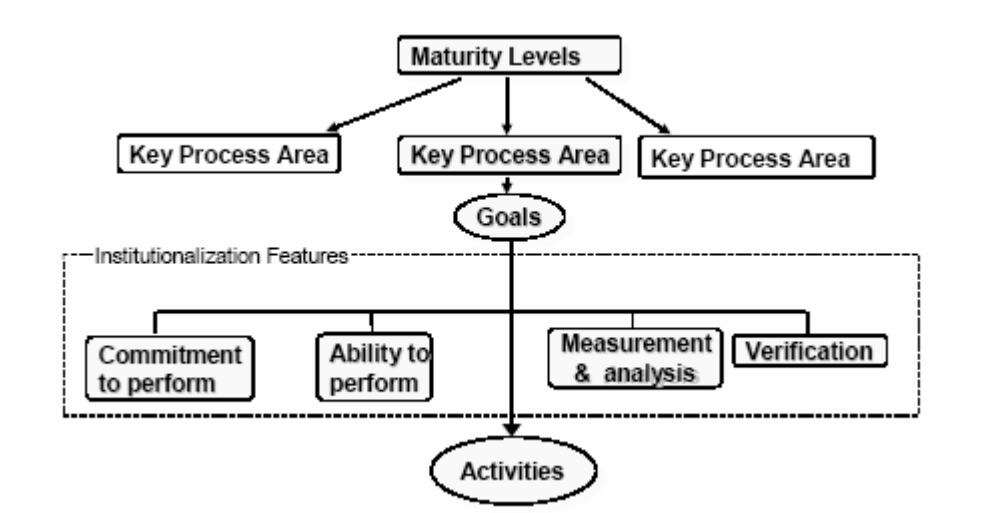


Figure 9: SA-CMM Architecture [SA-CMM]

The SA-CMM defines five levels of maturity and each level indicates process capability and contains key process areas.

Level	*Focus*	Key Process Area
5 Optimizing	*Continuous process improvement*	Acquisition Innovation Management Continuous Process Improvement
4 Quantitative	*Quantitative management*	Quantitative Acquisition Management Quantitative Process Management
3 Defined	*Process standardization*	Training Program Management Acquisition Risk Management Contract Performance Management Project Performance Management User Requirements Process Definition and Maintenance
2 Repeatable	*Basic project management*	Training to Support Evaluation Contract Tracking and Oversight Project Management Requirements Development and Management Solicitation Software Acquisition Planning
1 Initial	*Competent people and heroics*	

Table 2: Synopsis of the SA-CMM [SA-CMM]

One of the weaknesses with SA-CMM is that it only provides a framework the organizations can use to assess the maturity level of their internal acquisition processes. This assessment is very self-evaluating and subjective. Most of the guidance given in SA-CMM tells the procurer *what* to do in the procurement process. There is little direct guidance on *how* the procurement process should be carried out. However, SA-CMM might be useful for organizations in the initial phase of the development of software procurement standards when the overall task and activities are identified.

SPICE (ISO/IEC 15504)

This standard is formulated by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). "National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity." A major international initiative called SPICE (Software Process Improvement and Capability dEtermination) has been the driving force in the establishment of this particular ISO/IEC standard [SPICE].

The ISO/IEC 15504 standard is still under development and parts of it are only available as a technical report. Despite this, ISO/IEC 15504 provides a thorough framework for the assessment of software processes. Figure 10 shows the SPICE process model, including all process areas for SPICE.

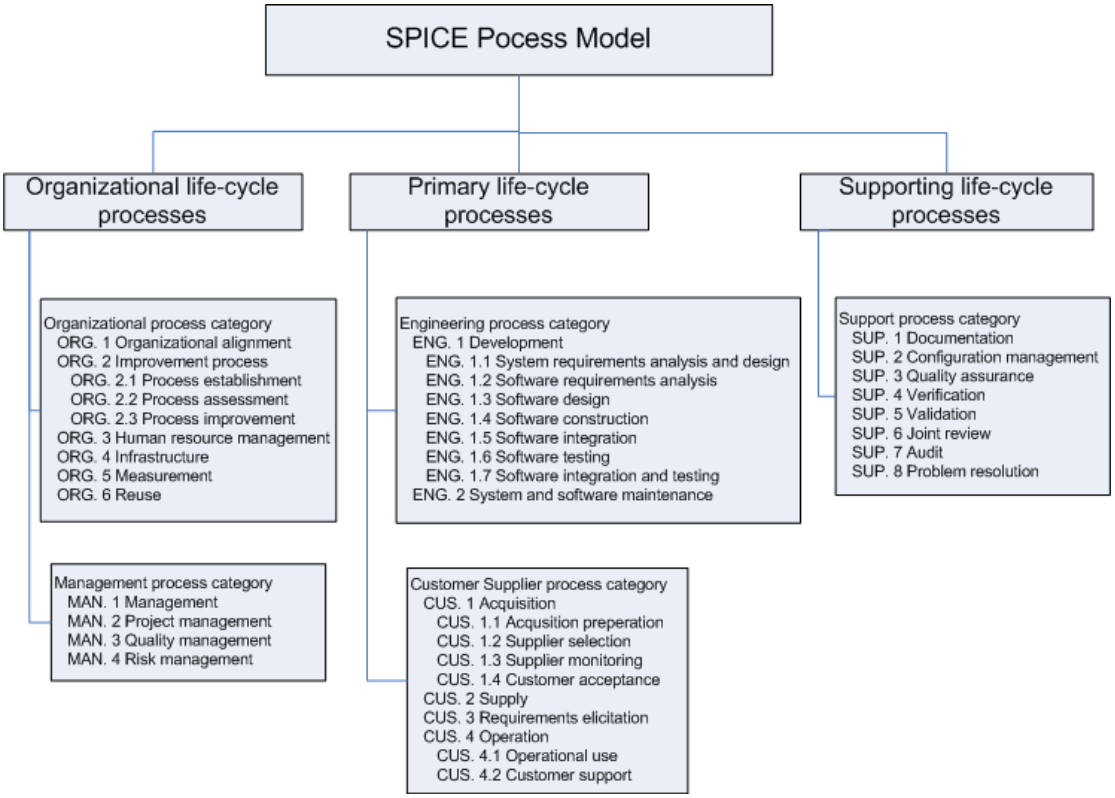


Figure 10: SPICE Process Area Model [Hass, 2002]

According to SPICE is Process assessment is applicable in the following circumstances: “

- by or on behalf of an organization with the objective of understanding the state of its own processes for process improvement;
- by or on behalf of an organization with the objective of determining the capability of another organization’s processes for a particular contract or class of contracts, or to determine the capability of its own processes for a particular requirement or class of requirements.”

Just like CMMI, SPICE operates with maturity levels to assist the process assessment. Figure 11 shows a model of the SPICE maturity levels.

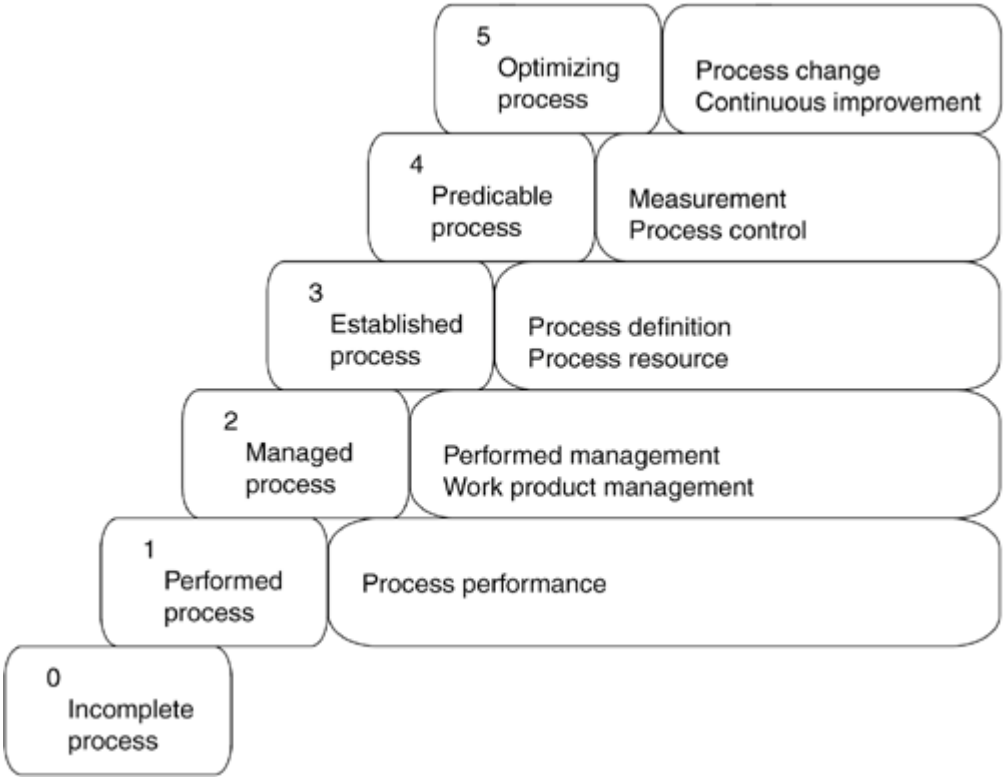


Figure 11: SPICE Maturity Levels [Hass, 2002]

Due to the fact that ISO/IEC 15504 doesn’t provide a Process Reference Model, the standard alone is not applicable to the acquisition process. A Process Reference Model describes a set of processes in terms of purpose and outcomes. ISO/IEC 12207 (see further down) includes a Process Reference Model within the domain of software engineering and would be applicable in the context of software acquisition. As a result of the absent of a Process Reference Model, ISO/IEC 15504 gives no guidance on the procurement process directly. It could, however, contribute during the assessment of an organization’s existing procurement process.

BOOTSTRAP 3.2

BOOTSTRAP is a software process assessment and improvement methodology compatible with ISO/IEC 15504 - that is, BOOTSTRAP is a practical implementation of ISO/IEC 15504 [Kuvaja, 1999], [Hass, 2002]. This methodology was initially developed in an ESPRIT project together with European industry. After the completion of the ESPRIT project, a non-profit organization, the BOOTSTRAP Institute, with the main objective of the continuous development and promotion of the BOOTSTRAP methodology, was established [BOOTSTRAP], [BOOTSTRAP Institute].

The BOOTSTRAP methodology contains a Process Reference Model aligned with the ISO/IEC 12207 standard. This model has some processes defined under the title "Customer-Supplier" that covers parts of the procurement process, but the details of this process model and related questionnaires are proprietary.

Thus, software procuring organizations may find the BOOTSTRAP methodology lacking comprehensive coverage of the whole procurement procedure. In addition, BOOTSTRAP provides little direct guidance to the activities involved during software procurements.

ISO/IEC 90003

The ISO/IEC 90003 standard "provides guidance for organizations in the application of the ISO 9001:2000 to the acquisition, supply, development, operation and maintenance of computer software" [ISO/IEC 90003]. This standard focuses on the supplying organization, not the procuring organization, in a software procurement. ISO 9001:2001 specifies "requirements for a quality management system where an organization

a) needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements, and
b) aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement of the system and the assurance of the conformity to customer and applicable regulatory requirements."

Even though ISO/IEC 90003 focuses on acquisition and supply, the guidance is limited and general. It requires further detailing and adaption to be the basis for operational procurement processes.

IEEE 1062-1998

"This is a recommended practice for performing software acquisitions. It describes a set of useful quality practices that can be selected and applied during one or more steps in a acquisition process" [IEEE 1062]. This recommendation divides the software acquisition process into nine steps, and each step is explained in some detail. The standard also includes appendixes with checklist for adaption to individual needs and guidelines for the establishment of acquisition plans.

The nine steps in the software acquisition process are: “

Step 1:
Planning organizational strategy. Review acquirer’s objectives and develop a strategy for acquiring software.

Step 2:
Implementing organization’s process. Establish a software acquisition process that Þts organization’s needs for obtaining a quality software product. Include appropriate contracting practices.

Step 3:
Determining the software requirements. Define the software being acquired and prepare quality and maintenance plans for accepting software supplied by the supplier.

Step 4:
Identifying potential suppliers. Select potential candidates who will provide documentation for their software, demonstrate their software, and provide formal proposals. Failure to perform any of these actions is basis to reject a potential supplier. Review supplier performance data from previous contracts.

Step 5:
Preparing contract requirements. Describe the quality of the work to be done in terms of acceptable performance and acceptance criteria, and prepare contract provisions that tie payments to deliverables. Review contract with legal counsel.

Step 6:
Evaluating proposals and selecting the supplier. Evaluate supplier proposals, select a qualified supplier, and negotiate the contract. Negotiate with an alternate supplier, if necessary.

Step 7:
Managing supplier performance. Monitor supplier’s progress to ensure all milestones are met and to approve work segments. Provide all acquirer deliverables to the supplier when required.

Step 8:
Accepting the software. Perform adequate testing and establish a process for certifying that all discrepancies have been corrected and that all acceptance criteria have been satisfied.

Step 9:
Using the software. Conduct a follow-up analysis of the software acquisition contract to evaluate contracting practices, record lessons learned, and evaluate user satisfaction with the product. Retain supplier performance data.”

The intended audience for this recommended practice is organizations acquiring software that “runs on any computer system regardless of the size, complexity, or criticality of the software.”

IEEE 1062-1998 is a good basis for software procurements. Organizations with limited experience related to software procurement will probably get good guidance from this practice. However, well-experienced organizations may find the checklists and guidelines a bit incomplete.

ISO/IEC 12207 amendment 1

The ISO/IEC 12207 standard establishes a common framework for software life cycle processes. It contains "processes, activities, and tasks that are to be applied during the acquisition of a system that contains software, a stand-alone software product, and a software service and during the supply, development, operation, and maintenance of software products." ISO/IEC 12207 is written for "acquirers of systems and software products and services and for suppliers, developers, operators, maintainers, managers, quality assurance managers, and users of software products" [ISO/IEC 12207].

This standard includes a general Process Reference Model. ISO/IEC 12207 is not focused on the procurement process, and it is based on software development needs. It is therefore little support for software procurement, and tailoring is needed. Nevertheless, this standard gives usable results when it is applied during software procurements.

In Table 3, each of the standards and methods are summed up and evaluated according to purpose, intended audience and disadvantages.

Standard	Purpose	Intended Audience	Disadvantages
CMMI-AM	Define acquisition practices	U.S Government	Needs adaptation and downscaling to be applicable for smaller organizations.
SA-CMM	Framework that can be used by organizations to improve the maturity of their internal acquisition processes.	All kind of organizations	Little direct guidance on the procurement process. Very subjective self-evaluation.
SPICE	Methodology for process assessment in general	All kind of organizations	Gives no guidance on the procurement process.
BOOTSTRAP 3.2	Software process assessment and improvement methodology.	A variety of software-producing units.	Partial coverage of the procurement process. Little direct guidance on the procurement guidance.
ISO/IEC 90003	Guidelines for the application of ISO 9001:2000.	Organizations developing and supplying software.	"Wrong" audience. Limited guidance on the procurement process.
IEEE 1062-1998	Quality practices that can be selected and applied during the software acquisition process.	Individuals and organizations that acquire and supply software.	No major disadvantages. Checklists and guidelines are not comprehensive.
ISO/IEC 12207, amendment 1	Define life cycle software processes, activities, and tasks.	All kind of organizations	Based on software development needs, with limited support for software procurement.

Table 3: Summary of procurement standards and methods

In addition to the available standards, we looked at some other approaches to software procurement. “IT Purchasing Guidebook for Small Enterprises” [Hansen et al., 1999] is a comprehensive book written by the ASSIST project with funding from the SPRITE-S^2 program of the European Commission. “The objective of the project was to make available to smaller organizations practical information about improving IT purchasing practices”. There is also an analysis tool available together with the book intended to collect information regarding the organization’s existing software procuring procedures. Based on this information the book gives specific recommendations for procedure improvements.

In “Evaluating Software Engineering Standards” [Pfleeger et al., 1994] and “Investigating the Influence of Formal Methods” [Pfleeger et al., 1997], the authors evaluates standards and formal methods used in software engineering. In the first report, the authors found that the software engineering standards have “…a lot to learn from standards in other engineering disciplines. Our standards lack objective assessment criteria, involve more process than product, and are not always based on rigorous experimental results.” The lack of empirical, quantitative evidence that standards and recommended practices improve products and processes is pointed out in the latter report as well. However, results from investigation made in the latter report suggest that using formal methods may contribute to a good result.

2.4 Chapter summary

In this chapter we have presented some of the research and related work done in this field. Firstly, we have detailed the software procurement procedure and pointed out the tasks included. The procurement of software is a complex, never-ending cyclical process. This cycle can be contracted into a six step procurement process; the Requirement phase, Invitation to Tender (ITT), Evaluation of vendor responses, Vendor/product selection, Contract negotiation, and Installation, testing and acceptance phase.

Secondly, we have detailed the risk management discipline. A significant share of software projects run into problems like budget overruns and missed deadlines. Utilizing risk management may remedy some of these problems.

Different parties in the world of software engineering offer standards and formalized methods to help organizations in their software procurements. Their applicability for small and medium sized organizations is varying. We have in this chapter evaluated some of the available procurements standards and methods in the context of small and medium sized organizations.

It is likely to believe that most organizations have a defined procurement process in accordance with these six steps. However, analysis indicates that this is not true for a significant part of the organizations in Europe.

In the next chapter we detail the research methods and strategy employed in our investigation of small and medium sized organizations procuring software intensive systems (SIS). This investigation is an attempt to identify the main weaknesses in the current software procurement procedures.

3 Method

3.1 Introduction

In this Chapter we present the strategy used to answer the research questions. The research focus is detailed in Section 3.2. In Section 3.3 we give an overview of the available empirical strategies, followed by method triangulation theory. In addition, the selection of strategy is described. In Section 3.4, the planning of the investigation is outlined, including the validity evaluation. The operation of the investigation is described in detail in Section 3.5.

3.2 Research focus

3.2.1 Detailed problem definition

As described in the introduction, this project investigates how inexperienced procurers and smaller organizations work when they buy software-intensive systems. More precisely, using a goal definition template [Briand et al., 2002], the objective is to:
Investigate what risks and suitable mitigating actions are known, for the purpose of formulating a roadmap:" From non-aware to aware software procurer", in the context of small and medium sized organizations procuring software-intensive systems. The investigation is limited by the research methods available: Archival research, surveys, and interviews.

To be able to perform the investigation defined above, a survey has been conducted in 13 organizations in Norway. The organizations have been asked to describe their procurement process and what problems they have encountered in previous procurement projects. In addition, they are asked to identify possible risks related to the procurement process and suitable mitigation actions.

Our definition of small and medium sized organizations is only related to the number of employees, which is fewer than 250 persons [Congrex]. We have not included any criteria related to turnover or balance sheet.

3.2.2 Overall research questions (RQ1-RQ3)

Based on the scope of the project detailed in the previous section, three focused research questions are formed:

- RQ1: What problems have smaller and medium sized organizations experienced in previous software procurements?
- RQ2: What risks do smaller and medium sized organizations see in the process of procuring a software intensive system?
- RQ3: What mitigating actions are known among the smaller and medium sized organizations?

3.3 Research paradigms and methodology

3.3.1 Empirical strategies

In the preparations for this section of the report, a litterateur-study of work from several researchers in the software research community has been conducted [Basili et al., 1986], [Basili 1996], [Kitchenham et al., 2002], [Tichy, 1998], [Perry et al., 2000], [Fenton et al., 1994], [Wohlin et al., 2000], [Pfleeger et al., 2001], [Bratthall et al. 2001]. Most of this literature reference software engineering generally, and not software procurement especially. This is mainly because of the lack of papers based on empirical research in the software procurement discipline. However, many of the aspects of software engineering in general also relates to procurement. The validity of this prestudy is therefore not compromised by this choice.

We have seen that several theories and claims are made. However, the authors seem to agree upon one thing - the need for further work and emphasizing on the empirical part of software engineering [Basili 1996], [Kitchenham et al., 2002], [Tichy, 1998]. One of the main challenges is to create a credible empirical discipline for software engineering with satisfying guidelines for the research and reporting processes.

It is claimed that empirical studies in software engineering research have not had the same success as in other parts of modern science [Perry et al., 2000]. This is widely discussed in several articles, and possible reasons are presented. N. Fenton et al. [Fenton et al., 1994] claims that software engineering research got off to a bad start. They characterize many of the publicized articles as “analytical advocacy research” with poor experiment and statistical design. Victor Basili [Basili, 1996] discusses the differences between software engineering and other fields like physics, medicine and manufacturing, where empirical research is widespread. These differences could be the reason for the lack of success in software engineering. Basili also suggests that the distinctive characteristics of software projects often make it hard to compare studies.

As software engineering doesn’t have long traditions in empirical research, parts of the research community have glanced at other spheres to get ideas for their work. This has resulted in both guidelines and templates for designing, conducting and evaluating empirical studies. One of the first articles that emphasized the need for experimentation in software engineering was released by Basili, Selby & Hutchens in 1986 [Basili et al., 1986]. This article includes both a framework for analyzing and designing experimental work performed in software engineering, and recommendations for performing future experiments. The framework presented consists of four categories; definition, planning, operation and interpretation, each corresponding to phases of the experimentation process. This article has been an inspiration and source for much of the research in the software engineering area.

As mentioned above, a lot of the work in the software engineering research community has aimed at developing guidelines and templates for the empirical research. The tendency from the past was software engineering driven by technology development and advocacy research. This is not acceptable in the long run if control of the software development is desired. To gain control, the ability to evaluate new methods and techniques before using them is necessary [Wohlin et al., 2000]. This

can be achieved by performing empirical studies like surveys, experiments and case studies, and turn software engineering into a science.

Qualitative/quantitative research

There are two distinct approaches to empirical studies; quantitative/fixed and qualitative/flexible research. While quantitative research is based on numerical data, qualitative research is founded on individual, often subjective, analysis. According to Cambridge Institute for Research, Education and Management (CiREM), quantitative research is: "Research that focuses on measuring and counting facts and the relationship among variables, and that seeks to describe observations through statistical analysis of data. It includes experimental and non-experimental research and descriptive research (research that attempts to describe the characteristics of a sample or population)." Further they state that qualitative research is: "Research that focuses on the experiences, interpretations, impressions or motivations of an individual or individuals, and that seeks to describe how people view things and why. It relates to beliefs, attitudes and changing behavior." [CiREM]

Qualitative and quantitative research may very well investigate the same subject, but address a different type of questions [Wohlin et al., 2000]. Quantitative research seeks to quantify a relationship or to compare two or more groups [Creswell, 2003]. In software engineering, qualitative research is applied to explain the causes of a certain phenomenon. There has been an ongoing 'paradigm war' between quantitative researcher and qualitative researchers, both sides striving to indicate the weak points of the opponents approach. Robson [Robson, 2002] suggests a pragmatic approach, based on contributions from other researcher, in an attempt to end this dispute. This suggestion can in short be described as a collaboration where the best from both camps are used and complement each other. This approach is exemplified in Section 3.3.2, where the use of triangulation is described. Creswell [Creswell, 2003] supports this suggestion and claims that: "Mixed methods research has come of age. To include only quantitative or qualitative methods falls short of the major approaches being used today in the social and human sciences."

Purpose – Descriptive, Explanatory, Explorative or Emancipatory

There can be several objectives for conducting an investigation. The most common classification of the purposes of enquiry is descriptive, explanatory and explorative [Babbie, 1990]. Robson [Robson, 2002] adds another classification called emancipatory. His classification is described below. An investigation can be concerned with more than one purpose, but often one purpose will be dominant. It is also possible that the purpose of the investigation changes along with the evolution of the investigation. One may start with an explorative survey to gather information for a more thorough, in-depth explanatory investigation.

Robson [Robson, 2002, pp 59-60] summarizes some of the characteristics and attributes of the classifications as follows: “

1 *Exploratory*

- To find out what is happening, particularly in little-understood situations.
- To seek new insights.
- To ask questions.
- To assess phenomena in a new light.
- To generate ideas and hypotheses for future research.
- Almost exclusively of flexible design.

2 *Descriptive*

- To portray an accurate profile of persons, events or situations.
- Requires extensive previous knowledge of the situation etc. to be researched or described, so that you know appropriate aspects on which to gather information.
- May be of flexible and/or fixed design.

3 *Explanatory*

- Seeks an explanation of a situation or problem, traditionally but not necessarily in the form of causal relationship.
- To explain patterns relating to the phenomenon being researched.
- To identify relationships between aspects of the phenomenon.
- May be of flexible and/or fixed design.

4 *Emancipatory*

- To create opportunities and the will to engage in social action.
- Almost exclusively of flexible design.”

Strategies – survey, case study or experiment

As mentioned above, there exists three major types of investigation [Robson, 2002]; survey, case study and experiments. Their range of use may overlap and thus making a choice between them depends on factors like the purpose and conditions for the empirical investigation. Criteria like available resources, experience and need for replication of the investigation, should be included in the strategy selection.

The choice of empirical strategy also depends on the available data and the appropriate approach to the investigation. Depending on the design of the investigation, a classification as shown in Table 4 can be made [Wohlin et al., 2000].

Strategy	**Qualitative/Quantitative**
Survey	Both
Case study	Both
Experiment	Quantitative

Table 4: Qualitative vs. quantitative in empirical strategies

Survey
According to Pfleeger and Kitchenham, "the survey is probably the most commonly-used research method world-wide" [Pfleeger et al., 2001]. This method tries to capture the current state of a situation or a research area, and create an understanding of the selected sample of subjects. This sample of subjects should be as representative for the population studied as possible, otherwise the validity of the investigation is threatened.

Pfleeger and Kitchenham define the survey as: "A survey is not just the instrument (the questionnaire or checklist) for gathering information. It is a comprehensive system for collecting information to describe, compare or explain knowledge, attitudes and behavior. Thus, the survey instrument is part of a larger survey process with clearly-defined activities:

1. Setting specific, measurable objectives
2. Planning and scheduling the survey
3. Ensuring that appropriate resources are available
4. Designing the survey
5. Preparing the data collection instrument
6. Validating the instrument
7. Selecting participants
8. Administrating and scoring the instrument
9. Analyzing the data
10. Reporting the results"

There are several ways to conduct a survey, but questionnaires and interviews are the most common ones [Babbie, 1990]. "Surveys have the ability to provide a large number of variables to evaluate, but it is necessary to aim at obtaining the largest amount of understanding from the fewest number of variables since this reduction also eases the analysis" [Wohlin et al., 2000]. The survey is suitable in a wide range of investigations, with descriptive, explanatory or explorative objectives.

Case study
The use of case studies as a research method has met some skepticism among researchers. It has been viewed as a less desirable form of inquiry than the other empirical strategies. This has been related to arguments like little basis for scientific generalization [Kennedy, 1976] and the amount of time needed to execute a case study [Feagin et al., 1991]. Despite this, other researchers claim that the use of case studies is highly applicable in the right conditions [Kitchenham et al., 1995], [Yin, 1994], [Wohlin et al., 2000].

There have been several attempts to define what a case study is [Stoecker, 1991], [Schramm, 1971], [Kitchenham et al., 1995]. Robert K. Yin [Yin, 1994] one of the frequently cited contributors in the research work regarding case studies, defines the scope of a case study as follows:

"A case study is an empirical inquiry that

- investigates a contemporary phenomenon within its real-life context, especially when
- the boundaries between phenomenon and context are not clearly evident."

He continues with a technical definition: “The case study inquiry

- copes with the technically distinctive situation in which there will be many more variables on interest than data points, and as one result
- relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result
- benefits from the prior development of theoretical propositions to guide data collection and analysis.”

Case study research is often used to monitor projects, activities or assignments, and is an observational method. The method can be suitable in the comparison of two methods. Compared to experiments, the case study has a lower level of control which can be both an advantage and a disadvantage. The lack of control could lead to problems with confounding factors. Another issue is the scale-up problem, i.e. factors may have another influence in a small case study than it has in a large case study [Wohlin et al., 2000]. Case studies are easier to plan than experiments, and the lack of control may result in the discovery of unpredictable aspects [Wohlin et al., 2000].

Experiment

Experiments are the research method that offers the most control over the situation that is being investigated. The objective is to manipulate a few of the variables that can affect the outcome of the experiment while the others are fixed. This makes the researcher able to measure the effect of the manipulation empirically. “Experiments are appropriate to investigate aspects, including:

- Confirm theories, i.e. to test existing theories.
- Confirm conventional wisdom, i.e. to test people’s conceptions.
- Explore relationships, i.e. to test that a certain relationship holds.
- Evaluate the accuracy of models, i.e. to test that the accuracy of certain models is as expected.
- Validate measures, i.e. to ensure that a measure actually measures what it is supposed to.” [Wohlin et al., 2000].

As mentioned above, there are several factors that should be considered when choosing an empirical strategy. Table 5 shows a comparison of the empirical strategies described above based on some of the possible selection factors.

Factor	Survey	Case Study	Experiment
Execution control	No	No	Yes
Measurement control	No	Yes	Yes
Investigation cost	Low	Medium	High
Ease of replication	High	Low	High

Table 5: Comparison of empirical strategies [Wohlin et al., 2000]

3.3.2 Method triangulation

One problem or weakness that may affect the validity of many investigations is the uncertainty related to the unknown, confounding factors. This problem must be taken seriously; otherwise the whole investigation may become worthless. Different suggestions have been proposed to avoid this particular problem. This project put emphasize on triangulation. One way to classify triangulation has earned acceptance among several researcher [Patton, 1980], [Yin et al., 1983], [Denzin, 1989]. This classification defines four types of triangulation:

- Data triangulation
- Observer triangulation
- Methodological triangulation
- Theory triangulation

The idea of triangulation is to improve the validity, accuracy and conviction of the findings from investigation. According to studies and research papers [Yin et al., 1983], [Patton, 1980], [Denzin, 1989] using multiple sources of evidence, increases the likelihood of achieving this improvement, compared to the use of single source. As Yin [Yin, 1994] claims, "With triangulation, the potential problems of construct validity also can be addressed, because the multiple sources of evidence essentially provide multiple measures of the same phenomenon".

The four types of triangulation have different approaches to the multiple source investigation. While data triangulation uses more than one method of data collection (e.g. interviews, observation, documents), observer triangulation uses more than one observer in the investigation. Methodological triangulation implies the combination of quantitative and qualitative research, and theory triangulation uses multiple theories or perspectives.

Yin [Yin, 1994] further claims that there are two types of data triangulation. He distinguishes between, what he calls convergence of multiple sources of evidence and nonconvergence of multiple sources of evidence. This is shown in Figure 12 below. Bratthall & Jørgensen [Bratthall et al. 2001] supports this claim in their empirical study investigating the differences in the outcome of studies based on multiple and single data sources. They suggested that "…using multiple data source triangulation both for the purpose of *increasing confidence* in findings as well as for *making more and other findings* can deliver some such value".

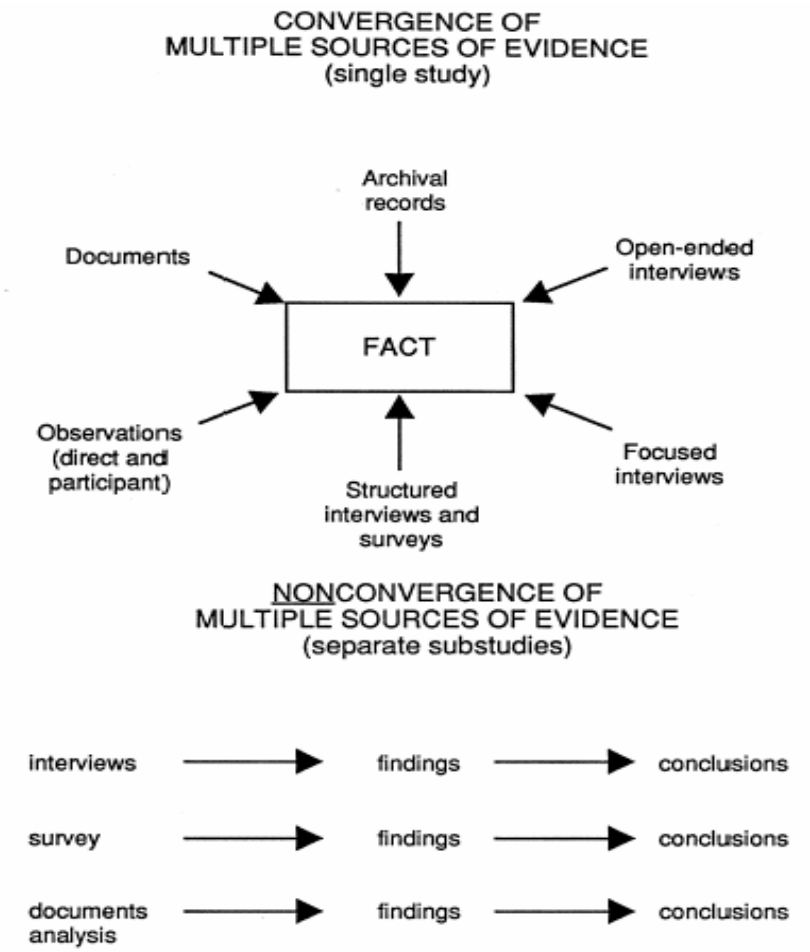


Figure 12: Convergence and Nonconvergence of multiple sources of evidence [Yin, 1984]

3.3.3 Chosen strategy

Based on the discussion in the previous sections, the choice of empirical strategy was conducted. The objective of this study is to find the current state of how procurement of software-intensive systems is done in small and medium sized organization in Norway. Based on the findings from the investigation, a set of general guidelines will be formulated. Since this is a one-man project, the available resources are limited. Nevertheless, the intention is to generate a result that is applicable for as large a population as possible. This leads to the need for a possible replication of the investigation.

Based on the conditions above and the purpose of the investigation, a survey is the best strategy. By using a survey, there should be possible to get a general impression of how the procurement process is conducted, for a relative low cost. The disadvantage of using a survey is the threat to the validity to the investigation. If the sample of subjects participating in the investigation is too small or not representative, the result will not be valid in for the whole population. This, and other threats to the investigation, is examined in Section 3.4.6.

To increase the confidence and hopefully be able to make other findings, an additional in-depth interview is carried out after the survey. This type of triangulation has been

successful in other investigations [Bratthall et al. 2001], and should also be feasible in this project. The interview is carried out after the questionnaire is ended, and the possibility to follow up some of the tendencies and interesting responses is present. Because the data from the questionnaire is available during the in-depth interviews, it is decided to use semi-structured interviews. A set of predetermined questions is the base of the interview, but there is also possible to include additional questions based on the respondents' answers from the questionnaire or the interview [Robson, 2002].

Our strategy is an investigation conducted in three steps. First, an archival research is carried out to get an overview over the published work and contributions available. In addition, as shown above, some research regarding empirical strategies is done. This research was an input to the design of the questionnaire which was sent out to the participating organizations. The data collected through the questionnaire was used in the design of the in-depth interview.

3.4 Investigation planning

3.4.1 Context selection

The context of an investigation can be characterized by four dimensions [Wohlin et al., 2000]:

- Off-line vs. on-line
- Student vs. professional
- Toy vs. real problems
- Specific vs. general

The context of the investigation in this project is small/inexperienced organizations in Norway procuring software-intensive systems, and hence the investigation is run partly on-line as some of the organizations are in the middle of a procurement project. The investigation is conducted by a graduate student with guidance from professionals. A real problem is addressed, i.e. the formulation of guidelines for stepwise improvement of an organization's ability to procure software-intensive systems. We believe that it is possible to generalize the results of our investigation outside our scope, but this question is further elaborated on in Section 3.4.5.4.

3.4.2 Hypothesis formulation

Based on the research questions RQ1, RQ2 & RQ3 stated in Section 3.2.2, a set of hypotheses was created. The relation between the research questions and the hypothesis are shown in Table 6. The candidate hypotheses are detailed and evaluated in Appendix 1. The hypotheses passing the evaluation are tested against the data gathered through the survey and interviews in Section 5.3. The hypotheses testing forms the empirical foundation for the conclusion on the research questions in Section 5.4. The null hypotheses are defined below the corresponding alternative hypothesis.

- H1.1: Organizations consider software procurement as being a high-risk activity.
    - H1.0: Organizations don't consider software procurement as being a high-risk activity.

- H2:.1 Organizations follow a particular standard when they procure software.
    - H2.0: Organizations don't follow a particular standard when they procure software.

- H3.1: Organizations integrate risk management in their procurement project.
    - H3.0: Organizations don't integrate risk management in their procurement project.

- H4.1: TCO is emphasized as a selection criterion in the procurement process.
    - H4.0: TCO is not emphasized as a selection criterion in the procurement process.

- H5.1: Organizations with a defined, formalized procurement process are more satisfied with previous procured software-intensive systems than organizations with ad-hoc procurement processes.
    - H5.0: Organizations with a defined, formalized procurement process are not significantly more satisfied with previous procured software-intensive systems than organizations with ad-hoc procurement processes.

- H6.1: Organizations without a contract change clause experience changes to the initial contract more frequent than organizations with a contract change clause.
    - H.6.0: Organizations without a contract change clause do not experience changes to the initial contract more frequent than organizations with a contract change clause.

- H7.1: Organizations find the documentation and information from the suppliers satisfactory.
    - H7.0: Organizations don't find the documentation and information from the suppliers satisfactory.

- H8.1: Organizations integrating risk management in procurement projects are more satisfied with their procurements than those who don't.
    - H8.0: Organizations integrating risk management in procurement projects aren't more satisfied with their procurements than those who don't.

- H9.1: Organizations managing knowledge management from previous completed software procurements are more satisfied with their procurements than those who don't.
    - H9.0: Organizations managing knowledge management from previous completed software procurements aren't more satisfied with their procurements than those who don't.

These hypotheses are the foundation in the attempt to answer the research questions. In addition, the qualitative data gathered in the questionnaire and the interviews is analyzed to strengthen the research.

Research Question	**Hypothesis**
RQ1	H2, H3, H6, H7, + qualitative data
RQ2	H1, H2, H3, + qualitative data
RQ3	H2, H3, H4, H5, H8, H9, + qualitative data

Table 6: Relation between research questions and hypotheses

3.4.3 Selection of subjects

Participants in this survey are one employee in each of the 13 organizations from a wide range of business sectors. The participants are all volunteers and the selection was based, somewhat, on convenience sampling, as all of the organizations are from Norway. The employees participating are all involved in the process of software procurement or have good knowledge of how this is conducted by their organization.

Contact with the participants was established by e-mail correspondence and telephone/face-to-face conversation. A total of approximately 150 organizations in Norway and Sweden were informed about the project and were asked to participate in the survey. These organizations were selected only based on their size. As mentioned above, 13 of the organizations agreed to participate in the survey.

The organizations participating share some characteristics:

- They are all Norwegian.
- The organizations have procured a software-intensive system in the past years.
- The organizations are all small or medium sized, i.e. fewer than 250 employees.

3.4.4 Instrumentation

The investigation is based on two measurement instruments; questionnaire and interviews. The initial information regarding experience-level, prevailing procurement procedures and known risks are gathered in the questionnaire. This data provides both the foundation of the analysis and the input to the design of the in-depth interview. The questionnaire and interview guidelines are presented in Appendix A2.

To ease the communication and distribution of the survey to the participants, a web based tool was used [Questback]. After an initial phase of brainstorming where potential questions for the questionnaire were discussed, the design phase started. Based on the research questions and the suggested hypotheses several drafts of the questionnaire were made. The testing and final preparations are described in Section 3.5.1.

During the design of the questionnaire, some of the suggested open-ended questions were found too complex and thus not suitable. It is our impression that participants in web-based questionnaire are usually more positive to closed questions, which requires less time to answer. The open-ended questions were included in the interview guide instead.

As mentioned in Section 3.3.3, it was decided to use a semi-structured interview. Even though the interview is conducted by the researcher himself, a comprehensive set of guidelines are designed. This is to avoid that important aspects of the interview/investigation are left out and forgotten. The interview guidelines include background information with a list of main themes covered in the interview together with a timeline for the interview. It also contains the information intended to the respondent and a set of predetermined questions. The interviewer brings with him the respondent's answers from the questionnaire to be able to ask some follow-up questions in addition. The semi-structured interview style also enables one to omit questions if they seem inappropriate and give additional explanations/information when needed [Robson, 2002]. This is especially useful since the participants may have different vocabulary and understanding of the questions due to different experience and education.

3.4.5 Validity evaluation

One important issue appears during the survey planning - the validity evaluation of the results. This task has to be done during the planning phase to ensure valid research results. Without the validity evaluation, one might end up with results that are not valid for the population from which the sample is drawn.

In the past, different types of threats to the validity of an investigation have been suggested [Cook et. al., 1979], [Campbell et. al., 1963]. In "Experiment in software engineering, An introduction" [Wohlin et al., 2000] four types of threats are presented. Most of the threats defined here are also applicable in the survey context.

According to Wohlin et al. the threats are:"

1. *Conclusion validity. This validity is concerned with the relationship between the treatment and the outcome. We want to make sure that there is a statistical relationship, i.e. with a given significance.*
2. *Internal validity. If a relationship is observed between the treatment and the outcome, we must make sure that it is a causal relationship, and that it is not a result of which we have no control or have not measured. In other words that the treatment causes the outcome.*
3. *Construct validity. This validity is concerned with the relation between theory and observation. If the relationship between cause and effect is causal, we must ensure two things: 1) that the treatment reflects the construct of the cause well (see left part of the figure) and 2) that the outcome reflects the construct of the effect well (see right part of the figure).*
4. *External validity. The external validity is concerned with generalisation. If there is a causal relationship between the construct of the cause, and the effect, can the result of the study be generalized outside the scope of our study? Is there a relation between the treatment and the outcome?*" [Wohlin et al., 2000, p. 63-64]

The next part of this section presents a list of threats to the validity of the investigation. In addition, every threat is evaluated to determine if it might cause any problems in the investigation. The marking used in the tables are as follows:

-: Threats that we believe will not be of any significance
+: Threats that might have an effect, but with low probability
++: Threats that could affect the result, with high probability
n/a: Threats which are not applicable for this investigation

3.4.5.1 Conclusion validity

Low statistical power	-
Violated assumption of statistical tests	+
Fishing and the error rate	-
Reliability of measures	++
Reliability of treatment implementation	n/a
Random irrelevancies in experimental setting	-
Random heterogeneity of subjects	-

Table 7: Conclusion validity

Low statistical power
The statistical power can be expressed as:

Power = P(reject H_0 | H_0 false) = 1 – P(type-II-error)

The statistical power depends on the selection of test and the selection of α-level used in the tests. This risk can be controlled by choosing applicable statistical tests and α-levels. In this survey, the α-level is set to 0.05 and thereby reducing the risk to an acceptable level.

Violated assumption of statistical tests
Since the number of participants is 13, the choice of statistical tests becomes important. This is due to the parametric tests' assumptions of approximate normal distribution and independent samples. With less than 30 observations, we can't assume that our sample is normal distributed.

Fishing and the error rate
Since the person performing the survey doesn't have any connections to the organizations investigated in this project, the probability of fishing for a specific result is low. As long as the confidence intervals of the tests are narrow, the threat from the error rate is not extensive.

Reliability of measures
Depends on the design of survey, but should be considered. Some of the questions in the questionnaire and the interview are based on subjective measures like satisfaction. This could be a threat to the conclusion validity [Wohlin et al., 2000]

Reliability of treatment implementation
The use of treatments is not present in this investigation.

Random irrelevancies in experimental setting
It is hard to prevent elements outside the experiment that may disturb the results. But the survey is not a measure of how the participants perform an activity. Thus any interruptions in the survey should not influence the results.

Random heterogeneity of subjects
The organizations participating in the survey come from a wide range of business sectors. This is a survey, not an experiment. Threats related to variations due to individual differences are not applicable here.

3.4.5.2 Internal validity

History	+
Maturation	+
Testing	+
Instrumentation	+
Statistical regression	-
Selection	++
Mortality	+
Ambiguity about direction of causal influence	+
Interactions with selection	n/a
Diffusion of imitation of treatments	n/a
Compensatory equalization of treatments	n/a
Compensatory rivalry	n/a
Resentful demoralization	n/a

Table 8: Internal validity

History
Some of the organizations might be in the middle of, or have just finished a software procurement project. Possible problems that occurred during this procurement might reflect the answers too much, and not be representative for a general view.

Maturation
The execution of the questionnaire is done over a short period of time. It should only take about 20 minutes to complete it. Possible threats related to maturation with the questionnaire are therefore small. Since an interview is conducted after the questionnaire, the possibility of maturation is present among the subjects participating in both methods. Respondents participating in both the questionnaire and the interview will not be given any feed-back on the collected data during the interview. This is done to minimize the possibility of maturation.

Testing
Each participant fills in the questionnaire only ones; any experience gained through the questionnaire should not affect the answers given. This might, however, be a threat to the validity of the interview. In order not to support unintended learning, the participants won't get any feedback from the investigation until it is completed.

Instrumentation
There is a possibility that the questionnaire and the interview are designed badly as a consequence of little experience. Mitigating actions like inspection of the questionnaire and the interview guide together with a pilot study are conducted to reduce this threat.

Statistical regression
The participants are not included based on a pre-survey classification. Threats due to statistical regression are not present.

Selection
The selection of participants is based on convenience sampling and voluntariness which results in a threat both to the internal and the external validity. The voluntary organizations are perhaps more interested in the research topic than the average organization which may influence the results.

Mortality
Since the number of participants is quite low, a significant drop-out will influence the credibility of the project. It is therefore important to emphasize the task of reminding the participants about the survey until a response is received.

Ambiguity about direction of causal influence
There could be other cause and effect relations that we're not aware of, affecting the results of the investigation. Mitigating actions conducted in this matter are a thorough pre-study and super-vision by experts from this section of the research community.

Interactions with selection
In this investigation only a single group of participants are included.

Diffusion or imitation of treatments
There exist no control groups in this investigation, and the possible threats connected to diffusion or imitations of treatments are not present.

Compensatory equalization of treatments
See Diffusion or imitation of treatments above.

Compensatory rivalry
See Diffusion or imitation of treatments above.

Resentful demoralization
See Diffusion or imitation of treatments above.

3.4.5.3 Construct validity

Inadequate preoperational explication of constructs	-
Mono-operation bias	-
Mono-method bias	-
Confounding constructs and levels of constructs	+
Interaction of different treatments	n/a
Interaction of testing and treatment	n/a
Restricted generalizability across constructs	n/a
Hypothesis guessing	+
Evaluation apprehension	+
Experimenter expectancies	+

Table 9: Construct validity

Inadequate preoperational explication of constructs
In the selection of the hypotheses made above, we tried to separate the ambiguous and inadequate hypotheses from the rest. As a result, the hypotheses that are chosen are well formulated and the threat minimized.

Mono-operation bias
In this investigation, the current software procurement procedure in several organizations is scrutinized. This threat is therefore minimized.

Mono-method bias
The use of both surveys and interviews should reduce this threat.

Confounding constructs and levels of constructs
It is hard to determine what level of experience and knowledge of software procurement the participants have. This could affect the results, but it will be noticed since the participants will include this information in the survey.

Interaction of different treatments
This research project is not investigating the relation between a treatment and the outcome.

Interaction of testing and treatment
This research project is not investigating the relation between a treatment and the outcome, and no testing is carried out.

Restricted generalizability across constructs
This research project is not investigating the relation between a treatment and the outcome.

Hypothesis guessing
There is a risk that the participants involved in the survey tries to give "the correct answer" according to their anticipated hypothesis. The use of both survey and interview will reduce this threat.

Evaluation apprehension
The organizations involved might have the impression that they are being evaluated during the project. This could result in the participants trying to look better then they are. It is crucial to emphasize the anonymity of the participants in the survey.

Experimenter expectancies
This can be a threat, but the survey and the interview raises the same questions in different contexts and wording. This should reduce the threat to an acceptable level.

3.4.5.4 External validity

Interaction of selection and treatment	++
Interaction of setting and treatment	-
Interaction of history and treatment	+

Table 10: External validity

- **Interaction of selection and treatment**

There is a possibility that the organizations participating in the project is not representative for the population we want to generalize to, i.e. small and medium sized organizations procuring SIS. Another issue arises if there is a divergence between what the participants say they do and what they do in practice. This lack of relation between attitude and behavior is hard to avoid without the use of direct observation.

- **Interaction of setting and treatment**

There should not be any issues related to this threat in this investigation.

- **Interaction of history and treatment**

It is possible that some of the organizations have conducted software procurement just ahead of the survey. If several problems have appeared as a result of this procurement, the probability of a biased point of view is present. These organizations' answers may differ from the general view, and thereby affect the result.

3.5 Data collection

3.5.1 Preparations

In Section 3.4.4 and Appendix 2, the instrumentation used in the investigation is detailed. To ensure that the initial questionnaire had an appropriate design, a review was performed. This review was first done by experienced researchers at DNV. Then students finishing their final year at the Master of Science study at NTNU reviewed the questionnaire. By using these two groups, both the quality and the comprehensibility of the questionnaire were tested.

The selection of subjects, in terms of sampling technique (Section 3.4.3), was determined before the design of the questionnaire was accomplished. Some information was given to the potential participants during the request/selection phase. This included the context and objective of the project, inducements, and treatment of the results, in addition to some information regarding the survey. After the determination of subjects and the design of the questionnaire were completed, additional information related to the distribution of the questionnaire was sent out to the participants. This included a link to the questionnaire and the space of time the questionnaire was accessible. The questionnaire was then published on a website, protected with a password given to the participants.

3.5.2 Execution

When the questionnaire was published on Questback [Questback], the organizations that had agreed to participate were notified. They were given the URL and password needed to access the questionnaire, by e-mail. The questionnaire was accessible for four weeks, which gave the participants ample time to complete it. A few days after the publishing, a reminder was sent to the participants who hadn't answered. Approximately two weeks after the publishing, participants failing to fill out the questionnaire were called and asked if they still were able to participate. In addition, e-mail correspondence was used during the last week the questionnaire was open. This resulted in 13 out of the 14 organizations who had said "yes" participating.

Within two weeks after the closure of the web-based questionnaire, the in-depth interview was conducted. Some of the organizations that participated in the questionnaire were asked to participate in the in-depth interview as well. Due to limited time and available manpower in this project, only three organizations were interviewed. The interview guide can be found in Appendix 2.

3.5.3 Data validation

After the completion of the questionnaire and the interviews, a "validity-inspection" of the collected data was conducted. This was done to ensure that the data was reasonable and that it had been collected correctly. If these aspects of the survey are corrupted, the data may be invalid.

It is a risk that the respondents didn't understand the questions in the questionnaire correctly and therefore filled them in incorrectly. To avoid this problem, the

questionnaire had definitions and descriptions of all of the terms that could cause problems. In addition, the last question was an open question where the respondents could describe possible difficulties with understanding the questionnaire.

There is also possible that some of the respondents did not take the participation in the survey seriously enough, and thereby corrupt the integrity of the collected data. This is hard to know, but the participants were informed about the context, reason and goal of the survey and we believe this is enough to convince them of its importance.

Questionnaire-answers given by the respondents participating in both the questionnaire and the interview were scrutinized. If there were additional questions arising based on the answers from the questionnaire, these questions were asked during the interview. The respondents participating in both investigations were not given any feed-back on the collected data from the questionnaire. This was done to prevent the participants from being influenced from earlier collected data (See Section 3.4.5.2).

Interviewer bias is a threat to the validity of the data collected during the in-depth interview. This can never be completely avoided, but care has been taken not to "lead" the respondent to a particular outcome. In addition, anonymity among the respondents is emphasized in this project. Both the questionnaire and the interview is arranged to preserve the anonymity, which may result in more valid data.

3.6 Chapter summary

In this chapter we have described the research strategy and methods employed in our investigation of small and medium sized organizations procuring SIS. Our choice of research strategy and methods is based on an extensive archival research of available theory published by field experts. In addition, we have detailed our research focus and objectives and defined three overall research questions.

This chapter also includes the planning of the investigation regarding hypotheses and instrumentation being used. In addition, an extensive validity evaluation of our investigation is conducted. There are some threats to both the internal and the external validity that must be taken serious. These threats are related to the selection of subjects in the investigation. However, conservative choice of α-level in the statistical tests will reduce this threat to an acceptable level and thereby maintain the validity of this investigation.

The next chapter presents the descriptive statistics of the quantitative data gathered from our investigation. In addition, the most interesting findings are listed.

4 Results

4.1 Introduction

In this Chapter, raw data from the investigations are presented. These data are further analyzed in the next Chapter. In Appendix A3, all the quantitative data from the questionnaire are presented in detail. The qualitative data gathered from the questionnaire and the interviews are presented and used in Section 5.3.

4.2 Descriptive statistics

After the completion of the questionnaire, some interesting findings based on the quantitative data were made. For each of the findings, we indicate the information used to justify that finding. The results are summarized in Table 11. If the findings are investigated further in the interviews, it is indicated in the column "Further investigated in interview". Each finding is discussed in detail below.

Finding number	Description	Questionnaire number(s)	Further investigated in interview
F1	The respondents are well experienced with software-intensive systems	Q2, Q4	
F2	Most organizations don't have a defined, formalized procurement process	Q7	X
F3	Most organizations don't have an appointed software procurement team	Q11	
F4	Most organizations don't consider software procurements as a high-risk activity	Q14	
F5	Organizations seldom integrate risk management in their procurement projects	Q17	X
F6	Organizations are fairly satisfied with previous procurements of software	Q18	
F7	Functionality is the most emphasized factor in the evaluation of potential suppliers/ products	Q24	

Table 11: Findings in the quantitative data

4.2.1 Finding F1: The respondents are well experienced with SIS

F1 was suggested by data from question 2 and question 4 in the questionnaire. The data gathered from these two questions are summarized in Figure 13 and Figure 14. According to question 2 in the questionnaire, about 70% of the respondents have four years or more work experience with software-intensive systems. In addition, Figure 13 shows that about 70 % of the respondents have been in their current position in the organization for two years or more. This information strengthens the overall value of the collected data, as the respondents hold a considerable amount of experience related to SIS.

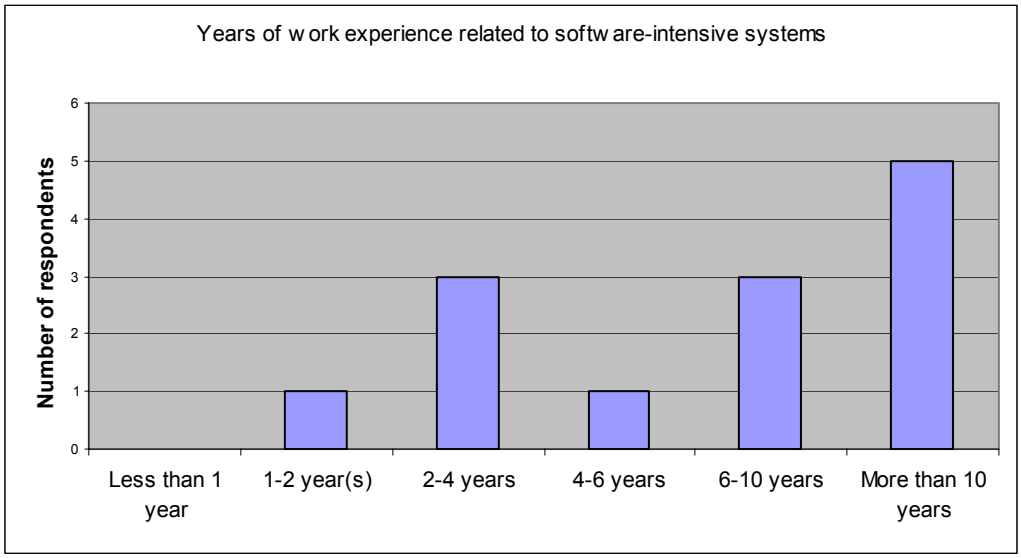


Figure 13: Respondents' work experience related to software-intensive systems

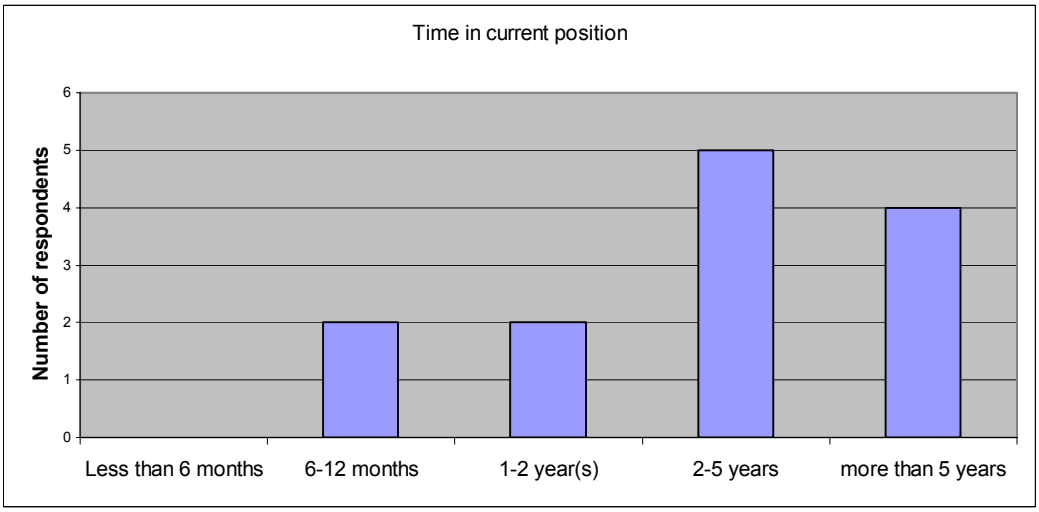


Figure 14: Respondents' experience in current position

After the completion of the questionnaire, it was discovered that there might be a weakness in question 2. It is possible that the respondents have included working experience related to text editor programs like MS Word and similar programs as well. However, we included a definition of SIS in the beginning of the questionnaire and thereby remedy this potential problem.

4.2.2 Finding F2: Most organizations don't use a defined, formalized procurement processes

F2 was suggested by data from question 7 in the questionnaire (See Figure 15). Only about 31 % of the organizations state that they have a defined, formalized procurement process. In addition, two of the organizations with a defined, formalized procurement process informed that they don't use this process during software procurements. This finding is further investigated in the interview.

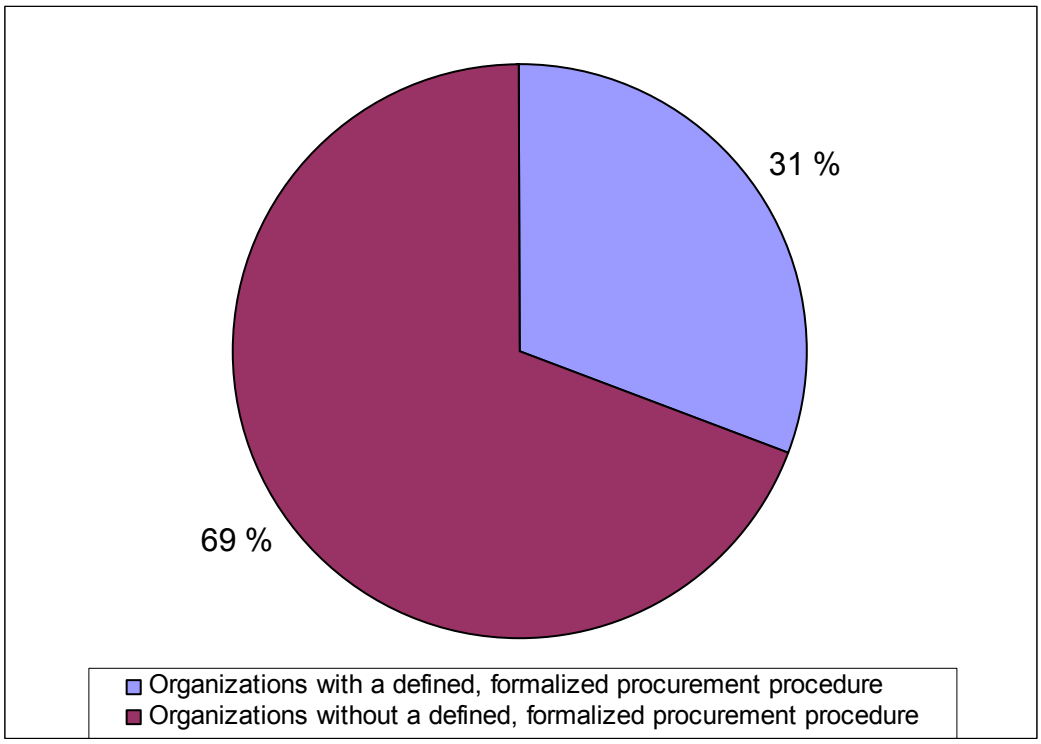


Figure 15: Distribution of organizations' use of a defined, formalized procurement process.

4.2.3 Finding F3: Most organizations don't have an appointed software procurement team

F3 is based on the data from question 11 in the questionnaire. As Figure 16 shows, almost 70% of the participating organizations do not have an appointed software procurement team.

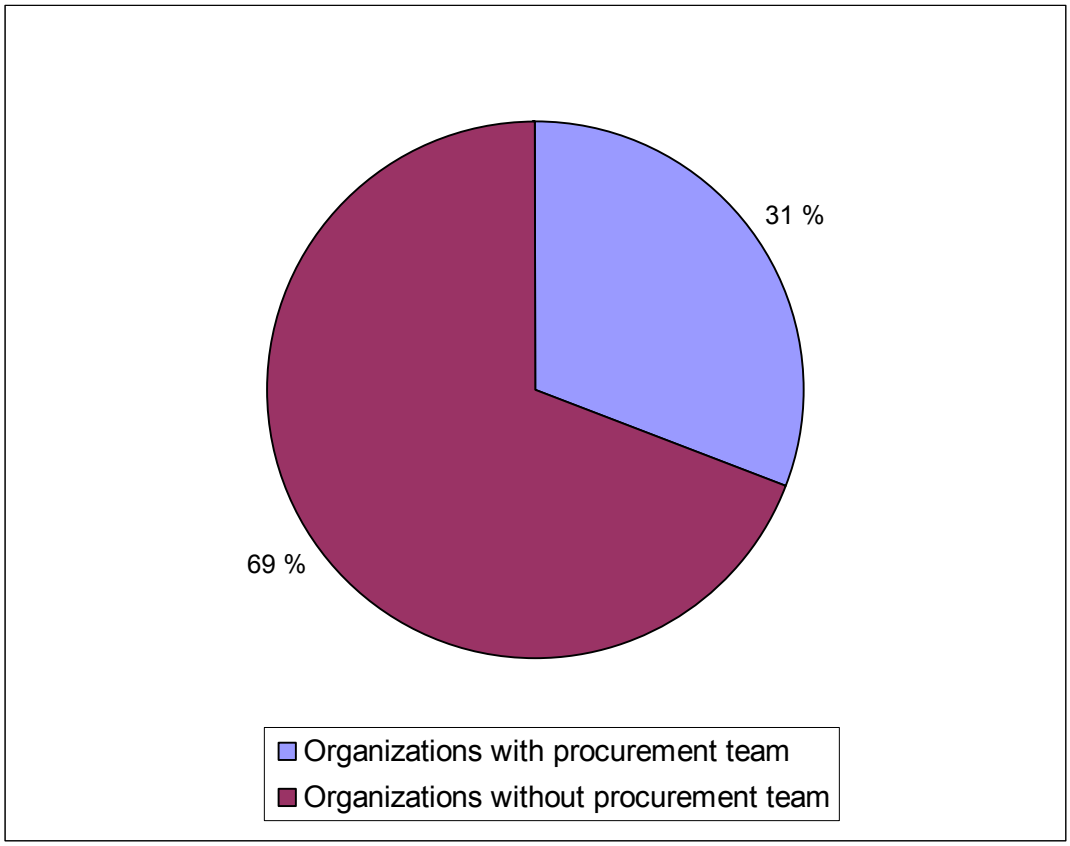


Figure 16: Participating organizations' use of software procurement team

4.2.4 Finding F4: Most organizations don't consider software procurements as a high-risk activity

F4 was suggested by data from question 14 in the questionnaire. Figure 17 shows the distribution of the answers given by the respondents. Only two organizations consider software procurement as a high risk activity. This means that about 85% of the participating organizations consider procurement as an activity with medium, low or very low risk.

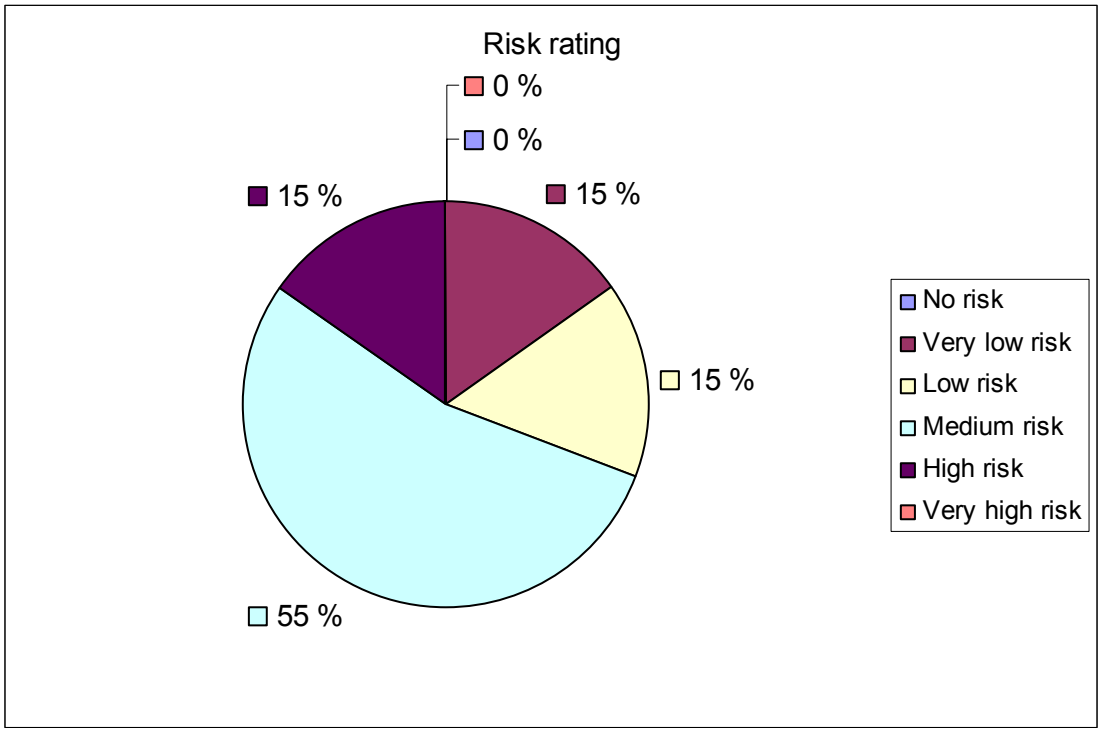


Figure 17: Organizations' rating of risk related to software procurement.

4.2.5 Finding F5: Organizations seldom integrate risk management in their procurement projects

F5 was suggested by data from question 17 in the questionnaire. The distribution of the answers is shown in Figure 18. This figure shows that about 77 % of the organizations participating in the survey seldom or never integrate risk management in procurement projects.

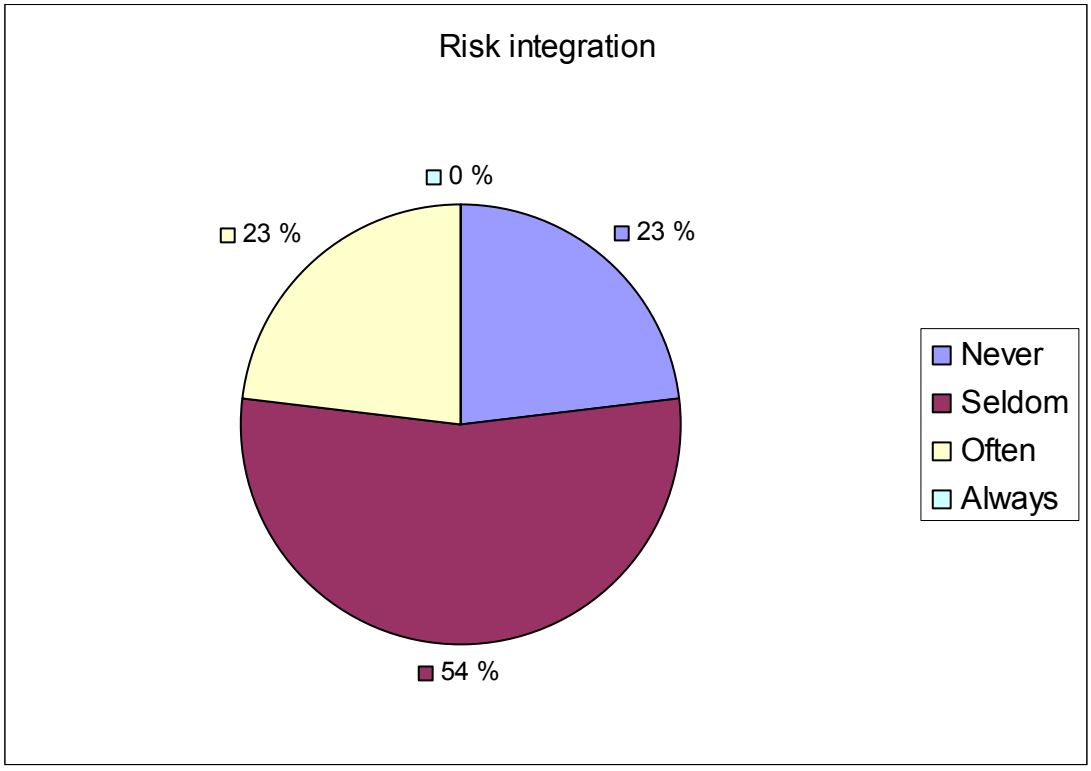


Figure 18: Frequency of risk management integration in procurement projects.

4.2.6 Finding F6: Organizations are fairly satisfied with previous procurements of software

F6 was suggested by data from question 18 in the questionnaire shown in Figure 19. This figure shows that about 84 % of the organizations participating in the survey are fairly satisfied or more with their previous procurements of software-intensive systems.

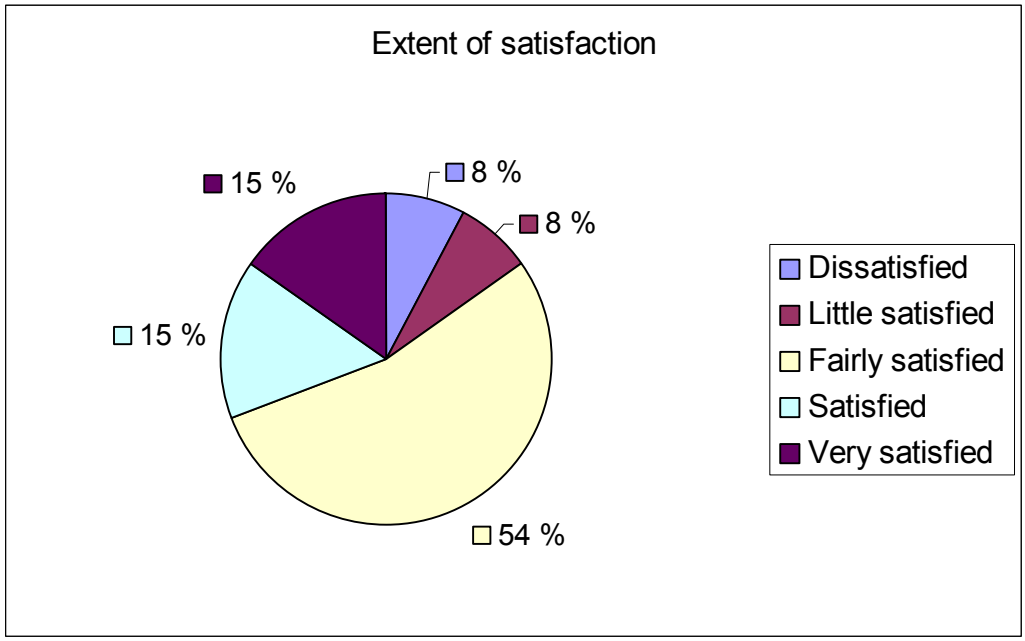


Figure 19: Organizations satisfaction with previous procurements of SIS

4.2.7 Finding F7: Organizations emphasize functionality most in the evaluation phase

F7 was suggested by data from question 24 in the questionnaire where the respondents were asked to indicate how they emphasize factors in the evaluation of potential suppliers/products. As shown in Figure 20, functionality is the factor that is most emphasized in the evaluation task.

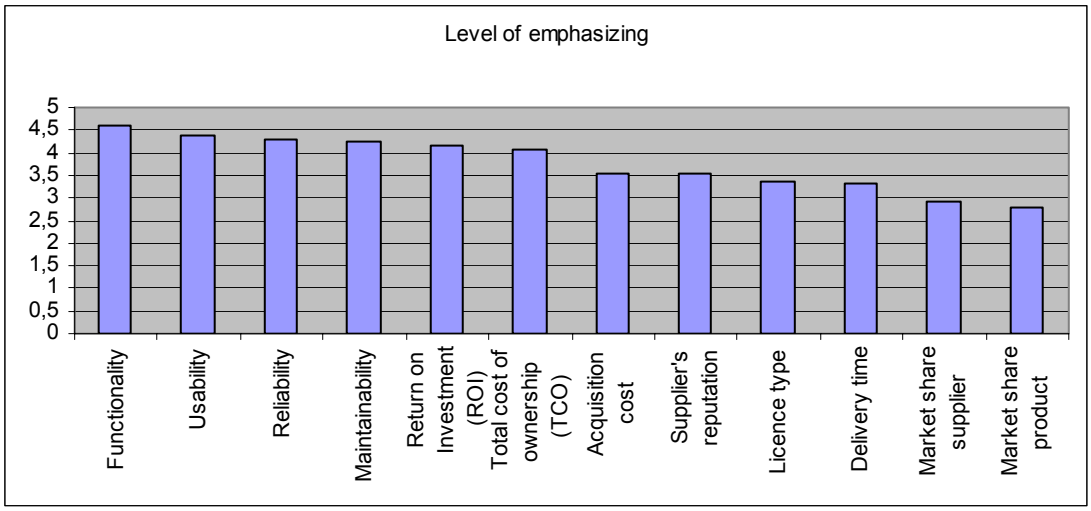


Figure 20: The participating organizations' emphasizing on evaluation factors

In addition, Figure 20 shows that 10 out of 12 factors have an average score above level 3. The fact that so many factors are important in the evaluation of suppliers/products, visualize some of the complexity related to software procurements.

4.3 Chapter summary

In this chapter we have presented the quantitative data gathered in the questionnaire. Based on the descriptive statistics, the most interesting findings are presented. These findings are, together with the hypotheses defined in Chapter 3, further analyzed in the next chapter.

5 Analysis and interpretation

5.1 Introduction

This chapter analyses the data presented in Chapter 4 in detail. Section 5.2 includes the investigation of the raw data, where invalid data is removed. In Section 5.3 the hypotheses formulated in Chapter 3 are tested against the data collected to see if it is possible to reject some of the null hypotheses. In Section 5.4 an interpretation of the qualitative data is conducted. Additional analysis and exploration of the gathered data is carried out in Section 5.5. An analysis and evaluation of the testing is presented in Section 5.6. Conclusions are included as well in this section.

5.2 Data set reduction

Some aspects of the questionnaire-design are intended to make the identification of invalid data easier. In questions where the respondents can choose from several alternative answers, the "other"-alternative is often included to enable answers outside the alternatives. In addition, some of the questions have follow-op question to deepen or state the reason for the given answers. However, some reductions were done during the initial analysis of the data from the questionnaire. As mentioned in Section 4.2.2, two of the organizations answered that they had a defined, formalized procurement procedure, but they didn't use this procedure during software procurements. One of the organizations were interviewed after the completion of the questionnaire, and the respondent confirmed that they had a procurement procedure which wasn't applicable for software procurements. The other organization was given some additional questions regarding the same issue via e-mail. This revealed that they have one main procurement procedure which they use during procurements of office equipment, maintenance equipment etc. In addition they have a procedure for software procurements as well. This results in a total of three organizations with a defined, formalized software procurement procedure.

The qualitative data collected in the questionnaire is mostly of good quality. However, some of the answers given are removed due to inaccuracy and ambiguity. Data from the interviews is merged together with the data from the questionnaire. The frequency of equal answers given by different respondents is registered to be able to see the tendencies in the collected information. Respondents that have failed to give answer to some of the question in the questionnaire are in some cases contacted via e-mail in an attempt to remedy the problem. Respondents, that in the end fail to answer a question used in a statistical analysis, are removed in this particular analysis to prevent their invalid data to influence the result.

5.3 Hypothesis testing

The hypothesis testing is done to see if it is possible to reject null hypothesis based on the data gathered in the investigation. The null hypotheses are formulated negatively, and the intention is to find out if there exists any foundation to reject these hypotheses. If the null hypothesis is not rejected, nothing can be said about the outcome, while if it is rejected, it can be stated that the hypothesis is false with a given significance [Wohlin et al., 2002]. We can choose between parametric and non-parametric test in our hypothesis testing. Parametric tests assume that the parameters involved have a specific distribution like normally distribution. Since we have few respondents, the best way to test our hypotheses is by performing a Mann-Whitney test. This test is a non-parametric test without the assumption of normally distributed parameters [Wohlin et al., 2000]. In addition, parametric tests also require that the parameters can be measured at least on an interval scale [Wohlin et al., 2000]. However, based on papers like [Dybå, 2001], [Davis, 1996] and [Tukey, 1986] we assume that the scales used in the questionnaire won't influence the testing significantly. A statistical software package called Minitab is used to perform the tests.

In addition to the Mann-Whitney, a t-Test can be used in the testing as well. This is a parametric test which assumes that the parameters are normally distributed. In this investigation we have too few respondents to be sure that the answers are normally distributed. However, Briand et al. [Briand et al. 1996] discusses the choice between parametric and non-parametric statistical methods. The authors claim that even if it is a risk using parametric methods when the required conditions are not fulfilled, it is in some cases worth taking that risk. Based on these claims, and the fact that the power of parametric tests is generally higher than for non-parametric test, the t-Test is also used in the testing. The t-Test is fairly robust to deviations from the preconditions, and is therefore used to double-check the hypotheses.

5.3.1 Hypothesis 1

As presented in Section 3.4.2, hypothesis 1 is formulated:

- H1.1: Organizations consider software procurement as being a high-risk activity.
    - H1.0: Organizations don't consider software procurement as being a high-risk activity.

To be able to determine if the organizations consider software procurements as a high-risk activity, the quantitative data gathered in question 14 in the questionnaire is investigated further. Figure 21 shows the distribution of the answers given by the respondents.

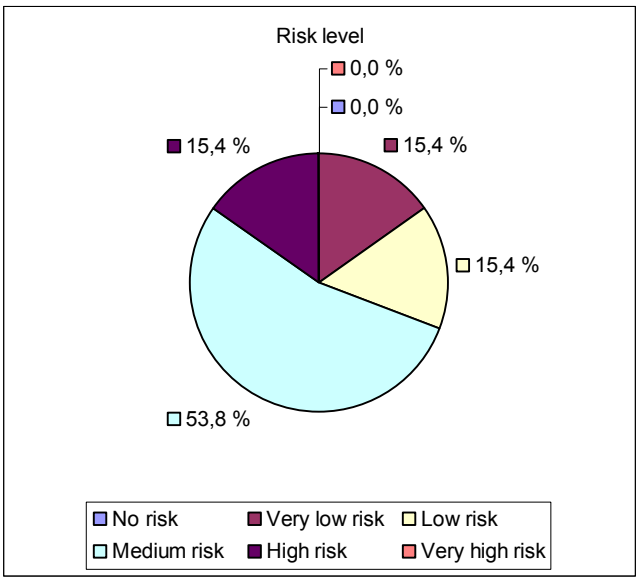


Figure 21: Respondents' rating of the risk related to software procurements

As stated in Appendix 1, α is decided to be less than 0.20. This means that at least 80% of the participating organizations must consider software procurements being a "high risk" or "very high risk" to reject H1.0. Only 15.4% of the participating organizations rate the risk related to software procurements as "high" or "very high". ***Ergo, we can't reject H1.0*** and nothing can be said statistically about hypothesis 1. However, it is quite clear that the participating organizations consider software procurement to be risky to some extent. More than half of them rate software procurements as a medium risky activity, and only 15.4 % have answered very low risk.

5.3.2 Hypothesis 2

The next hypothesis is formulated:

- H2:.1 Organizations follow a particular standard when they procure software.
    - H2.0: Organizations don't follow a particular standard when they procure software.

This hypothesis is tested against the data gathered in question 7 and 8 in the questionnaire, together with qualitative data from the interviews and e-mail correspondence. As mentioned in Section 5.2, the initial data gathered in the questionnaire had to be confirmed via further investigation. In Appendix 3, the quantitative data from the questionnaire states that four of the participating organizations have a defined, formalized procurement process. However, only two of these four organizations apply this process in their procurements of software as well. After some further investigation, this number is altered to three organizations with a defined, formalized process for SIS procurements. The distribution is shown in Figure 22.

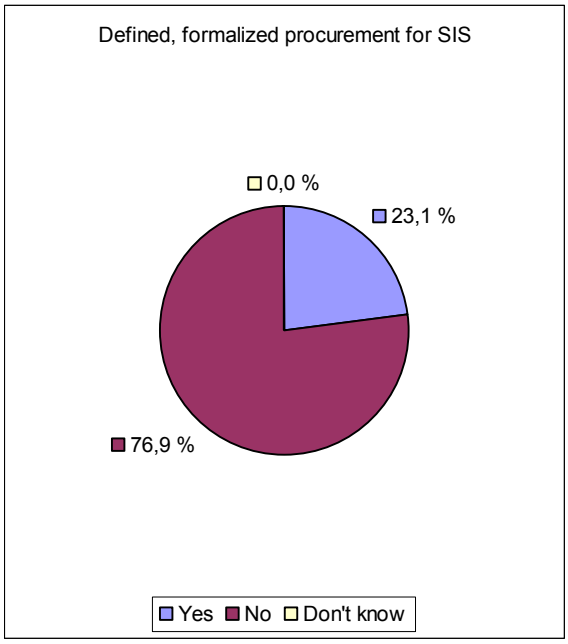


Figure 22: The use of defined, formalized process for SIS procurements among the participating organizations

Based on the chosen α level in the hypothesis evaluation in Appendix 1, at least 80 % of the participating organizations must have a defined, formalized process in their SIS procurements to reject the H2.0. As shown in Figure 22, about 23 % of the participating organizations have a defined, formalized procedure which means that ***we can't reject H2.0.*** The tendency in the gathered data indicates that the majority of the organizations procuring SIS are not using a defined, formalized procurement process.

5.3.3 Hypothesis 3

This hypothesis investigates the use of risk integration in procurement projects:

- H3.1: Organizations often integrate risk management in their procurement project.
    - H3.0: Organizations seldom integrate risk management in their procurement project.

To test this hypothesis, the data gathered in question 17 in the questionnaire is used. This question reveals how often the participating organizations integrate risk management in their procurement projects. The respondents could choose between four alternatives; never, seldom often and always. H3.0 is rejected if more than 80 % of the respondents integrate risk management often or always in their procurement projects. Figure 23 shows the answers given.

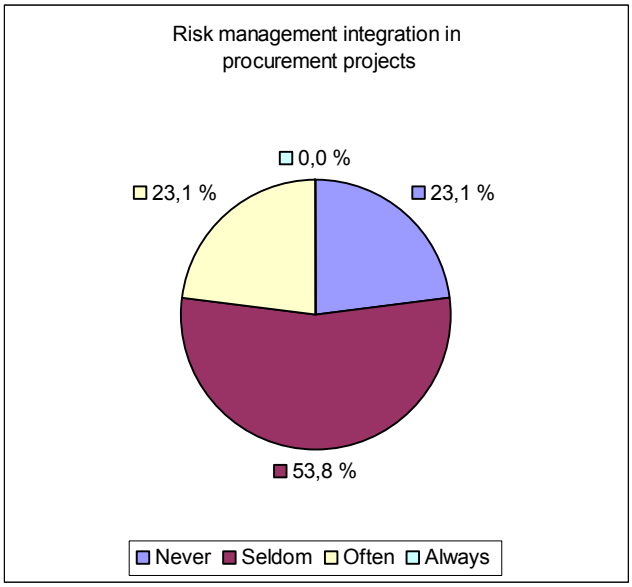


Figure 23: The integration of risk management in procurement projects

Only 23.1 % of the respondents say that risk management is often or always integrated in their procurement projects. Based on these data, ***we can't reject H3.0.*** It seems to be a tendency that organizations seldom or never integrate risk management in procurements projects. A total of 76.9 % of the organizations fits this characterization.

5.3.4 Hypothesis 4

Hypothesis 4 looks into the use of total cost of ownership as a selection criterion in the procurement process.

- H4.1: TCO is emphasized as a selection criterion in the procurement process.
    - H4.0: TCO is not emphasized as a selection criterion in the procurement process.

Data from question 24 in the questionnaire is used to test this hypothesis. In this question the participants were asked to rate the extent of emphasize a set of factors, including TCO, where given in the evaluation of potential products/suppliers. The null hypothesis H4.0 is rejected if more than 80 % of the participating organizations answer "high" or "very high" on this question. Figure 24 shows the result.

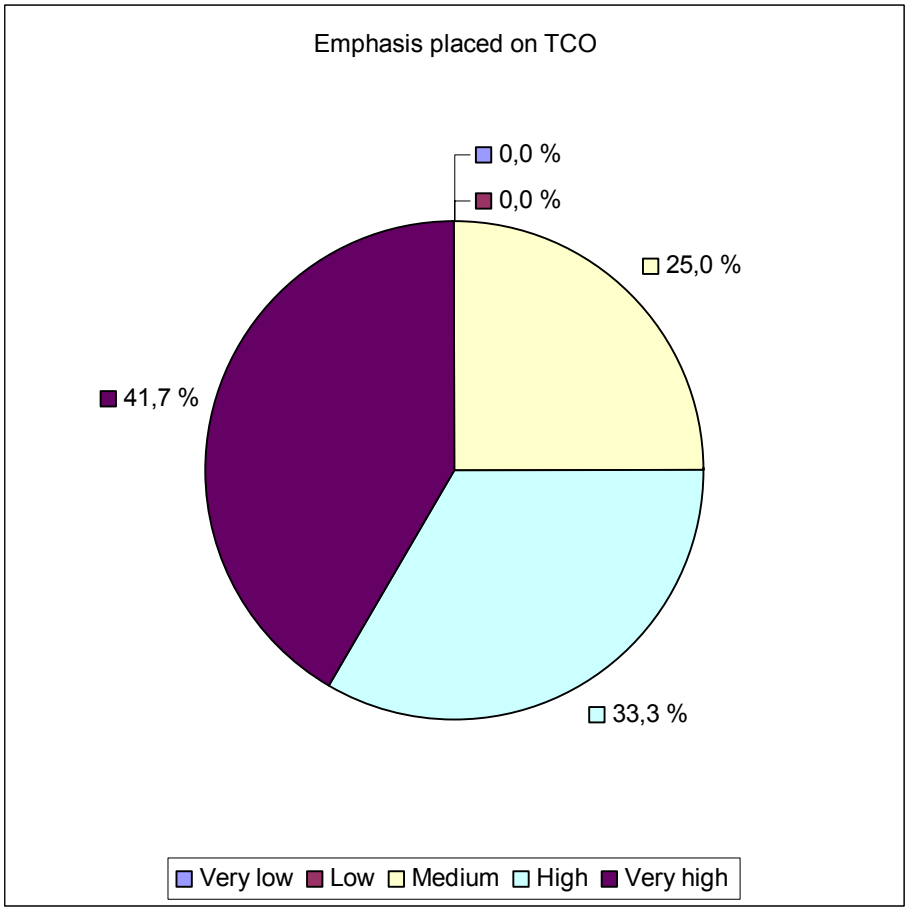


Figure 24: The emphasis placed on TCO in the selection of product/supplier

75 % of the respondents emphasize TCO "high" or "very high" in the selection phase. Ergo, ***we can't reject H4.0*** based on these data. But the participating organizations tend to emphasize TCO quite high, as none of them have chosen "low" or "very low".

5.3.5 Hypothesis 5

This hypothesis seeks to determine if there is any difference in the satisfaction with previous procured SIS between organizations with and without a defined, formalized procurement process.

- H5.1: Organizations with a defined, formalized procurement process are more satisfied with previous procured software-intensive systems than organizations with ad-hoc procurement processes.
    - H5.0: Organizations with a defined, formalized procurement process are not significantly more satisfied with previous procured software-intensive systems than organizations with ad-hoc procurement processes.

The data needed in this hypothesis test is gathered in question 7, 8 and 18 in the questionnaire. As mentioned in Section 5.3.2, qualitative data gathered in interviews and questions in e-mails supplements the data from the questionnaire.

The participating organizations are divided into two groups; organizations with a defined, formalized procurement process applicable for SIS and organizations without such a process. Then median of the two groups' satisfaction with previous software procurements is identified and compared with each other. The confidence level is set to 95.0, and the alternative hypothesis is that the population with a defined, formalized procurement procedure has a greater median than those without. The results from the Mann-Whitney test are:

Mann-Whitney Test: Satisfaction by procurement procedure

```
                                                N  Median
Satisfaction level without proc. Procedure     10   3,000
Satisfaction level with proc. Procedure         3   5,000


Point estimate for ETA1-ETA2 is -2,000
96,5 Percent CI for ETA1-ETA2 is (-3,000;-1,000)
W = 55,5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0090
The test is significant at 0,0049 (adjusted for ties)
```

The results show that we can be 96.5% confident that the difference between the two group medians is greater than or equal to -3.000 and less than or equal to -1.000. Because 0 is not within the confidence interval, ***we can reject H5.0*** with 96.5% confidence, and conclude that the organizations without a procurement procedure are less satisfied with their procurement than the organizations with a procurement procedure. The calculated p-value at 0.0049, which is less than the chosen α-level at 0.05, understates the rejection of H5.0.

To double-check our result, a t-Test is carried out. This test compares the two groups mean level of satisfaction, and determines if there is a confident statistical argument to say that the two means are not equal. We use a 2-sample t-Test and the confidence

interval is set to 95.0. It is assumed that the two groups have unequal variance. The results from the t-Test are:

Two-Sample T-Test satisfaction by procurement procedure

Include	N	Mean	StDev	SE Mean
0	10	2,800	0,789	0,25
1	3	4,667	0,577	0,33

```
Difference = mu (0) - mu (1)
Estimate for difference:  -1,86667
95% upper bound for difference:  -0,97911
T-Test of difference = 0 (vs <): T-Value = -4,48  P-Value = 0,005  DF = 4
```

The P-value in this result tells you how likely it is that you would obtain your samples if the null hypothesis is true. In this case it is a 0.5% chance that we would obtain our samples if H5.0 was true. Based on this result ***we can reject H5.0*** and claim with 99.5% certainty that organizations with a defined, formalized process for SIS procurements are more satisfied with their procurements than organizations without such a process.

The result from the t-Test is visualized in Figure 25. Organizations without a defined, formalized procedure for SIS procurements are gathered in group 0 and the organizations with such a procedure are gathered in group 1. We can see the difference in the level of satisfaction between the two groups.

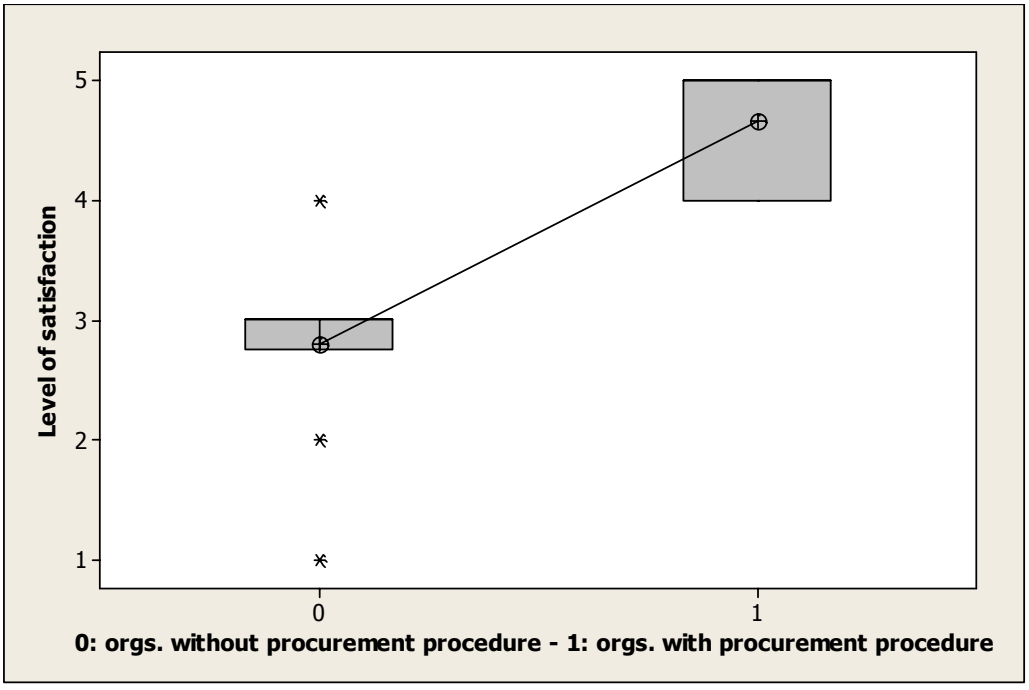


Figure 25: Boxplot of the t-Test used in the testing of hypothesis 5.

5.3.6 Hypothesis 6

Hypothesis 6 investigates the effect of contract change clauses. It seeks to check if organizations with a contract change clause experience fewer changes to the initial contract than organizations without such a clause.

- H6.1: Organizations without a contract change clause experience changes to the initial contract more frequent than organizations with a contract change clause.
    - H.6.0: Organizations without a contract change clause do not experience changes to the initial contract more frequent than organizations with a contract change clause.

This hypothesis is tested against the data gathered in question 28 and 29 in the questionnaire. The result from the question 28 is shown in Figure 26. Almost 70 % of the participating organizations include a contract change clause in their contracts between themselves and the supplier.

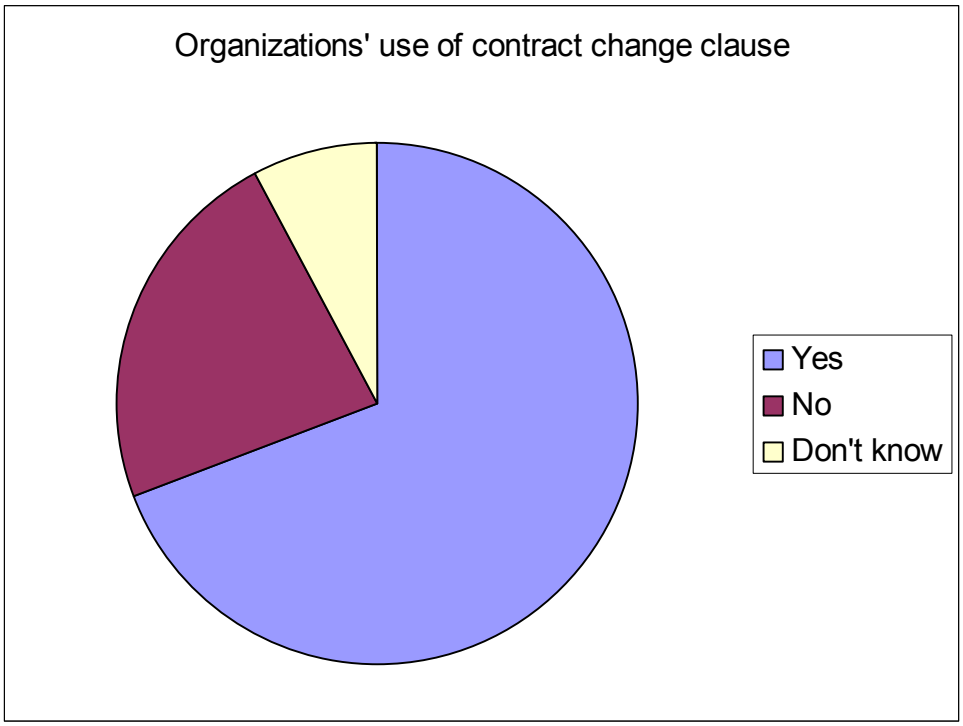


Figure 26: The use of contract change clause among the participating organizations

Before the statistical test is conducted two of the respondents' answer is removed to avoid their invalid influence on the statistical test. This is due to the fact that one of the respondents answered "I don't know" in question 28 and another respondent answered "I don't know" in question 29. To test hypothesis 6, Minitab is used to see if there is a statistical foundation to claim that there is a difference in the frequency of contract changes among the two groups of organizations. Based on the same reasoning as described in Section 5.3.5, we perform a Mann-Whitney test and a t-Test. The Mann-Whitney test is conducted with the confidence interval sat to 95.0 and

alternative hypothesis defined: “Organizations without a contract change clause have a higher contract change frequency median than organizations with a contract clause”. The results are:

Mann-Whitney Test: Contract change frequency by contract change clause

```
                                                N  Median
Contract change frequency without clause        3   2,000
Contract change frequency with clause           8   2,000


Point estimate for ETA1-ETA2 is 0,000
96,8 Percent CI for ETA1-ETA2 is (-2,000;1,000)
W = 16,0
Test of ETA1 = ETA2 vs ETA1 > ETA2


Cannot reject since W is < 18,0
```

The last line in the results states that ***H6.0 can not be rejected*** due to a too small W value. The W value is a calculated value which provides an estimate used to see if there is a significant difference between the groups. In this case, the W value was to small to claim that there is a difference. Just as we did in the testing of hypothesis 5, we also conduct a t-Test. The mean level of the two groups is calculated based on the answers given in question 29 in the questionnaire. The two mean values are then compared with each other in a 2-sample t-Test in Minitab. The confidence level is sat to 95.0 and it is assumed that the two groups have unequal variance. The results from Minitab are:

Two-Sample T-Test Contract change by contract clause

```
Include  N   Mean  StDev  SE Mean
0        3   2,00   1,00     0,58
1        8  2,250  0,463     0,16


Difference = mu (0) - mu (1)
Estimate for difference:  -0,250000
95% upper bound for difference:  1,502281
T-Test of difference = 0 (vs <): T-Value = -0,42  P-Value = 0,359  DF = 2
```

The P-value is too big to reject the null hypothesis with a α-level at 0.05. Ergo, ***we can’t reject H6.0***, and nothing can be said about the contract changes clause’s effect on the change frequency with a significant certainty.

5.3.7 Hypothesis 7

This hypothesis investigates the participating organizations' satisfaction with the documentation and information given by the suppliers.

- H7.1: Organizations find the documentation and information from the suppliers satisfactory.
    - H7.0: Organizations don't find the documentation and information from the suppliers satisfactory.

To be able to test this hypothesis, data gathered in question 30 in the questionnaire is used. The respondents were asked to rate their satisfaction with the documentation and information they get from the suppliers. Figure 27 shows the respondents' answers.

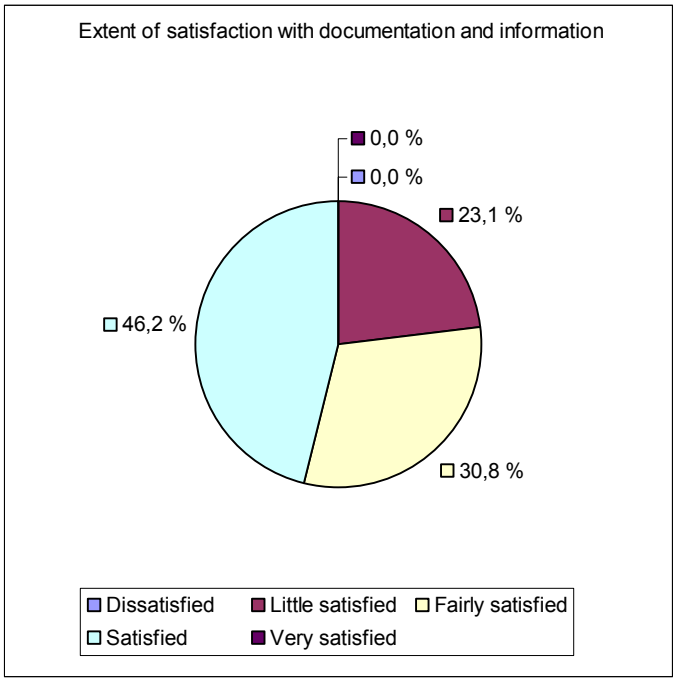


Figure 27: The respondents' satisfaction with documentation and information received from the suppliers

In Appendix 1, the criterion for rejection of the null hypothesis is defined as: more than 80 % of the respondents answering "fairly satisfied", "satisfied" or "very satisfied". As Figure 27 shows, about 77 % of the respondents have chosen one of the three highest ratings. This means that ***we can not reject H7.0***. However, the data show a tendency towards that most of the organizations are quite satisfied with the documentation and information they receive from the suppliers.

5.3.8 Hypothesis 8

Hypothesis 8 investigates if there is a relation between the integration of risk management and the extent of satisfaction with previous procurements of SIS.

- H8.1: Organizations integrating risk management in procurement projects are more satisfied with their procurements than those who don't.
    - H8.0: Organizations integrating risk management in procurement projects aren't more satisfied with their procurements than those who don't.

The data needed to test the hypothesis is gathered in question 17 and 18 in the questionnaire. The participating organizations' integration of risk management in procurement projects is shown in Figure 28.

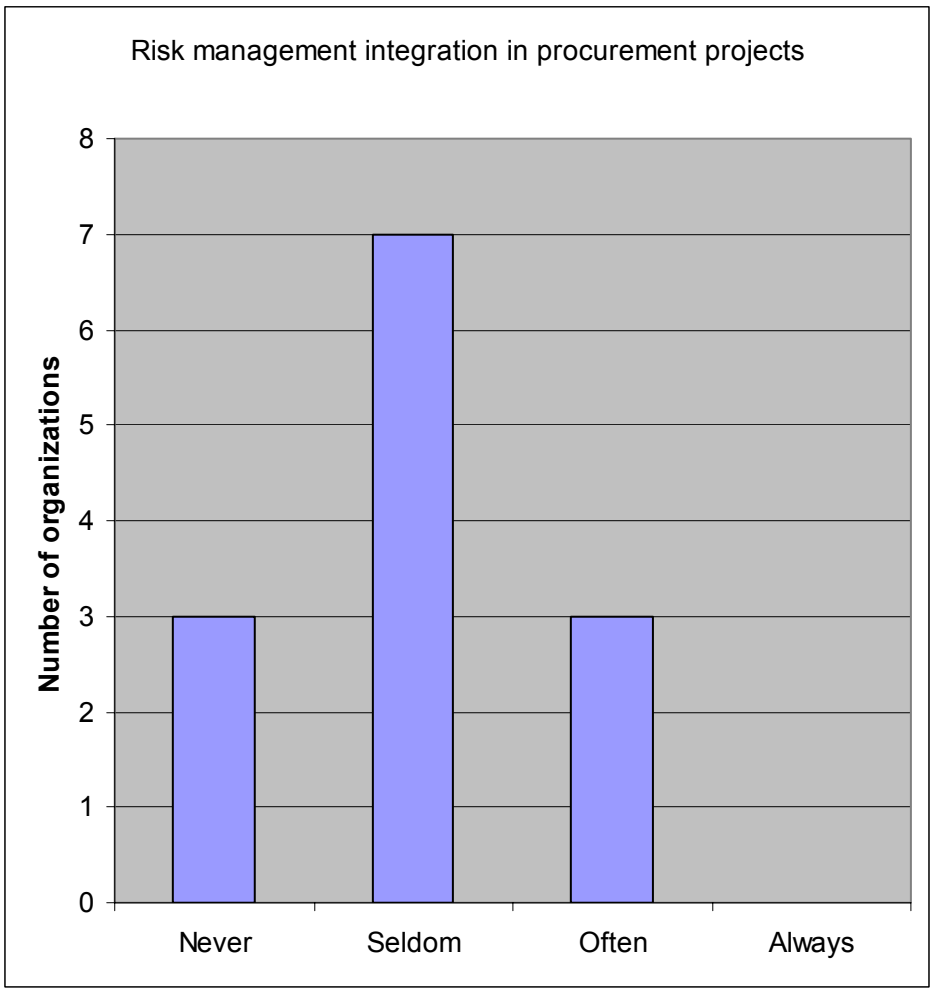


Figure 28: The integration of risk management in procurement projects

The respondents are divided into two groups; respondents answering "never" or "seldom" and respondents answering "often" or "always". This results in ten respondents in the first group and three in the latter group. To find out if there is a difference in the extent of satisfaction with previous procurements, we perform a Mann –Whitney test and a t-Test with Minitab. The confidence interval is sat to 95.0

in both tests, and the alternative hypothesis is, as stated above, that organizations integrating risk management are more satisfied with their procurements than organizations that seldom or never do it. The results from the Mann-Whitney test are:

Mann-Whitney Test: Satisfaction by risk integration

```
                                                N  Median
Satisfaction level without risk integration    10   3,000
Satisfaction level with risk integration        3   4,000


Point estimate for ETA1-ETA2 is -1,000
96,5 Percent CI for ETA1-ETA2 is (-2,999;0,999)
W = 62,0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,1024
The test is significant at 0,0834 (adjusted for ties)
```

The Mann-Whitney test shows that there is insufficient evidence to reject the claim that the medians are equal. This is due to the fact that the 96.5 confidence interval ranges from -2.999 and 0,999. This interval includes 0, which is the null hypothesis. We can also see that the p-value, 0.0834, is greater than the α-level at 0.05. Ergo, ***we can not reject H8.0***. To confirm the results we carry out a t-Test. The confidence interval is set to 95.0 and we assume unequal variance in the two groups. The results are shown below:

Two-Sample T-Test: Satisfaction by risk integration

```
Include   N  Mean  StDev  SE Mean
0        10  3,00   1,05     0,33
1         3  4,00   1,00     0,58


Difference = mu (0) - mu (1)
Estimate for difference:  -1,00000
95% upper bound for difference:  0,56891
T-Test of difference = 0 (vs <): T-Value = -1,50  P-Value = 0,115  DF = 3
```

The P-value is larger than α-level at 0.05, which means that the there is no significant difference in the extent of satisfaction between the two groups. This supports the results from the Mann-Whitney test. To see if there is a relation between these to factors at all, a regression analysis is executed. The results from Minitab are shown below.

Regression Analysis: Satisfaction level versus Risk integration

The regression equation is
Satisfaction level = 2,56 + 0,333 Risk integration

Predictor	Coef	SE Coef	T	P
Constant	2,5641	0,9603	2,67	0,022
Risk integration	0,3333	0,4546	0,73	0,479

S = 1,11359 R-Sq = 4,7% R-Sq(adj) = 0,0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	0,667	0,667	0,54	0,479
Residual Error	11	13,641	1,240		
Total	12	14,308			

Unusual Observations

Obs	Risk integration	Satisfaction level	Fit	SE Fit	Residual	St Resid
1	2,00	1,000	3,231	0,309	-2,231	-2,09R

R denotes an observation with a large standardized residual.

Based on the P-value (0.479) and R-Sq(adj) (0.0%), the regression analysis indicates that there is no relation between the extent of satisfaction and the integration of risk management in procurement projects. The P-value is much larger than the chosen α-level at 0.05. R-Sq(adj) describes the amount of variation in the satisfaction level that is explained by the risk integration factor. In this case, the risk integration explains nothing of the variation in the satisfaction level.

5.3.9 Hypothesis 9

With Hypothesis 9 we seek to find out if there is a relation between the use of knowledge management and the satisfaction with previous procurements.

- H9.1: Organizations managing knowledge management from previous completed software procurements are more satisfied with their procurements than those who don't.
    - H9.0: Organizations managing knowledge management from previous completed software procurements aren't more satisfied with their procurements than those who don't.

The data is gathered from question 21 and question 18 in the questionnaire. Question 21 is an open-ended question resulting in qualitative data in the answers. During the interpretation of the answers, we found out that the quality of the data was not good enough to be used for hypothesis-testing. One of the organizations failed to answer this question. In addition, at least five of the other organizations failed to give complementary answers. As a result, we choose to omit this hypothesis from further testing.

5.4 Qualitative data interpretation

Both the questionnaire and the interview generated large amounts of qualitative data in addition to the quantitative data analyzed above. This section will present the most interesting findings in the qualitative data. The findings will be used in our attempt to answer the overall research questions RQ1, RQ2 and RQ3. We use a combination of quasi-statistical and editing approach to interpret and analyze the qualitative [Crabtree et al., 1992], [Drisko, 2000]. The quasi-statistical approach relies largely on the conversion of qualitative data into quantitative data. In this analysis, we use word and phrase frequencies to determine the relative importance of terms and concepts. The editing approach is more interpretive then the quasi-statistical approach and thereby more useful in the analysis of the interviews [Robson, 2002]. Even though humans have deficiencies as analysts [Sadler, 1981], we choose the editing approach to extract the most interesting findings in the interviews.

5.4.1 Qualitative data gathered in the questionnaire related to RQ1

The first research question investigates what problems the respondents have experienced: “What problems have smaller and medium sized organizations experienced in previous software procurements?” In question 20 in the questionnaire, the respondents were asked to list the challenges they have met in previous SIS procurements. Their answers are listed in Table 12 below. We also try to identify in which phase(s) of the procurement phase each challenge is most relevant. Some of the challenges may appear or should be addressed in several phases, which is indicated with the number representing each phase. The phases are given a number from 1 to 6, representing;

1. The requirement phase,
2. Invitation to tender,
3. Evaluation of vendor responses,
4. Vendor/product selection,
5. Contract negotiation,
6. Installation, testing and acceptance phase

Challenge	Phase
Involve the users at an early enough stage, so they feel like “owners” of the new system.	1
Lack of resources needed to perform applicable follow-up	1,5
Little flexibility	1,6
User-friendliness	1,6
To ensure that the good features/functions in the old systems also are included in the new system	1,6
The organization's needs demands to much bespoken/tailor-made solutions	1,3,4
Many stakeholders involved simultaneously	1,3,4,6
Small budgets	1,4,5
The system doesn’t fulfill the requirements related to:	
- stability and availability - functionality - support	1,4,6
Hard to find systems that covers the requirements good enough	3,4
Choice between relatively similar suppliers	4
IT-support of bad quality	4,5
Workload and costs related to the implementation often is a shock	5,6
Implementation	6
Installation problems	6
Integration problems	6

Table 12: Software procurement challenges experienced by the participating organizations

We can see that there is an overweight of challenges that appears/should be addressed in phase 1 and 6. In addition to the data gathered in question 20, the answers given in question 19 are of interest. In this question the respondents were asked to state the reason for their level of satisfaction given in question 18 (See Section 4.2.6). Table 13 shows the answers which included criticism of earlier software procurements.

Reasons
Complex graphical user interface
Little dynamic solution
Lack of user-friendliness
Converting problems
Lack of quality assurance of the data transmitted to the new system
Mistakes made by the supplier during implementation
Pop-up problems during the installation
IT-support of varying quality
"Hard" to run a "alteration-project" when things are quite ok as they are
Don't get the most faired solution when you build upon standard package systems
Product doesn't fulfill expectations

Table 13: Reasons for dissatisfaction with previous software procurements

These data supports the finding we made in Table 12. Most of the reasons given in question 18 may be avoided with better guidance in phase 1 and 6.

5.4.2 Qualitative data gathered in the questionnaire related to RQ2

In question 15 in the questionnaire the respondents were asked to list the four largest risks related to software procurements in their organization. Table 14 below shows the answers given, sorted by frequency. Some of the answers may to some extent overlap, or be the result of other risks' appearance. This is due to the short answers given and difference in how detailed the respondents answered. We have decided to list them together, and analyze them further down.

Risk	**Frequency**
Cost: - related to adjustments - Implementation costs not estimated - Support and maintenance cost not estimated - High maintenance costs	6
Implementation	5
Lack of functionality/system doesn't solve the user's needs	3
Lack of support	3
Limitation in further development of system	3
User-friendliness	2
Integration with other software	2
Software doesn't meet expectations/promises	2
The new system is more resource demanding than the old one	1
Testing not enough extensive	1
Complexity	1
Stability	1
Development speed	1
Training/education	1
Low exploitation rate	1
Unforeseen system requirements	1
Scalability	1
Data safety	1
Operation and maintenance needs not defined	1
Extra licensing related to further procurements not estimated	1
Bugs	1
Missing plan for bespoken solution	1
Supplier doesn't have the required skills	1
Supplier/competence disappear from the market	1
Operation	1

Table 14: Identified risks in Question 15 in the Questionnaire

A total of 25 risks have been identified by the respondents. However, as mentioned above, some of these risks overlap. This is due to the different level of detailing in the answers given by the respondents. Take “cost” as an example; this risk is the consequence of the occurrence of many of the other risks listed in Table 14. The same can be said about “Lack of functionality” which could be an overall description for many of the other risks. Instead of gathering all the risks in a few overall groupings, we chose to list them all to avoid losing some of the information given.

The risks listed in Table 14 are used to answer Research Question 2: “What risks do smaller and medium sized organizations see in the process of procuring a software intensive system?” It is quite clear that the risks related to “cost” and “implementation” have been emphasized by the respondents. In addition, we can see that both “lack of functionality” and “lack of support” are mentioned by more than one respondent. This counts for “limitation in further development”, “user-friendliness” and “integration with other software” as well.

5.4.3 Qualitative data gathered in the questionnaire related to RQ3

As stated in Section 3.3.2, research question 3 is: “What mitigating actions are known among the smaller and medium sized organizations?” In Table 6, hypotheses H2, H3, H4, H5, H8 and H9, together with additional qualitative data, are listed as the data sources scrutinized in the attempt to answer RQ3. The qualitative data gathered in question 16 in the questionnaire gives direct answers to RQ3. The respondents were asked what mitigating actions they perform to get control over potential risks. Table 15 lists the answers given.

Mitigating actions
Probability calculations of the identified risks
Consult with references
Doesn't enter into a "marriage" at an early stage
Keeps the ambitions low during the software procurement
Distribute as updated information as possible to every stakeholder
Prefer market-leading software
Buy software the IT-support partner has competence about
Plan the implementation in detail
The software is evaluated as a project and a project group consisting of 2-4 persons conduct research reveal as many potential problems as possible
Comparison with the requirements
Analysis of the system's functional and technologically features
Proof of concept
Testing of products before procurement
Cost/benefit analysis
Formal procurement process with risk evaluation
Interview supplier and reference-customers regarding support and competence
Check if user groups exists due to their importance to force further development
Evaluate supplier's economical state
Evaluate product's market share

Table 15: Mitigating actions given by the respondents

A total of 9 out of the 13 participating organizations contributed to the list in Table 15. The remaining four organizations answered: “Very few. More like a superficial search among potential programs”, “None”, “None beyond the selection process” and “We do our best”. It is likely that the participating organizations know more mitigation actions than the 19 listed above. However, about half of the mitigating actions listed in Table 15 are suggested by the three organizations with a defined, formalized procurement procedure. This may imply that organizations with a defined procurement procedure are more aware of the possible mitigating actions, and have put them into system.

5.4.4 Qualitative data gathered in the interviews

The data gathered in the interviews are quite extensive. Therefore an interpretation is conducted, and only the most interesting findings not already mentioned are presented here.

Finding 8
None of the interviewed organizations have ever heard of standards describing the software procurement process. They have neither tried to find out if there exist standards that could guide them in their software procurements.

Finding 9
None of the interviewed organizations integrate risk management in their software procurement projects, but they all integrate risk management in other types of projects they conduct.

Finding 10
None of the interviewed organizations have a TCO model in use. Instead they make TCO estimates based on experience and/or information from the supplier.

Finding 11
All the interviewed organizations base their knowledge management on personal continuance. None of them develop experience reports or any written material regarding the accomplishment of procurement projects.

5.5 Additional data mining

5.5.1 Factors' influence on the results

During the analysis and interpretation of the data gathered in our investigation, the opportunity and need to conduct analysis beyond the hypothesis-testing in Section 5.3 was discovered. Based on some of the questions in the questionnaire, the respondents were given certain "characteristics". Two of these characteristics are already mentioned in Section 5.3; organizations with a defined, formalized procurement procedure and organizations integrating risk management in procurement projects. In addition, the respondents experience and the use of an appointed procurement team are introduced. This results in four characteristics (Related question in the questionnaire):

A. Organizations with a defined, formalized procurement process (Q7 and Q8)
B. Organizations with respondents having long working experience related to SIS,
   i.e. 6 years or longer (Q2).
C. Organizations integrating risk management in procurement projects, i.e. often or always integrates risk management (Q17).
D. Organizations having an appointed procurement team (Q11).

Based on these characteristics, we will investigate if there are some of them that have greater impact on the organizations' level of satisfaction with previous procurement projects and the organizations' consideration of software procurement as a risky activity. Answering this investigation may give us a pointer to what the organizations should prioritize on their way to improve procurement skills.

To be able to find out the impact of each factor, we test all possible combination of factors the organizations can have. This is done based on the matrix shown in Table 16. The legend of Table 16 is: "O" means that the factor is not applicable for the organization, while "X" is the opposite.

A	B	C	D
O	O	O	O
O	O	O	X
O	O	X	O
O	O	X	X
O	X	O	O
O	X	O	X
O	X	X	O
O	X	X	X
X	O	O	O
X	O	O	X
X	O	X	O
X	O	X	X
X	X	O	O
X	X	O	X
X	X	X	O
X	X	X	X

Table 16: Factor combination matrix

Based on this matrix we need to identify where each organizations satisfy the given combination of factors and calculate the mean satisfaction level and mean risk level for this combination. With these figures present, we will be able to compare each of the four factor's impact.

The final matrixes showing the groups of organizations satisfying a given combination of factors can be found in Table 19, Table 20 and Table 21 in Appendix 4. Due to the fact that very few organizations satisfy combinations of three or four factors (See Table 20), we choose not to investigate these combinations any further. Figure 29 shows the mean level of satisfaction for each "factor-combination group". The raw data can be found in Appendix 3.

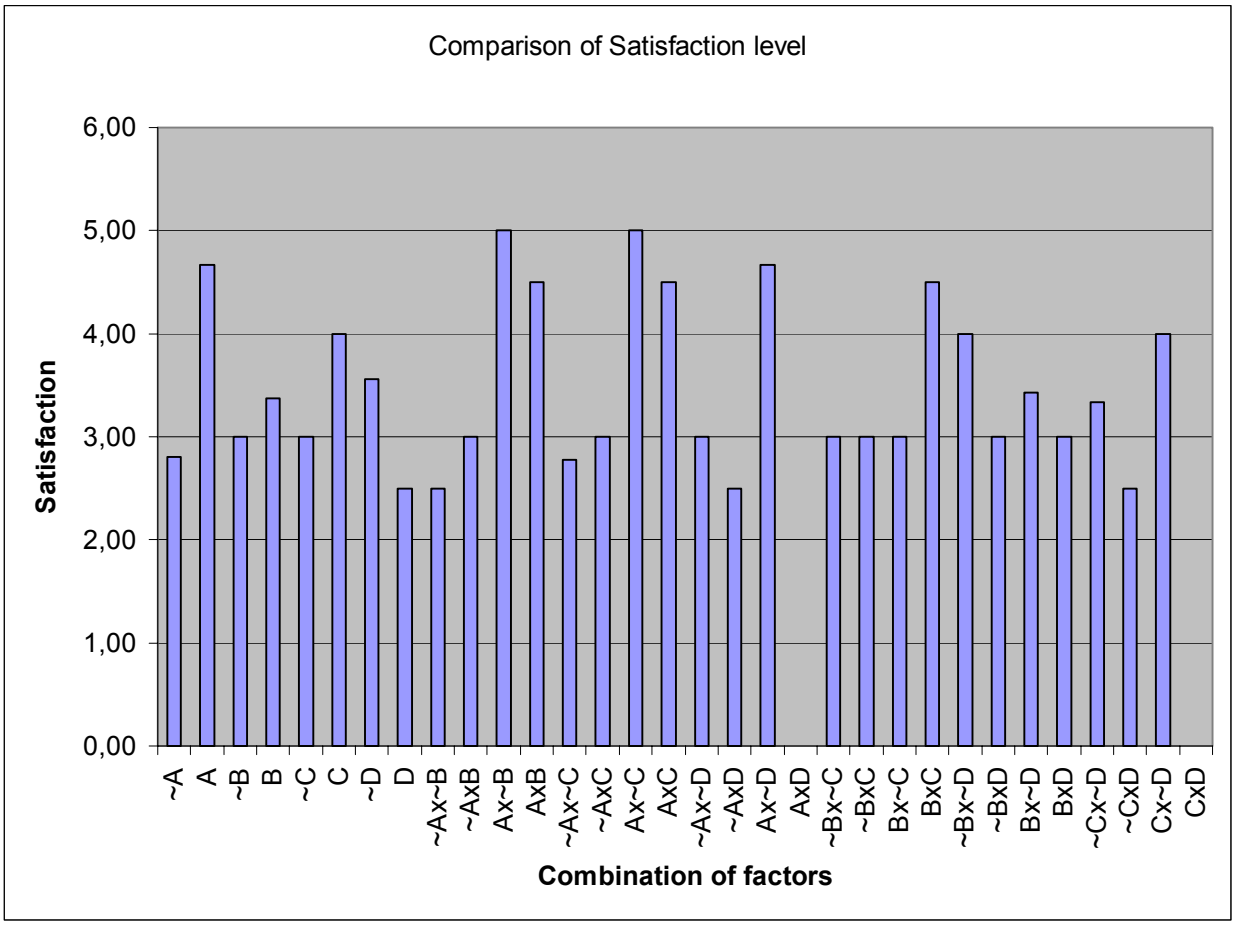


Figure 29: Mean level of satisfaction with previous software procurements

We are also interested in how factor A, B, C and D affect how each respondent have considered software procurement as a risky activity. The mean risk-level for each "factor-combination group" is illustrated in Figure 30. The raw data can be found in Appendix 3.

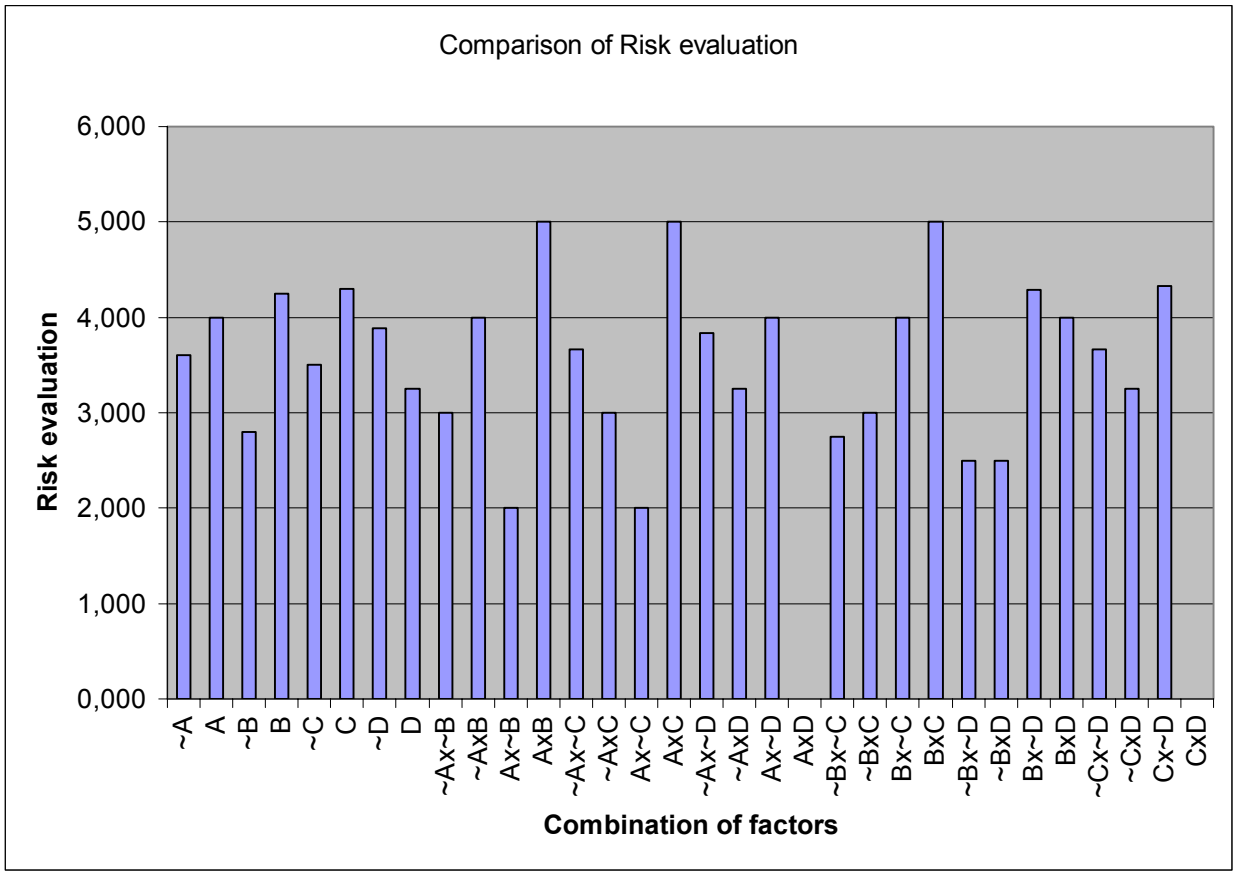


Figure 30: Mean risk-level for each combination of factors

Both Figure 29 and Figure 30 give us an overview of the mean levels related to the given combination of factors. But to get into the details, tables with calculations and boxplots are needed. A comprehensive list of all the tables and boxplots are included in Appendix 3. Tables and boxplots that are related to the most interesting findings are included in this section as well. The findings in this section are given the numbers from F8 and further, since F1-F7 were used in Section 4.2.

5.5.1.1 Finding F12: Procurement procedures' positive influence on the satisfaction level

The first two bars in Figure 29 indicate that it is a significant difference between the level of satisfaction with previous procurements between organizations with a defined procurement procedure (A) and organizations without such a procedure (~A). The descriptive statistics are shown in the textbox below and Figure 31 shows the boxplots.

~A/ A

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction level	~A	10	2,800	0,249	0,789	3,000
	A	3	4,667	0,333	0,577	5,000
Risk level	~A	10	3,600	0,221	0,699	4,000
	A	3	4,00	1,00	1,73	5,00

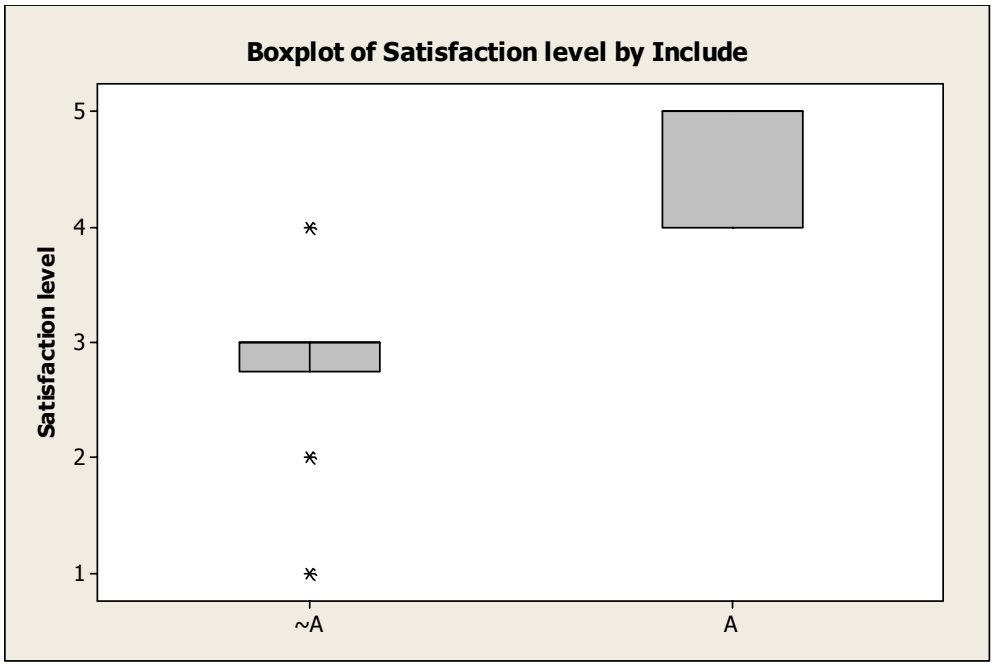


Figure 31: Satisfaction level for organizations with and without defined procurement procedures

This finding is in accordance with the findings in hypothesis 5. The statistical testing done in Section 5.3.5 applies in this section as well. The positive influence, usage of defined procurement procedures has on the satisfaction level, is present in the combination with other factors as well. Only one combination with A/~A involved has a larger satisfaction level difference. This is (~Ax~B) vs (Ax~B), with 2.5 "points" difference in mean satisfaction level. However, it is impossible to test if there is a significant difference between the two means, as only one organization satisfies the combination (Ax~B). This is a problem in some of the other combinations as well, and makes it impossible to investigate any further. See Appendix 3 for further details regarding this topic.

5.5.1.2 Finding F13: Experienced respondents consider software procurement as more risky than inexperienced respondents

Based on the bar chart in Figure 30, it seems to be a significant difference in the risk level between experienced (B) and inexperienced (~B) respondents. If we scrutinize the statistics for these two groups we get the data and the boxplot below:

B/ ~B

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	B	8	3,375	0,324	0,916	3,000
	~B	5	3,000	0,632	1,414	3,000
Risk level	B	8	4,250	0,164	0,463	4,000
	~B	5	2,800	0,374	0,837	3,000

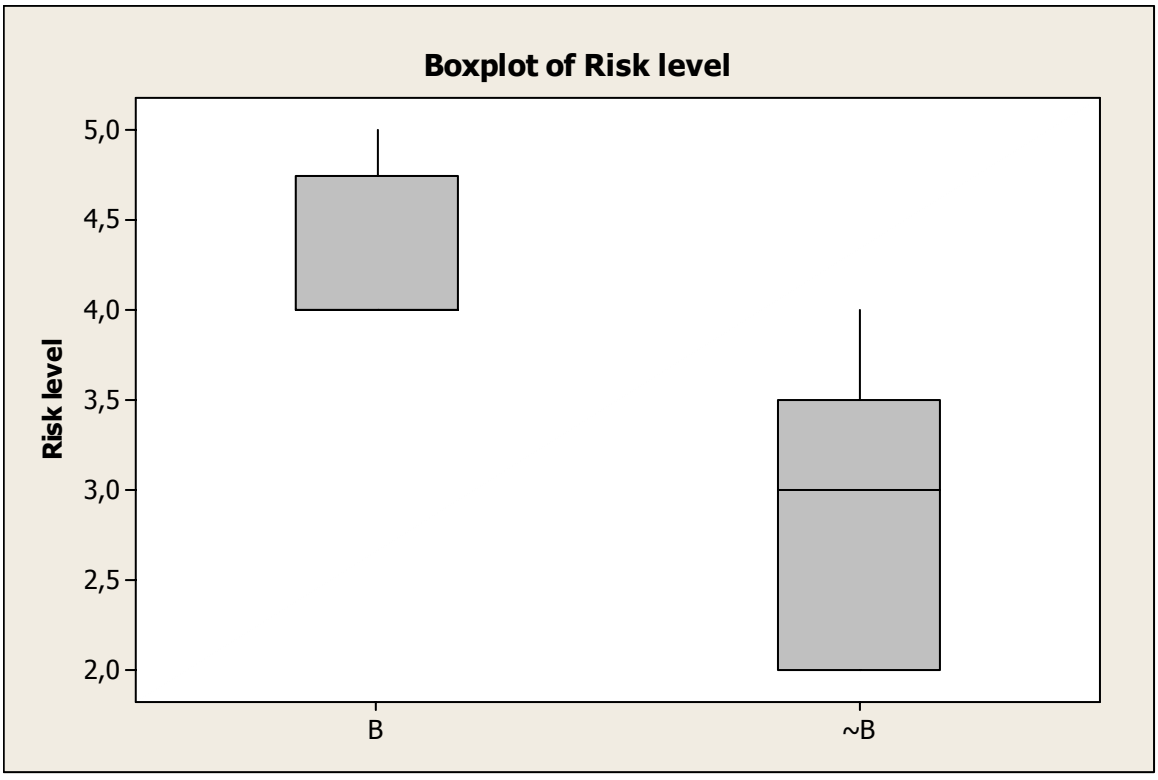


Figure 32: Boxplot of the mean risk level in organization with and without experienced respondents

The descriptive data confirms our observation in Figure 30. To find out if it is a significant statistically difference in the risk level between the two groups, we perform a Mann-Whitney test. This is done in Minitab, and the confidence interval is sat to 95.0. The results from the test are shown below:

Mann-Whitney Test: Risk level inexperienced/experienced respondent

```
                                N  Median
Risk level inexperienced resp.  5   3,000
Risk level experienced resp.    8   4,000


Point estimate for ETA1-ETA2 is -1,500
95,2 Percent CI for ETA1-ETA2 is (-2,000;-1,000)
W = 18,0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0079
The test is significant at 0,0042 (adjusted for ties)
```

The results show that we can be 95.2% confident that the difference between the two group medians is greater than or equal to -2.000 and less than or equal to -1.000. Because 0 is not within the confidence interval, we can with 95.2% confidence claim that the organizations with an experienced respondent consider software procurement to be more risky than organizations with an inexperienced respondent. The p-value at 0.0042, which is less than the α-level at 0.05, understates this claim.

To check the claim made above, we can perform a Kruskal-Wallis test. The Kruskal-Wallis test is used to make inferences about the equality of medians for two or more populations. In this case the null hypothesis is that the median risk level related to software procurements is equal among the respondent groups based on their experience with SIS. The confidence interval is sat to 95.0, and the results are shown below:

Kruskal-Wallis Test: Risk level versus Work experience

```
Kruskal-Wallis Test on Risk level

                              Ave
Work experience      N  Median  Rank      Z
2                    1   3,000   3,5  -0,94
3                    3   3,000   4,3  -1,35
4                    1   2,000   1,5  -1,47
5                    3   4,000   8,0   0,51
6                    5   4,000   9,8   2,05
Overall             13           7,0

H = 6,99  DF = 4  P = 0,136
H = 8,34  DF = 4  P = 0,080  (adjusted for ties)

* NOTE * One or more small samples
```

The results show that the p-value is a bit larger than the chosen α-level. However, we can with 92 % certainty claim that the risk level is related to the level of work experience. We assume that this decrease in certainty is due to the low amount of samples used in the test. But the claim should be made with some reservations.

5.5.1.3 Finding F14: Risk management integration influences the satisfaction level among experienced procurers

The bar chart in Figure 29 and the descriptive statistics shown below indicates that there is a difference in the level of satisfaction with previous software procurements related to the integration of risk management (C vs ~C). However, after some statistical testing (See Appendix 4), we see that we can not claim that there is a significant difference between the satisfaction levels.

~C/C

Descriptive Statistics: Satisfaction level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction level	~C	3	4,000	0,577	1,000	4,000
	C	10	3,000	0,333	1,054	3,000

When we include the experience factor (B), we can see that the difference in satisfaction level between procurers integrating and not integrating risk management increases (BxC vs. Bx~C). In addition decreases the standard error.

Bx~C

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction level	~(Bx~C)	7	3,429	0,528	1,397	3,000
	Bx~C	6	3,000	0,258	0,632	3,000

BxC

Descriptive Statistics: Satisfaction level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction level	~(BxC)	11	3,000	0,302	1,000	3,000
	BxC	2	4,500	0,500	0,707	4,500

We choose to conduct a Mann-Whitney test to check if there is a significant difference in satisfaction level between the two groups. α-level is set to 0.05 and the results are shown below.

Mann-Whitney Test: Satisfaction level Bx~C vs BxC

```
                              N  Median
(Bx~C) Satisfaction level     6   3,000
(BxC)  Satisfaction level     2   4,500


Point estimate for ETA1-ETA2 is -1,500
93,3 Percent CI for ETA1-ETA2 is (-3,000;0,000)
W = 21,5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at
0,0478
The test is significant at 0,0369 (adjusted for ties)
```

The Mann-Whitney test indicates there is 3.69% probability to be wrong in the assumption that experienced procurers who integrate risk management in their software procurements are more satisfied than those procurers who fail to integrate risk management. This is below the chosen α-level, which means that we maintain our assumption. However, we should be aware of the confidence interval given includes 0. This indicates that we should make this claim with reservations.

5.5.2 Selection criteria

Question 24 in the questionnaire investigated to what extent the participating organizations placed emphasize upon 12 identified criteria during the evaluation of potential suppliers/products. The respondents could choose between five alternatives in the rating of emphasize; very low, low, medium, high and very high. This scale is transformed into a scale ranging from 1 to 5 with 1 representing very low and 5 very high. The other alternatives between are represented in the same logical way. Figure 33 shows the average score for each criterion.

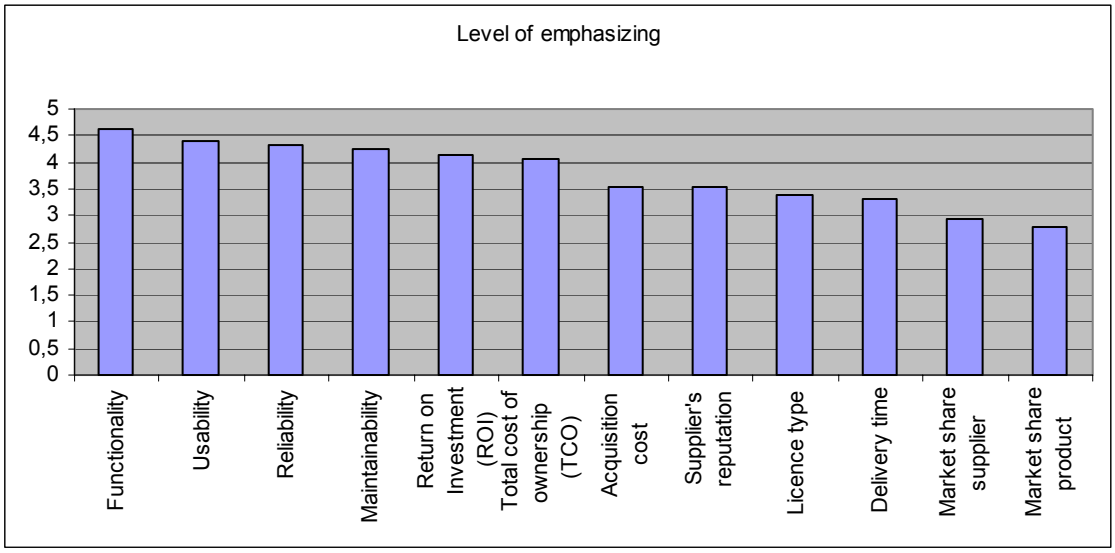


Figure 33: Level of emphasize placed upon evaluation criteria

We can see that all except two criteria, ”Market share supplier” and ”Market share product”, have an average score above 3. This means that 10 out of 12 evaluation criteria are rated Medium or higher in average. “Functionality” is the most emphasized evaluation criterion of the 12 criteria in the question. However, “Usability”, Reliability”, Maintainability”, “ROI” and “TCO” have all received an average score above 4. This means that half of the 12 criteria have an average score above “High”.

In addition, the respondents were asked to give examples of other criteria they used in the evaluation of potential suppliers/products. Nine of the 13 participating organizations gave examples on additional criterion. Table 17 shows the given answers with the frequency.

Evaluation criterion	Freq.
Support	3
Compatibility/integrability with existing resources	3
Supplier's location	2
Possibility to adjust the software in accordance with future needs, i.e. scalability etc.	2
Technical solution	1
Innovation	1
Governmental requirements	1
Supplier's capability to solve problems/challenges during the sales process	1
Supplier's capability to adjust the solution in accordance with the procurer’s needs	1
Previous experience with the supplier	1
Payback-time	1
Discounts	1

Table 17: Additional evaluation criteria

The most frequent criterion was “Support” and “Compatibility/integrability with existing resources” given by three respondents. In addition, “Supplier’s location” and “Possibility to adjust the software in accordance with future needs, i.e. scalability etc.” were suggested by more than one respondent. Based on these answers it seems to be of importance for the procurer to have easily access to support. They also emphasize that the solution is “dynamic”, i.e. easily fits the existing system and can be adjusted if future needs appear.

As mentioned in Section 4.2.7, the fact that so many factors are emphasized in the evaluation of potential suppliers/products indicates some of the complexity related to software procurements. In addition, the stakeholders involved in software procurements often emphasize the evaluation factors differently. As a result, finding a solution satisfying every stakeholder is difficult.

5.5.3 Investigation of the feasibility of the supplier's proposal

Question 27 in the questionnaire investigated the participating organizations' use of different methods to check the feasibility of the suppliers' proposals/approaches. The respondents could choose between four different alternatives and/or include their own alternatives. The distribution of the answers is shown in Figure 34.

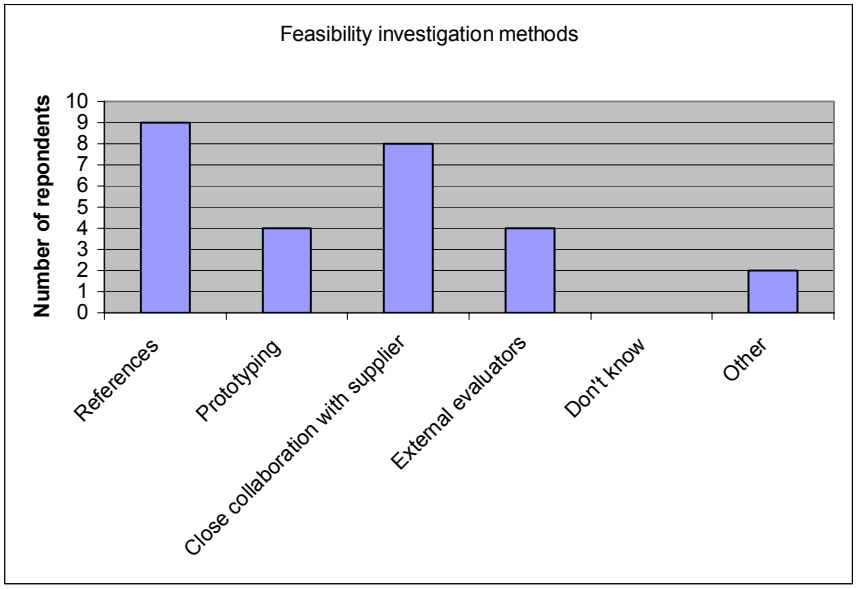


Figure 34: Feasibility investigation methods used by the participating organizations

Getting references is the most applied method to investigate the feasibility of the supplier's proposal/approach among the participating organizations. One of the organizations failed to answer this question. This means that 75% of the organizations who answered this question use references, followed by "Close collaboration with the supplier" with coverage at almost 67%. "Prototyping" and "External evaluators" are both used by four of the participating organizations. None of two latter methods are used exclusively, but always in combination with one of the other methods. This doesn't apply for "References" and "Close collaboration with supplier". None of the participating organizations use all methods in their feasibility investigation, but eight out of the twelve respondents say they use a combination of two or more methods.

5.6 Analysis and evaluation

In this section, the analysis and testing conducted in Chapter 4 and 5 are summed up and evaluated. We try to find out what conclusions can be made and how we can use this knowledge. Each of the research questions is evaluated based on our findings and test answers in Chapter 4 and 5. Table 6 from Section 3.4.2 is included below to repeat the relation between the hypothesis and the research questions. In addition, Table 18 summarizes the analysis and testing of each hypothesis. The first column shows the results from the hypothesis testing done in Chapter 5.3. The "Quantitative data"-column shows what the quantitative data indicates and the "Possible trend"-column shows the possible trend we can interpret from the analysis. "Yes" and "No" indicates our belief in the alternative hypothesis.

Research Question	Hypothesis
RQ1	H2, H3, H5, H6, H7 +qualitative data
RQ2	H1, H2, H3, + qualitative data
RQ3	H2, H3, H4, H5, H8, H9, + qualitative data

Table 6: Relation between research questions and hypotheses

- RQ1: What problems have smaller and medium sized organizations experienced in previous software procurements?
- RQ2: What risks do smaller and medium sized organizations see in the process of procuring a software intensive system?
- RQ3: What mitigating actions are known among the smaller and medium sized organizations?

Hypothesis	Statistical test	Quantitative data	Possible trend
H1	No	Yes	Yes
H2	No	No	No
H3	No	No	No
H4	No	Yes	Yes
H5	Yes	Yes	Yes
H6	No	No	No
H7	No	Yes	Yes
H8	No	No	No
H9	-	-	-

Table 18: Hypothesis evaluation

5.6.1 RQ1 Conclusions

In research question 1 we try to reveal what kind of problems the organizations have experienced in previous software procurements. In Section 5.4.1, the qualitative data related to RQ1 are presented. There seem to be a tendency towards that the participating organizations have experienced most of their problems during the implementation and operation phase. This is not surprising, since the consequences of unidentified risks and shortcuts often appear in the late phases of the procurement cycle. These consequences may result in problems not foreseen by the procurer. The sources to the unidentified risks, however, seem often to be the result of wrong/bad decisions made in some of the earlier phases. Functional and technical weaknesses of the final system are often due to wrong requirement specification or lack of quality assurance of the requirements during the requirement phase. Another reason may be lack of comprehensive testing or wrong selection of supplier. Based on F7 in Section 4.2.7, that organizations emphasize functionality most in the evaluation phase, the need for thorough requirement definition and testing is even more obvious.

Based on the hypothesis testing conducted in Section 5.3 and previous findings, it is possible to identify some of the reasons to the problems the participating organizations have experienced in previous software procurements. Firstly, according to F2 in Section 4.2.2 and H2 in Section 5.3.2 there is a tendency towards that most of the organizations don't use a defined, formalized procurement procedure. This may be one of the main reasons for the problems the organizations have experienced. As mentioned in Section 2.3, there exist several standards and guidelines with varying usability which a software procuring organization can employ. However, F8 in Section 5.4.4 indicates that few organizations know about these software procurement standards. Organizations that are not using a defined procurement process may not have chosen this alternative deliberately.

Finding 3 in Section 4.2.3 and results from H5 in Section 5.3.5 indicates the rarely use of appointed procurement teams may have an influence on the final result. F3 in Section 4.2.3 indicates that most organizations don't use an appointed software procurement team. In addition, the results in Section 5.3.5 show that organizations with an appointed software procurement team are significantly more satisfied with their previous procurements. Finding 11 in Section 5.4.4 explains some of the reason for this difference in level of satisfaction. All the interviewed organizations base their knowledge management on personal continuance which may imply that knowledge regarding software procurements are best utilized if the same people are doing the software procurements every time.

Finding 5 in Section 4.2.5 and the result from H3 in Section 5.3.3 show a tendency among the participating organizations not to integrate risk management in their procurement projects. This will be discussed further in Section 5.6.2, but this may be a source to some of the problems experienced by the procurers. Without a comprehensive and thorough management of the risk involved in procurement projects, the probability of running into problems increases. F9 indicates that risk management is used to some extent in other projects conducted by the organizations. This may imply that the organizations don't regard risk management necessary in procurement projects.

5.6.2 RQ2 Conclusions

In research question 2 we seek to reveal the risk seen by smaller and medium sized organizations in their procurements of software intensive systems. Qualitative data related to RQ2 is presented in Section 5.4.2 in addition to the findings in the interviews. Analysis of quantitative data conducted in the Chapter 4 and 5 are also evaluated in this conclusion.

As mentioned in Section 5.4.2, a majority of the 25 risks identified by the organizations are related to cost and implementation. This finding is in accordance with some of the findings made in Section 5.6.1. Many of the problems known among the respondents were related to the late phases of the procurement cycle, which includes the implementation. These problems have most likely lead to extra costs and workload, which explains many of the risks identified. It is easier to identify risks based on previous experienced problems.

Statistics Norway [SSB] has conducted a comprehensive investigation regarding Norwegian organizations' use of IT. Their findings are in accordance with the findings made in our investigation [SSB_stats]. "IT-costs higher than expected" is the barrier influencing most against the use of IT among the participating organizations.

Many of the risks given by the respondents should be possible to treat with thorough risk management and good procurement procedures. However, finding 5 in Section 4.2.5 and H3 in Section 5.3.3 indicates that the use of risk management in procurement projects is quite rare. This may be due to finding 4 in Section 4.2.4 and results from H1 in Section 5.3.1 which shows that most of the organizations don't consider software procurements as a high-risk activity. This low risk assessment may be the biggest risk related to software procurement. Without the awareness of risks related to software procurement and integration of proper risk management, the chance of getting into trouble increases. This may be the main reason for the high share of procurement projects ending in budget overruns and missed deadlines. However, the results from H8 in Section 5.3.8 show that there is no statistical foundation for claiming that the level of satisfaction with previous software procurements is related to the use of risk integration.

Finding 2 in Section 4.2.2 and results from H2 in Section 5.3.2, show that most of the organizations do not use a defined, formalized procurement procedure. It is reasonable to believe that several of the risks listed in Table 14 in Section 5.4.2 would be easier to treat with a defined procurement procedure implemented.

Finding 13 in Section 5.5.1.2 indicates that respondents with high experience consider software procurement as more risky activity than inexperienced respondents. This may be due to the saying "once bitten twice shy". But there are no statistical analysis showing that the more experienced respondents integrate risk management in their software procurements more often than the less experienced. This is a bit surprising, since it is reasonable to believe that the awareness of risks results in mitigating actions. We may conclude that experienced procurers accept the level of risk related to software procurements, and, despite their higher risk rating, fail to integrate risk management more often then less experienced procurers. Finding 14 in Section 5.5.1.3 is also of interest. F14 indicates that experienced procurers who integrate risk

management in their software procurements are more satisfied than the experienced procurers who fail to integrate risk management.

In addition, regression tests show that the level of experience has a low affect on the level of satisfaction with previous software procurements, and we can't statistically say that experienced procurer are more satisfied than less experienced procurers (See Appendix). So even though more experienced procurers accept the risk related to software procurements and choose not to integrate risk management, they are still no more satisfied with their procurements than less experienced procurers. However, this could relate to F6 in Section 4.2.6 showing that the organizations are fairly satisfied with their previous software procurements.

5.6.3 RQ3 Conclusions

Research question 3 investigates what mitigation actions are known among the smaller and medium sized organizations. Qualitative data related to RQ3 is presented in Section 5.4.3 and Section 5.4.4. In addition is the analysis of the quantitative data in Chapter 4 and 5 emphasized in this conclusion.

Some of the findings mentioned in Section 5.6.1 and 5.6.2 are also applicable for this conclusion. In Section 5.4.4 we suggested that organizations with a defined procurement procedure are more aware of the possible mitigating actions. If we assume that this is true and combines it with F2 in Section 4.2.2 and H2 in Section 5.3.2 which indicates that few organizations have a defined procurement procedure, problems arise. Finding 8 in Section 5.4.4 shows that none of the interviewed organizations have even heard of software procurement standards. This indication makes bad worse, and may imply the need for education and/or consciousness-raising among software procuring organizations.

In the RQ2 conclusion in the previous section, we saw that cost is considered a big risk among the respondents. Based on this awareness, it is likely to believe that the respondents have mitigating actions to treat this risk. Even though Figure 33 in Section 5.5.2 shows that TCO is an emphasized selection criterion, finding 10 in Section 5.4.4 is a bit surprising. F 10 shows that none of the interviewed organizations have a TCO model. Instead, TCO is based on estimates, experience and information given by the supplier. This may lead to wrong TCO calculations and unforeseen costs.

5.7 Conclusion

Based on the conclusions in Section 5.6.1-5.6.3, an overall question arise: “Is the problems like budget overruns, missed deadlines and poor quality a result of poor processes or lack of knowledge/awareness among the procurers?” In the prestudy in Chapter 3, we saw that there exist standards and guidelines related to both software procurement and risk management. However, not all of the available material is applicable for small and medium sized organizations with limited resources and experience. In our investigation, we have identified problems, risks and mitigating actions related to software procurement, suggested by small and medium sized organizations. Based on the information received from the participating organizations we have made some interesting findings.

Since the number of participants is relatively low, our study is far from conclusive. The statistical confidence in our findings is varying, and further investigation is needed to determine the final answers to the research question. However, tendencies and trends have been identified, giving us a basis for making some claims.

Our investigation seem to indicate that small and medium sized organizations procuring software intensive systems have experienced most problems in the late phases of the procurement cycle. To avoid such problems, thorough planning and well-defined procedures is a good start. However, most of the participating organizations do not have a defined, formalized procurement procedure even though our findings show that organizations with such procedures are more satisfied with their procurements. There may be several reasons to this, but the interviews indicate that the unawareness of existing software procurement standards is high. In addition, most of the participating organizations don’t consider software procurement as a high-risk activity.

The most experienced procurers participating in this investigation consider software procurement as more risky than their less experienced colleagues. But surprisingly enough they do not integrate risk management into procurement projects more frequent than the less experienced procurers, which do this quite seldom.

Based on the empirical data gathered in this investigation, the biggest problem related to software procurement seems to be lack of awareness and competence among the procurers. Comprehensive software procurement standards and guidelines are available, but few use them. We believe that by implementing the most applicable standards or guidelines mentioned in Section 2.3, software procurers in small and medium sized organizations would be well-equipped for their future procurements. In addition, managing the knowledge and experience from previous procurements may be helpful to avoid making the same mistakes time and again.

5.8 Chapter summary

In this chapter, the data gathered in the questionnaire and interview are analyzed and interpreted in detail. After the removal of invalid data, the hypotheses defined in Chapter 3 are tested. Based on the hypothesis testing we can claim with very high confidence that organizations with a defined, formalized software procurement procedure are more satisfied with their previous procurements than the organizations without such a procedure. In addition, the data shows several other possible trends.

In this chapter, we have also interpreted and analyzed the qualitative data gathered in the questionnaire and interviews. This data analysis results in findings additional to the ones found in Chapter 4 and shows that our multi analysis method based on multiple data sources have been successful.

Based on our findings and analysis, we have ended this chapter with conclusions of the research questions defined in Chapter 3. In addition, we have concluded the overall investigation. In Chapter 6, we will discuss and sum up this project.

6 Discussion and summary

6.1 Introduction

In this chapter the investigation is summarized and evaluated. In Section 6.2 a summary of the findings made in the investigation is presented. Section 6.3 evaluates the accomplishment of the project and list limitations and possible weaknesses. In Section 6.4, a valuation of the results is performed. The grand question addressed in this section is: "How can we make the world better with these results?" Section 6.5 presents suggestions for further work.

6.2 Project summary

In this report, we have sought answers to three questions concerning software procurements conducted by small and medium sized organizations: 1) What problems have smaller and medium sized organizations experienced in previous software procurements? 2) What risks do smaller and medium sized organizations see in the process of procuring a software intensive system? and 3) What mitigating actions are known among the smaller and medium sized organizations? Using data gathered from 13 organizations through questionnaires and interviews, we made some interesting findings. These are, among others:

1. Most organizations don't have a defined, formalized procurement procedure,
2. The use of a defined, formalized procurement procedure has a positive influence on the level of satisfaction with software procurements,
3. Most organizations don't have an appointed procurement team,
4. Most organizations don't consider software procurements to be a risky activity,
5. Most organizations seldom integrate risk management in their software procurements,
6. Experienced procurers consider software procurements more risky than less experienced procurers, but they still don't integrate risk management in their software procurements more frequent,
7. Functionality is the most emphasized evaluation criteria during software procurements

The findings indicate that small and medium sized organizations don't employ the procedures and techniques available when they conduct software procurements. It is hard to determine if this is a deliberate choice or a result of unawareness. However, findings made in the interviews seem to indicate the latter alternative. Based on the findings made in this investigation, there seem to be a need for skill upgrading among the procurers and more comprehensive guidance related to software procurements. This finding is analogous with empirical studies conducted by other contributors [PROBE], [Goldenson et al., 2000].

Helpful standards, methodologies and guidelines are already available [Hansen et al., 1999], [IEEE 830-1998], [IEEE 1062], [ISO/IEC 12207], [Cooper at al., 2005]. However, none of them offer sufficient guidance to software procurements. Our

advice for software procurers is to investigate the available material related to software procurement and utilize the best features and advices. Our findings show that organizations with a defined, formalized procurement method are more satisfied with their previous software procurements than organizations without such a procedure.

We also encourage software procurers to manage the knowledge and experience gained from completed software procurement projects to avoid making the same mistakes again and again. In addition, risks related to software procurements should be managed seriously and systematically to decease the risk for project failures.

6.3 Project evaluation

The findings made in this report need to be interpreted with some caution. Firstly, the response rate of the questionnaire is somewhere between 8 and 10 %. This is quite low, and only 13 organizations participated in the survey. As a result, the statistical power suffers and our attempt to generalize the findings to the target population is jeopardized. However, we have been conservative in the selection of alpha level in our statistical testing, which should increase the generalizability. As a result, we think that our findings indicate the tendencies of the whole population.

There are limitations related to the researcher's experience with similar investigations. As a result, errors and misinterpretations during the investigation may have affected the results. The chosen research strategy should mitigate this threat to the validity of the investigation. Both multiple analyze methods and multiple data sources are utilized, and this approach has been successful in other investigations [Bratthall et al., 2001]. In addition, a comprehensive validity evaluation of the investigation is conducted and mitigating actions employed when needed.

However, there are some limitations related to the research method used. Firstly, all the data used in this investigation is gathered in one country. This yields a possible sampling bias, but we believe that our sample is representative in terms of industries covered and software systems procured. Secondly, the survey is based on software procurers' subjective self-evaluation. There is always a possibility that there is a divergence between how people say they conduct tasks and how they actually do it. Future research needs to include observations of the subjects investigated to confirm the data collected via questionnaires and interviews. Thirdly, some of the measurements used in the questionnaire are not optimal. "Level of satisfaction" is used frequent, without any guidance given. Satisfaction is often closely related to a person's expectation. It is therefore possible that two persons evaluate the same product differently regarding their level of satisfaction.

6.4 Valuation of project

Due to tough competition and the never-ending search for competitive advantages, successful software procurements are crucial. Investments in software are often expensive for small and medium sized organizations, and budget overruns may in worst case end in bankruptcy. Based on the fact that about two thirds of all IT-projects run into problems like missed deadlines, poor quality and budget overruns, studies like the one we have conducted are needed.

During the investigation, some organizations refused to participate due to their policies. These organizations regard their competence and experience related to software procurement as an *asset*, and they declined to share this knowledge with others. This underlines the value of projects like the one we have conducted.

In addition, there is a big difference in software development costs between countries. This difference results in more and more IT-projects being outsourced, and buying software has become more common. If the procuring organizations lack knowledge and competence related to software procurements, they may find themselves in big trouble before they know it. To be able to face the pending challenges related to outsourcing, empirical studies revealing the reasons to previous projects failures is a good starting point.

Compared with other contributions in the software procurement field, this report is quite unique. Instead of just establishing a new standard or a new set of guidelines, we have investigated the current software procurement procedures and indicated the main weaknesses. Based on the results from the investigation, we present the most important initiative software procuring organizations need to take in the attempt to improve their ability to procure and use software intensive systems.

The findings in this report can be viewed as indications and guidance for software procurers and further research. However, the validity and generalizability of our findings can be improved in the future by using designs that can remove these limitations.

6.5 Advice to procurers

Based on the research conducted in this report some initial advice to future procurers of software intensive systems can be given:

1. Look into the available software procurement standards and methods examined in Section 2.3 and develop a defined and formalized software procurement procedure. As a minimum, IEEE 1062 [IEEE 1062] and the work of Hansen et al. [Hansen et al., 1999] should be studied during the development of this procedure.
2. Employ IEEE's "Recommended Practice for Software Requirements Specification" [IEEE 830-1998] in the requirement phase of the procurement cycle.
3. Integrate risk management into software procurement projects. [Cooper et al., 2005] offers some guidance in this task.
4. Calculate and utilize total cost of ownership in the evaluation and selection of product/supplier.
5. Take software procurements seriously, and allocate sufficient resources needed to be able to conduct a through procurement project.
6. Evaluate software procurements both during conduction and after completion. Manage the experience and knowledge gained from the procurement. This experience will help you to be better prepared for the next procurement.

6.6 Further work

Further work is needed to strengthen the statistical power of our findings. Future investigation should include a larger sample size and subjects from a wider geographical area. In addition, empirical research is needed to determine the influence of software procurement standards and other tools and techniques like risk integration and knowledge management related to procurements. It is also recommended to consider other measurements which are less charged than "satisfaction". Research strategies like case studies should be introduced to improve the control of the environmental variations.

Bibliography

[AS/NZS4360] AS/NZS 4360, Risk Management, Standards Australia, Sydney, NSW, 2004.

[Addison et al., 2002] Addison, T. and Vallabh, S. "Controlling software project risks: an empirical study of methods used by experienced project managers", *Proccedings of the 2002 annual research conference of the South African institute of computer science and information technologists on Enablement through technology*, pp 128-140, 2002

[Aftenposten] Aftenposten, "Offentlig IT-sprekk for 6 mrd. hvert år", *Økonomi*, pp. 33, 4th March 2004 (In Norwegian)

[Babbie, 1990] Babbie, E. "Survey research methods", Wadsworth, 1990, ISBN 0-524-12672-3.

[Banker et al., 1992] Banker, R.D. and Kemerer, C.F. "Performance evaluation metrics for information systems development: A principal-agent model" *Information Systems Research,* VOL 3, Issue 4, pp. 379–401, 1992.

[Basili et al., 1986] Basili, V. R. , Shelby, R. W. and Hutchens D. H., "Experimentations in Software Engineering", *IEEE transactions on software engineering,* vol. SE-12, NO. 7, pp. 733-741, July 1986.

[Basili, 1996] Basili, V. R., "Editorial", *Empirical Software Engineering Journal*, vol. 1, NO. 2, 1996.

[BCS, 2004] "The Challenges of Complex IT Projects" The report of a working group from the Royal Academy of Engineering and the British Computer Society, 2004, ISBN 1-903496-15-2.

[BOOTSTRAP] "BOOTSTRAP: Europe's assessment method", Software, IEEE, VOL 10, Issue 3, pp. 93-95, May 1993.

[Bratthall et al., 2001] Bratthall, L. and Jørgensen, M. "Can You Trust a Single Data-Source Software Engineering Case-Study?" Proceedings of Empirical Assessment in Software Engineering (EASE 2001), April, 2001. Is also published in Bratthall, L. "Empirical Studies of the Impact of Architectural Understanding on Software Evolution", University of Oslo, 2001, ISSN 1501-7710.

[Briand et al., 1996] Briand, L. C., Morasca, S. and El Emam, K. “On the Application of Measurement Theory in Software Engineering”, Journal of Empirical Software Engineering, 1 (1), pp. 61-88, 1996.

[Briand et al., 2002] Biand, L. C., Morasca, S. and Basili, V. ”An Operational Process for Goal-Driven Definition of Measures”, IEEE transactions on software engineering, VOL. 28, NO. 12, pp. 1106-1125, Dec 2002.

[Brodman et al., 1994] Brodman, J.G. and Johnson, D.L. “What small businesses and small organizations say about the CMM”, Proceedings to the 16th International Conference on Software Engineering, pp. 331-340, May 1994

[BS IEC 62198:2001] Project risk management, British Standards Institution, 2001

[buyIT] buyIT “Managing Risk In Open Systems Procurement, A Practical Guide”, Blackwell, Great Britain, 1995, ISBN 1-85554-650-7.

[Campbell et. al., 1963] Campbell, D. T. and Stanley, J. C. “Experimental and Quasi-Experimental Designs for Research”, Houghton Mifflin Company, US, 1963.

[CMMI-AM] Bernard, T., Gallager, B., Bate, R. and Wilson, H. “CMMI Acquisition Module (CMMI-AM)” Version 1.1, CMU/SEI-2005-TR-011, 2005.

[Cook et. al., 1979] Cook, T. D. and Campbell, D. T. “Quasi-Experimentation – Design and Analysis Issues for Field Settings”, Houghton Mifflin Company, US, 1979.

[Cooper et al., 2005] Cooper, D., Grey, S., Raymond, G. and Walker, P. “Project Risk Management Guidelines, Managing Risk in Large Projects and Complex Procurements”, John Wiley & Sons Ltd, England, 2005, ISBN 0-470-002281-7.

[Crabtree et al., 1992] Crabtree, B. F. and Miller, W. L. “Primary Care Research: a multi-method typology and qualitative road map”, In Crabtree and Miller, eds, *Doing Qualitative Research.* Thousand Oaks, California, 1992.

[Creswell, 2003] Creswell, J. W., “Research design: Qualitative, quantitative, and mixed methods approaches”, 2nd edition, Thousand Oaks, California, 2003, ISBN 0-7619-2442-6

[Davenport et al., 1998] Davenport, T. H., Long, D. W. D. and Beers, M. C. ”Successful Knowledge Management Projects”, *Sloan Management Review,* pp. 43-57, winter 1998.

[Davis, 1996] Davis, D. “Business Research for Decision Making”, Fourth Edition, Belmont, California: Duxbery Press, 1996.

[Denzin, 1989] Denzin, N.K. “The research Act”, (3rd edition), Prentice-Hall, 1989.

[Dingsøyr et al., 2002] Dingsøyr, T. and Conradi, R. ”A Survey of Case Studies of the Use of Knowledge Management in Software Engineering”, *Journal of Software and Knowledge Engineering,* pp. 391-414, 2002.

[Drisko, 2000] Drisko, J. W. ”Qualitative data analysis: It’s not just anything goes!” Charleston, SC: Society for Social Work and Research Annual Conference, 30th Jan, 2000.

[Dybå, 2001] Dybå, T. “Enabling Software Process Improvement: An Investigation of the Importance of Organizational Issues”, PhD Thesis, NTNU, IDI Report 7, 2001.

[Feagin et al., 1991] Feagin, J.R., Orum, A.M. & Sjoberg, G. “A case for the case study”, Chapel Hill: University of North Carolina Press, 1991.

[Fenton et al., 1994] Fenton, N., Pfleeger, S. L. and Glass, R. L. "Science and Substance: A Challenge to Software Engineers″, *IEEE Software,* pp. 86-95, July 1994.

[Finkelstein et al., 1996] Finkelstein, A., Spanoudakis, G. and Ryan, M. ”Software Package Requirements & Procurement”, Proceedings of the 8th International Workshop on Software Spesification and Design, pp. 141-145, March 1996.

[Getto et al., 2002] Getto, G., Gantner, T. and Vullinghs, T. ”Software Acquisition: Experiences with Models and Methods”, Daimler Chrysler, Research and Technology, Ulm Germany, 2002.

[Gibbs, 1994] Gibbs, W. “Software’s chronic crisis”, *Sci.Am.*, pp 86-95, Sept 1994.

[Goldenson et al., 2000] Goldenson, D. R. and Fisher, M. J. ”Improving the Acquisition of Software Intensive Systems” CMU/SEI-2000-TR-003, 2000.

[Hansen et al., 1999] Hansen, S., Dorling, A., Schweigert, T. and Lovett, J. ”IT Purchasing Guidebook for small enterprises. A self-help guide to higher value from IT purchases”, QAI Europe, UK, 1999.

[Hass, 2002] Hass, A. M. J. “Configuration Management Principles and Practice”, Addison Wesley, 2002, ISBN 0-321-11766-2.

[IEEE 830-1998] IEEE “Recommended Practice for Software Requirements Specifications”, International standard IEEE Std 830-1998, 1998.

[IEEE 1062] IEEE “Recommended Practice for Software Acquisition”, International standard IEEE Std 1062-1998, 1998.

[ISO/IEC 9126] ISO “Information Technology – Software Product evaluation – Quality Characteristics and Guidelines for their use”, International standard ISO/IEC 9126, 1991.

[ISO/IEC 12207] ISO “Information technology – Software life cycle processes” Amendment 1, International standard ISO/IEC 12207:1995/Amd.1:2002, 2002.

[ISO/IEC 15504] ISO “Information Technology – Process assessment”, International standard ISO/IEC 15504, 2004.

[Kemp, 1993] Kemp, A. “Software procurement and superconcurrent engineering”, *Computing & Control Engineering Journal,* VOL 5, NO 5, pp 299-303, Dec 1994

[Kennedy, 1976] Kennedy, M.M. “Generalizing from single case studies”, *Evaluation Quarterly,*3, pp 661-678, 1976

[Kitchenham et al., 2002] Kitchenham, B. A., Pfleeger, S. L., Pickard, L. M., Jones, P.W., Hoaglin, D. C., Emam, K. E. and Rosenberg, J. "Preliminary Guidelines for Empirical Research in Software Engineering", *IEEE transactions on software engineering,* vol. 28, NO. 8, pp. 721-733, Aug 2002

[Knell et al., 2002] Knell, S., Woodward, C., Boespflug, C. and Gogna, N. “Buying the Elephant: A Portfolio Approach to IT Procurement”, Information technology white paper, London, Canada: Info-Tech Research Group, 2001.

[Kuvaja, 1999] Kuvaja, P. “BOOTSTRAP 3.0 – A SPICE1 Conformant Software Process Assessment Methodology”, Software

Quality Journal, Springer Science + Business Media B.V., VOL 8, Number 1, pp. 7-19, 1999.

[Landauer, 1995] Landauer, T. K. "The Trouble with Computers: Usefulness, Usability and Productivity", MIT Press, Cambridge, MA, 1995.

[Lichtenstein, 2004] Lichtenstein, Y. "Puzzles in the software development contracting", Communications of the ACM, VOL. 47, pp. 61-65, 2004

[Markensten et al., 2004] Markensten, E. and Artman, H. "Procuring a usable system using unemployed personas", ACM International Conference Proceeding Series, Proceedings of the third Nordic conference on Human-computer interaction, pp. 13-22, 2004.

[May, 1998] May, L.J. "Major Causes of Software Project Failures", Available at: http://stsc.hill.af.mil/crosstalk/ frames.asp?uri=1998/07/causes.asp. (Accessed April 2005.)

[Mayrand et al., 1996] Mayrand, J. and Coallier, F. "System acquisition based on software product assessment", Proceedings of ICSE-18, IEEE, 1996.

[Mogilensky, 1990] Mogilensky, J. "Future approaches to software procurement", Proceedings of the conference on TRI-ADA '90, pp 543-550, 1990

[Ochs et al., 2001] Ochs, M., Pfahl, D., Chrobok-Diening, G. and Nothhelfer-Kolb, B., "A Method for Efficient Measurement-based COTS Assessment and Selection – Method Description and Evaluation Results", Proceedings of the 7th International Software Metrics Symposium (METRICS '01), 2001

[Oxford, 1995] Oxford Dictionary and Thesaurus, 1995

[Patton, 1980] Patton, M.Q. "Qualitative Evaluation Methods", Sage publications, 1980.

[Perry et al., 2000] Perry, D. E., Porter, A. A. and Votta, L. G. "Empirical Studies of Software Engineering: A Roadmap", *The Future of Software Engineering* - ICSE2000, Finkelstein, ed. June 2000.

[Pfleeger et al., 1994] Pfleeger, S.L., Fenton, N. and Page, S. "Evaluating Software Engineering Standards", Computer, Vol 7, NO 9, pp 71-79, Sept. 1994

[Pfleeger et al., 2001] Pfleeger, S.L. and Kitchenham, B.A. “Principles of survey research: part 1: turning lemons into lemonade”, ACM SIGSOFT, VOL. 26, NO. 6, Nov. 2001.

[Polanyi, 1967] Polanyi, M. “The Tacit Dimension”, Doubleday, 1967.

[Powell et al., 1996] Powell, P.L. and Klein. J.H. “Risk Management for Information System Development”, Journal of Information Technology, Vol. 11, pp. 309-319, 1996.

[Rapcsák et al., 2000] Rapcsák, T., Sági, Z., Tóth, T. and Kétszeri, L. “Evaluation of tenders in information technology”, Decision Support Systems, VOL 30, Issue 1, pp. 1-10, Dec. 2000

[Rickman, 2001] Rickman, D. M. “A new process for requirements understanding”, Digital Avionics Systems, The 20th Conference, VOL. 1, pp. 4D4/1-4D4/6, Oct. 2001.

[Robson, 2002] Robson, C. “Real World Research: A resource for social scientists and practitioner-researchers”, Blackwell Publishers, Great Britain, 2002, ISBN 0-631-21304-X.

[Ropponen et al., 2000] Ropponen, J. and Lyytinen, K. ”Components of Software Development Risk: How to Address Them? A Project Manager Survey”, IEEE Transaction on Software Engineering, vol. 26, NO. 2, pp. 98-112, Feb 2000

[SA-CMM] Cooper, J. and Fisher, M. “Software Acquisition Capability Maturity Model (SA-CMM)” Version 1.03, CMU/SEI-2002-TR-010, 2002.

[Sadler, 1981] Sadler, D. R. “Intuitive data processing as a potential source of bias in educational evaluations”, Educational Evaluation and Policy Analysis 3, pp. 25-31, 1981.

[Scown, 1998] Scown, P. “Improving the procurement process: humanizing accountants with a human factors education”, Proceedings of the international conference on Information systems, pp1-7, Dec 1998

[Schramm, 1971] Schramm, W. “Notes on case studies of instructional media projects”, Working paper, the academy for Educational Development, Washington, DC, 1971

[Snir et al., 1999] Snir, E. M. and Hitt, L. M. ”Vendor screening in IT contracting with a pilot project”, Proceedings of the 20th international conference on Information Systems, pp 324-327, Jan 1999

[Stoecker, 1991] Stoecker, R. “Evaluation and rethinking the case study”, The Sociological Review, 39, pp. 88-112, 1991.

[Tichy, 1998] W. F. Tichy, "Should Computer Scientists Experiment More?", *IEEE Computers*, vol. 31, NO. 5, pp. 32-39, 1998

[Tukey, 1986] Tukey, J. W. “Data analysis and behavioral science or learning to bear the quantitative man’s burden by shunning badmandaments”, The collected work of John W. Turkey, Volume III: Philosophy and principles of data analysis: 1949-1964, Pacific Grove, California: Wadsworth, 1986.

[Verhoef, 2002] Verhoef, C. “Quantitative IT portfolio management”, Science of Computer Programming, VOL 45, Issue 1, pp. 1-96, Oct 2002

[Verhoef, 2005] Verhoef, C. “Quantifying the value of IT-investments” Science of Computer Programming, VOL 56, Issue 3, pp. 315-342, May-June 2005

[Wiig, 1997] Wiig, K. M. “Knowledge management: Where Did It Come From and Where Will It Go?”, *Expert Systems with Applications*, 13, pp 1-14, 1997.

[Wohlin et al., 2000] Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B. and Wesslen, A. "Experimentation in software engineering. An introduction", Kluwer Academic Publishers, 2000, ISBN 0-7923-8682-5.

[Yin, 1994] Yin, R.K. “Case Study Research: Design and Methods”, 2nd edition, Thousand Oaks, California, 1994, ISBN 0-8039-5662-2.

Online references:

[BOOTSTRAP Institute] http://www.bootstrap.org
(Accessed May 2005)

[Britannica] http://www.britannica.com/eb/article?tocId=9106314
(Accessed March 2005)

[CiREM] http://www.cirem.co.uk/definitions.html#q
(Accessed April 2005)

[CMMI] http://www.sei.cmu.edu/cmmi/models/#modules
(Accessed May 2005)

[Congrex] www.congrex.nl/05m07/SME_Definition_2005.pdf
(Accessed June 2005)

[ikt] http://www.ikt-norge.no/templates/Page.aspx?id=507
(Accessed May 2005)

[Questback] https://www.questback.com
(Accessed March 2005)

[SSB] http://www.ssb.no
(Accessed May 2005)

[SSB_stats] http://statbank.ssb.no/statistikkbanken/
(Accessed May 2005)

[SPICE] http://www.sqi.gu.edu.au/spice/
(Accessed May 2005)

[Webster] http://www.webster.com
(Accessed March 2005)

Appendix

A1 Hypotheses evaluation

In this section we detail all the candidate hypotheses and discuss their usability in this investigation. Each hypothesis is given a rating which indicated our overall view of it. The hypotheses with good rates are used in the final analysis.

C1: Organizations consider software procurement as being a high-risk activity.

Source: Questionnaire and Interview

Rate: Good.

Requirements:

- include a question in the questionnaire and/or interview that explores this matter
- the participants have answered the question related to this issue in the questionnaire.

Reject requirement:
A significant amount, i.e. more than 80%, of the organizations considers the software procurement process as activity with medium or less risk.

Why:

- This hypothesis can be based on measurable data achieved form the questionnaire.
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations general view on software procurement

C2: Organizations follow a particular procurement standard when they procure software.

Source: Questionnaire

Rate: Good.

Requirements:

- include a question in the questionnaire that explores this matter
- the participants have answered the question related to this issue in the questionnaire.

Reject requirement:
A significant amount, i.e. more than 80%, of the organizations doesn't follow a particular procurement standard.

Why:

- This hypothesis can be based on a "yes/no-question" in the questionnaire.
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.

C3: Organizations often integrate risk management in their procurement project.

Source: Questionnaire

Rate: Good.

Requirements:

- include a question in the questionnaire that explores this matter
- the participants have answered the question related to this issue in the questionnaire.

Reject requirement:
A significant amount, i.e. more than 80 % of the participating organizations seldom or never integrates risk management in their procurement projects.

Why:

- This hypothesis is based on measurable data achieved from the questionnaire.
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.

C4: TCO is emphasized in the selection phase of the procurement process.

Source: Questionnaire

Rate: Good

Requirements:

- include a question in the questionnaire that explores this matter
- the participants have answered the question related to this issue in the questionnaire.

Reject requirement:
A significant amount, i.e. 80 %, of the organizations emphasizes TCO as less than highly important in the selection phase.

Why:

- This hypothesis is based on measurable data achieved from the questionnaire.
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.
- The use of TCO in the procurement process is an interesting research issue.
- The participants may not be familiar with TCO

C5: The mitigating actions known among the procurers cover all the known risks.

Source: Questionnaire/Interview

Rate: Poor.

Requirements:

- include a question in the questionnaire or interview that explores this matter
- the participants have answered the question related to this issue in the questionnaire or in the interview.

Reject requirement:
There are several risks that are not covered by the mitigating actions.

Why:

- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.
- It may be hard to reject the hypothesis based on available data.
- It is hard to compare mitigating actions directly with risks.
- The probability and consequences of the risks are not included.
- Will be a subjective interpretation by the researcher to decide the outcome of the hypothesis testing.

C6: Organizations include all stakeholders in the procurement process.

Source: Questionnaire and Interview

Rate: Medium.

Requirements:

- include a question in the questionnaire and/or the interview that explores this matter

- the participants have answered the question related to this issue in the questionnaire and/or in the interview.

Reject requirement:
A significant amount of the organizations doesn't include all stakeholders in the procurement process.

Why:
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.
- There are different stakeholders related to each procurement project and it is therefore hard to give an overall answer to this matter.

C7: Organizations with a defined, formalized procurement process are more satisfied with previous procured software-intensive systems than organizations with ad-hoc procurement processes.

Source: Questionnaire

Rate: Good.

Requirements:
- include a question in the questionnaire that explores this matter
- the participants have answered the question related to this issue in the questionnaire.
- there are both organizations with formalized procurement processes and ad-hoc procurement processes participating in the investigation (See H2).

Reject requirement:
A significant amount of the organizations with a defined, formalized procurement process is not more satisfied with their procurements of software-intensive systems than organizations with ad-hoc procurement processes.

Why:
- This hypothesis is based on measurable data achieved from the questionnaire.
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.

C8: Organizations without a contract change clause experience changes to the initial contract more frequent than organizations with a contract change clause.

Source: Questionnaire

Rate: Good.

Requirements:

- include a question in the questionnaire that explores this matter
- the participants have answered the question related to this issue in the questionnaire.

Reject requirement:
A significant amount of the organizations without a contract change clause seldom experiences changes to the initial contract.

Why:

- This hypothesis is based on measurable data achieved from the questionnaire.
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.

C9: Organizations find the documentation and information from the suppliers satisfactory.

Source: Questionnaire

Rate: Good.

Requirements:

- include a question in the questionnaire that explores this matter
- the participants have answered the question related to this issue in the questionnaire.
- there are both organizations with formalized procurement processes and ad-hoc procurement processes participating in the investigation (See H1).

Reject requirement:
A significant part, i.e. more than 80% of the participating organizations, finds the documentation and information from the suppliers little or not satisfactory.

Why:

- This hypothesis is based on measurable data achieved from the questionnaire.
- It is possible to reject the hypothesis based on available data.

- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.

C10: Organizations integrating risk management in procurement projects are more satisfied with their procurements then those who don't.

Source: Questionnaire

Rate: Good.

Requirements:

- include a question in the questionnaire that explores this matter
- the participants have answered the question related to this issue in the questionnaire.
- there are both organizations which integrate risk management in the procurement projects and organizations who don't do it (see H3).

Reject requirement:
A significant part of the organizations who integrate risk management into procurement projects are not more satisfied with their procurements of software-intensive systems than organizations who don't.

Why:

- This hypothesis is based on measurable data achieved from the questionnaire.
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.

C11: Organizations managing knowledge from previous completed software procurements are more satisfied with their procurements than those who don't.

Source: Questionnaire

Rate: Good.

Requirements:

- include a question in the questionnaire that explores this matter
- the participants have answered the question related to this issue in the questionnaire.
- there are both organizations who manage knowledge and organizations that don't integrate knowledge management in their daily operation.

Reject requirement:
A significant part of the organizations who manage knowledge are not more satisfied with their procurements than those organizations that don't manage knowledge.

Why:

- This hypothesis is based on measurable data achieved from the questionnaire.
- It is possible to reject the hypothesis based on available data.
- This hypothesis may give an insight into the organizations software procurement process and give valuable information regarding the current state.
- This hypothesis may reveal some of the weaknesses and problems with the current state of software procurement.

A2 Instrumentation

A copy of the questionnaire is presented here, followed by the interview guidelines.

Life Cycle Software Procurement (LCSP)-Software procurement

The purpose of this survey is to investigate how growing, Norwegian organizations perform procurement of software-intensive systems (see definitions below). Based on this survey and additional interviews, a set of guidelines for future software procurements will be formulated.

All response to this survey will be handled confidentially, including information on whether a company has participated. The result will describe and analyze the current state of practice of procurement of software-intensive systems in growing organizations in Norway. The final report will not contain detailed information about a certain company. Neither will it be possible to draw any conclusions about a given company.

A final report of this project will be electronically available to all respondents by email or through a web-link. A hard copy of the report will be sent, if a postal address is provided.

This questionnaire will require about 20 minutes to fill out. If you have any questions regarding the questionnaire, please contact Knut Steinar Engene; phone: xxxxxxxx or e-mail: xxxx@xxxx.

You may answer the questions in English or Norwegian

By "software intensive systems" we mean systems where some, though not necessarily all, functions of the system are implemented through or rely on software e.g. invoicing system, customer database, expert system. Standard packages like Microsoft Office without any adjustments falls outside this definition.

By "procurement" we mean the process of providing a software system, software product or software service. This process begins with the identification of a customer need and ends with the acceptance of the product and/or service needed by the customer.

---

2. How many years of working-experience related to software-intensive systems do you have?

- ☐ less than 1 year
- ☐ 1-2 years
- ☐ 2-4 years
- ☐ 4-6 years
- ☐ 6-10 years
- ☐ more than 10 years

---

3. What is your current position in the organization?

- ☐ Procurement manager
- ☐ ICT officer
- ☐ System user
- ☐ Senior management
- ☐ Other, specify here:

---

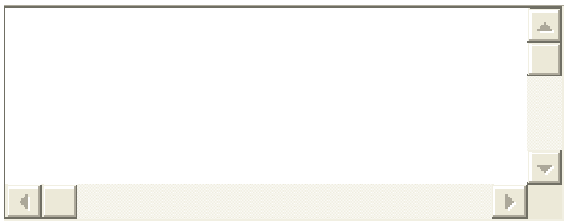
4. How long have you been in your current position?

- ☐ less than 6 months
- ☐ 6-12 months
- ☐ 1-2 years
- ☐ 2-5 years
- ☐ more than 5 years

5. When did your organization last buy a software-intensive system?

- ☐ currently
- ☐ less than 6 months
- ☐ 6-12 months
- ☐ 1-2 years
- ☐ 2-4 years
- ☐ more than 4 years
- ☐ Don´t know

6. Briefly describe what kind of software system this was



7. Do you have a defined, formalized procurement process in your organization?

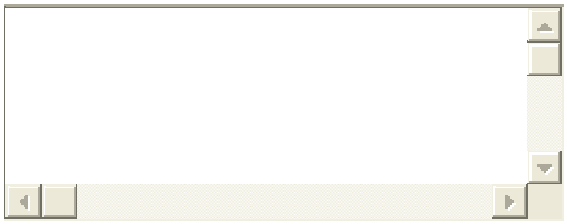
- ☐ Yes
- ☐ No
- ☐ Don´t know

8. Is this procurement process applicable for procurement of software-intensive systems as well?

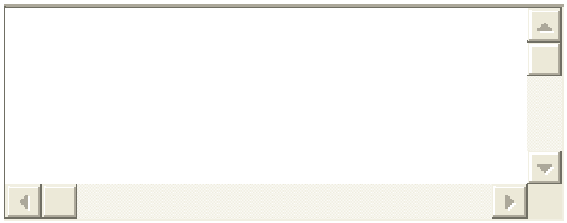
- ☐ Yes
- ☐ No
- ☐ Don´t know

This box is shown in preview only.
The following criteria must be fullfilled for this question to be shown :
Do you have a defined, formalized procurement process in your organization? - Yes

9. Please list the main steps in your procurement process (4-7 steps are common):



10. Could you please briefly/point-by-point describe how you usually conduct procurements of software:



11. Do you have a procurement team in your organization?

- ☐ Yes
- ☐ No
- ☐ Don´t know / NA

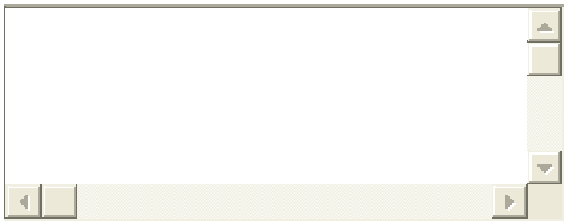
This box is shown in preview only.
The following criteria must be fullfilled for this question to be shown :
Do you have a procurement team in your organization? - Yes

12. Who are represented in the procurement team?

- ☐ Senior management
- ☐ ICT officer
- ☐ Technical experts
- ☐ End-users
- ☐ Financial experts
- ☐ External consultants
- ☐ Other, specify here: _____

This box is shown in preview only.
The following criteria must be fullfilled for this question to be shown :
Do you have a procurement team in your organization? - No
or
Do you have a procurement team in your organization? - <#na#>Don´t know / NA

13. What roles in the organization are involved in the procurement process?



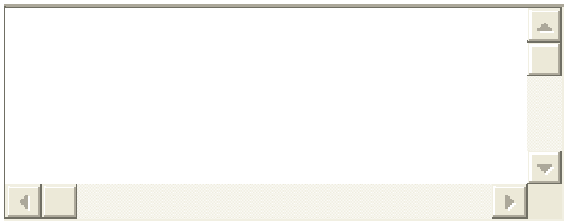
---

14. To what extent do you consider software procurement as a risky activity?

- ○ No risk
- ○ Very low
- ○ Low
- ○ Medium
- ○ High
- ○ Very high

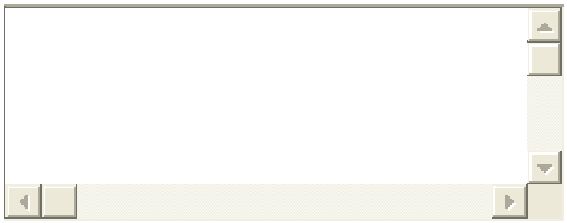
---

15. What are, in your opinion, the 4 highest risks related to software procurement projects in your organization? Please list them in ranked order, highest risk on top.



---

16. What mitigating actions do you perform to get control over potential risks?



---

17. Risk management refers to the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects. This involves identifying, analysing, assessing, treating, monitoring and communicating risks.

Do you integrate risk management in procurement projects?

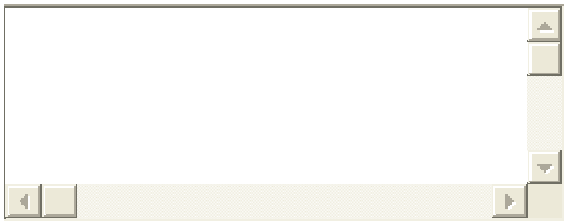
- ☐ Never
- ☐ Seldom
- ☐ Often
- ☐ Always

---

18. To what extent have you been satisfied with previous procured software-intensive systems, and especially business-critical systems?

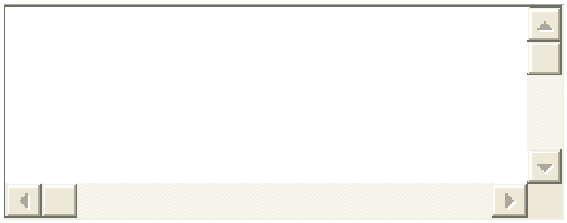
- ☐ Dissatisfied
- ☐ Little satisfied
- ☐ Fairly satisfied
- ☐ Satisfied
- ☐ Very satisfied

19. Please give a brief explanation to your last answer. What made you satisfied/dissatisfied?



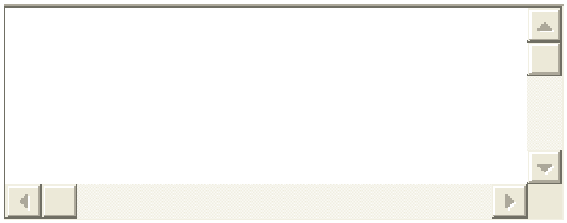
---

20. What challenges have you experienced in previous procurement projects?



---

21. How is experience/knowledge gained and retained from a completed procurement project managed in your organization?



We also need a little information about how you execute some of the tasks involved in software procurement:

23. How do you get information about the potential products/suppliers?

- ☐ Send out request for proposal to potential suppliers
- ☐ Perform own research
- ☐ Get recommendations from colleagues/interest groups
- ☐ Use external consultants
- ☐ Don't know
- ☐ Other, specify here:

24. To what extent are the criteria below emphasized in the evaluation of potential suppliers/products?

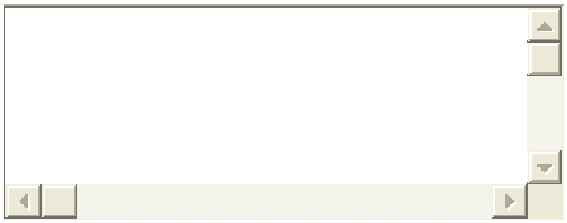
	Very low	Low	Medium	High	Very high	Don't know / NA
Acquisition cost	☐	☐	☐	☐	☐	☐
Delivery time	☐	☐	☐	☐	☐	☐
Functionality	☐	☐	☐	☐	☐	☐
License type	☐	☐	☐	☐	☐	☐
Maintainability	☐	☐	☐	☐	☐	☐
Market share product	☐	☐	☐	☐	☐	☐
Market share supplier	☐	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐	☐
Return on Investment (ROI)	☐	☐	☐	☐	☐	☐
Supplier's reputation	☐	☐	☐	☐	☐	☐
Total cost of ownership (TCO)	☐	☐	☐	☐	☐	☐
Usability	☐	☐	☐	☐	☐	☐

Definition of the criteria:

Acquisition cost: **Cost of the product**
Delivery time: **The length of time it takes from order to deliverance**
Functionality: **The capability of the software to provide functions which meet stated and implied needs when the software is used under specified conditions**
Licence type: **The type of licence of the product**
Maintainability: **The capability of the software to be modified**
Market share product: **The ratio/part of the market of similar products that is covered by this product**
Market share supplier: **The ratio/part of the market of similar suppliers that is covered by this supplier**
Reliability: **The capability of the software to maintain the level of performance of the system when used under specified conditions**
Return on Investment (ROI): **The amount of profit (return) based on the amount of resources (funds) used to produce it. Also, the ability of a given investment to earn a return for its use.**
Supplier's reputation: **What kind of reputation the supplier has in the industry**
Total cost of ownership (TCO): **The cost of using the product in its lifecycle**
Usability: **The capability of the software to be understood, learned, used and liked by the user, when used under specified conditions**

---

26. Could you list 2 other criteria influencing the selection of supplier/product:



---

27. How do you investigate the feasibility of the supplier's approach/proposal?

- ☐ Get references
- ☐ Use prototyping
- ☐ Close collaboration with the supplier
- ☐ Use external evaluator
- ☐ Don't know
- ☐ Other, specify here:

28. Do you include a contract change clause in the contract between you and the supplier which allows changes of the initial contract at specific conditions?

- ☐ Yes
- ☐ No
- ☐ Don't know

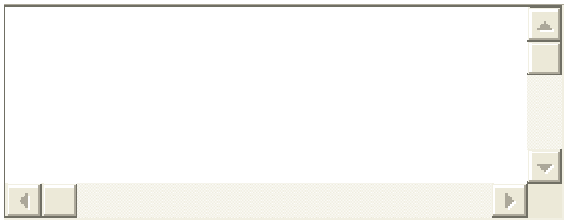
29. How often are there changes to the initial contract?

- ☐ Never
- ☐ Seldom
- ☐ Often
- ☐ Always
- ☐ Don't know

30. To what extent do you find the documentation and information from the suppliers regarding products satisfactory?

- ☐ Dissatisfied
- ☐ Little satisfied
- ☐ Fairly satisfied
- ☐ Satisfied
- ☐ Very satisfied

31. Where there any questions in the survey you found hard to answer? If yes, which one(s) and why?



Interview guide

Background information to Interviewer

Introduction

This is an interview guide that is part of a survey conducted by Knut Steinar Engene in collaboration with NTNU and Det Norske Veritas (DNV) Research department in the Life Cycle Software Procurement (LCSP) project. The purpose of this survey is to gather information on the participating organizations' procurement processes, the risk they see and how they use Total Cost of Ownership (TCO) in their procurement projects.

This interview guide includes a set of questions and information for the respondents. There is, however, possible to ask additional questions to follow up interesting responses. The interviewer must read the respondents answers from the questionnaire before the interview and see if there are answers that need further investigation. Please read the entire guide prior to conducting the first interview.

Themes covered in interview

The main themes in this interview are:

- How is software procurement conducted to day?
- The use of Total Cost of Ownership (TCO)
- Risks and Mitigating actions related to software procurement

Conventions

The following convention will be used in this interview guide:

Interviewer guidance, for the interviewer only	Arial
Questions/text to be read out to the respondents	*Times New Roman Italic*

Timeline for the interview

This interview should take a maximum of one (1) hour to accomplish, but it is nothing wrong in finishing earlier than that. But be sure to cover all areas within the timeline.

The time should be spent as follows:

- 5 min slack at the beginning for coffee, delays etc.
- 20 min for Procurement process
- 10 min for TCO
- 20 min for Risks and Mitigating actions
- 5 min round off

Interview start

Introduction and background

Thank you for taking time to participate in this interview. All information gathered in this interview will be anonymous to all but me, my supervisor Prof. Tor Stålhane and the DNV researchers working with the project.

This project is part of a master thesis at Norges Teknisk-Naturvitenskapelige Universitet (NTNU). The project is run in collaboration with Det Norske Veritas Research department.

This interview is held to gather more information about your procurement process in addition to the answers you gave in the questionnaire. This will then be input to establish a set of guidelines which can be used in future software procurements.

These guidelines can then be used by your and other organizations to improve your work relating to procurement of SIS.

Issues or questions from respondent and organizational unit

Please note any issues raised by the respondent. If answers can not be given, please note questions and get back to the respondent when an answer is found.

FPI-Q-1. Do you have any comments or questions before we start?

FPI-Q-2. Which organizational unit are you part of? Please give short description of its main tasks and responsibilities. Note: May be multiple belongings. Here we refer mainly to line belonging.

Procurement process

Get the overall picture, preferably as drawing

For these questions, make sure you have sheets of paper available, preferably A3 format together with an extra pen for the respondent to use. In addition, you'll need the respondents answers from the questionnaire.

We then move on to try to get more in-depth information regarding your procurement processes and who executes them, based on the answers you gave in the questionnaire. The following questions will focus on this.

FPI-Q-3. Could you please detail the steps in your procurement process?

FPI-Q-4. With this process, which parts of your organization have been involved in the process?

FPI-Q-5. Which processes or parts of processes, have been most important to make this work? Please exemplify why process elements have been important.

FPI-Q-6. Have you ever heard of software procurement standards?

FPI-Q-7. What have you done to find a standard that could assist you in the procurement process? If nothing, why not?

FPI-Q-8. Do you integrate risk management in other projects you're conducting? If yes, why are you not integrating risk management in every software procurement project?

TCO part

This project (LCSP) is looking for ways the procurement process can contribute to as low Total Cost of Ownership as possible. In order for us to do this we need to know a bit about how your organization works with Total Cost of Ownership.

The way we see Total Cost of Ownership it contains all costs related to the system during its entire lifetime (Life-Cycle), including both direct and indirect costs.

Costing

To help us in analyzing the risks relating to TCO, we need more information on who you calculate costs in procurement projects. The following questions will focus on this.

FPI-Q-9: Which cost elements are included when you compute the initial cost of the procurement project? Please describe and give examples.

FPI-Q-10: ***When*** *are operation, maintenance and change costs computed?*

	Before procurement, as part of initial Business Case
	During procurement project, before selecting solution
	During procurement project, after selecting solution but before start of operations
	After start of operations
	Combination of the above - Identify which ones
	None of the above – describe below:

FPI-Q-11: *How* ***are operation, maintenance and change costs computed? Please list typical cost elements.***

TCO usage

In situations where the respondent is not familiar with or using the TCO term, focus on the life-cycle cost and ask them to describe how life-cycle costs are handled in the initial procurement project. We are also looking to verify if TCO is in use at all and we expect some respondents to not be thinking in terms of TCO at all

The term Total Cost of Ownership (TCO) or LifeCycle Cost (LCC) are terms used to describe the total costs relating to a system from its inception [1] to it is retired from use. These costs have two main parts, the Procurement or Project costs covering the period from inception until the system is in full operation, and the second part consisting of the operations, maintenance, change and other costs incurred from full production is started (the initial project/procurement is finished) until the system is retired (replaced, scrapped) from use.

FPI-Q-12. Can you please give some examples of TCO or LCC in your organization?

TCO model

If TCO is in use, we want to know if they are using a defined model for TCO on an organizational level.

FPI-Q-13. Is a TCO model in use?

	Yes
	Partial
	No
	Don't know

If a Yes answer for previous question ask for documentation of the TCO model for further study. If Partial or No answer was received on previous question, please ask respondent to describe the TCO model in use, in addition to any documentation that might be available.

☐ Reference to documents given ☐ Documents found/received.

FPI-Q-14. Can you please describe the TCO model in use?

[1] Inception = Unfangelse, begynnelse

Risks with respect to TCO

During the interview, it may be handy to refer to their procurement process, and point to parts. A talkative person always has contributions here, but if the person does not like talking, the person may have to be handheld to look at more detailed areas.

As part of this project we are looking at risks in procurement projects and how they relate to TCO/LCC, the next questions will be in this area.

FPI-Q-15-1. What key risks have you seen during software system procurement?

FPI-Q-15-2. When was the hazard introduced?

FPI-Q-15-3. When could the risk have been detected?

FPI-Q-15-4. What role could detect it?

FPI-Q-15-5. What process could have detected the risk?

FPI-Q-15-6. What could mitigate the risk?

FPI-Q-15-7. What is the risk impacting? (will this be implicite in the risk description?)

FPI-Q-15-8. What role could mitigate the risk?

FPI-Q-16. How do the risks listed in the previous question impact TCO/LCC?

FPI-Q-17. What are the key risks in some example procurement project that would impact TCO/LCC?

FPI-Q-18. In your role, what metric/KPI (Key Performance Indicator) is used to see if you do a good job?

FPI-Q-19. Please exemplify what the main priorities are when critical project decisions are made.

FPI-Q-20. What feedback cycles have you in place to allow your organization to learn until next procurement project?

FPI-Q-21. In your role, what are the four most important ways of keeping a low TCO?

FPI-Q-22. What information could you have used to improve the TCO of procured SISs?

FPI-Q-23. What three major hinders do you have for achieving reduced TCO for a procured SIS?

Turning the table

FPI-Q-24. Now, we have been asking about what we belive is important. Is there something you would like to tell us, that we should have asked about?

Finishing up

The interview is now finished. We want to reassure the respondent of their anonymity and open again for any questions or comments from the respondent. If answers can not be given, please note questions and forward to Knut Steinar Engene (engene@stud.ntnu.no), and let the respondent know he will come back with an answer.

This brings us to the end of our questions. We will once again assure you that all information gathered in this interview will be anonymous to all but the DNV researchers working with the project.

FPI-Q-25: Do you have any final questions or comments?

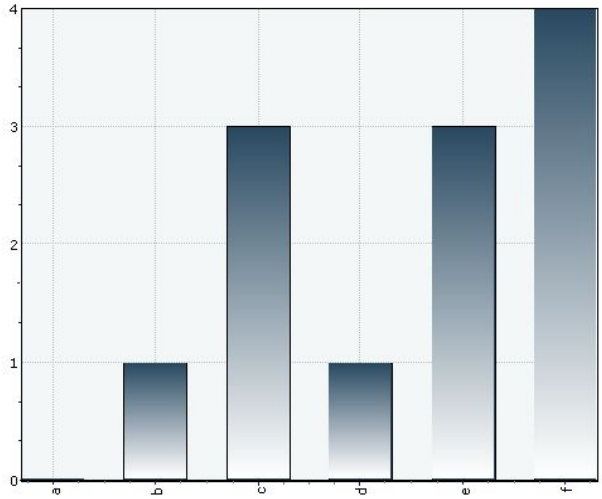
We are very grateful for all of your inputs, and thank you very much for taking the time to participate in this project.

A3 Raw data

This appendix contains the descriptive statistics based on the quantitative data collected in the questionnaire.

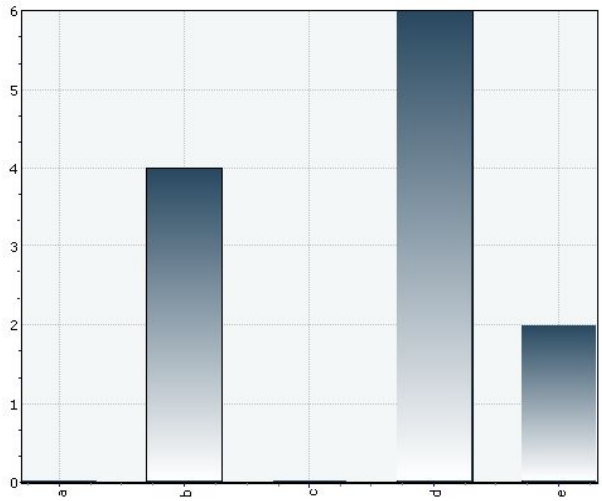
Life Cycle Software Procurement (LCSP)-Innkjøp av software

2. How many years of working experience related to software-intensive systems do you have?



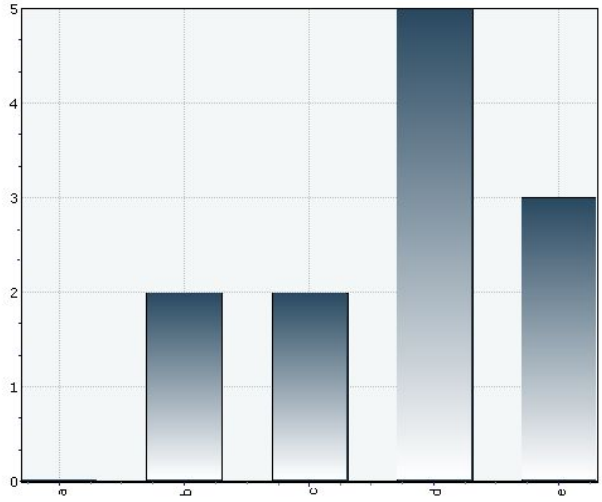
Alternatives	Value	Percent
a Less than 1 year	0	0 %
b 1-2 year(s)	1	8,3 %
c 2-4 years	3	25 %
d 4-6 years	1	8,3 %
e 6-10 years	3	25 %
f More than 10 years	4	33,3 %
Total	12	

3. What is your position in the organization?



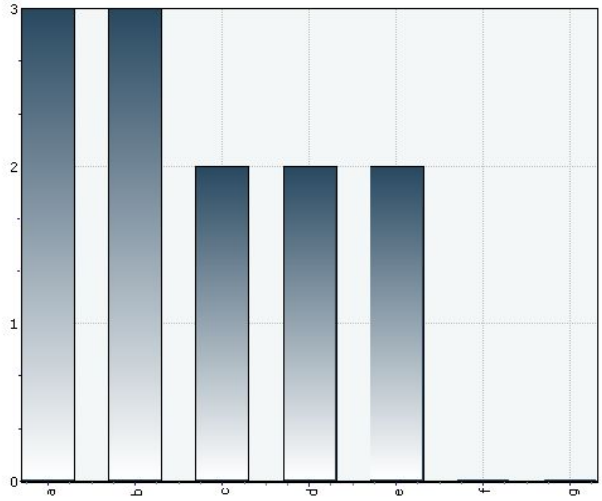
Alternatives	Value	Percent
a Procurement manager	0	0 %
b ICT officer	4	33,3 %
c System user	0	0 %
d Senior management	6	50 %
e Other	2	16,7 %
Total	12	

4. How long have you been in your current position?



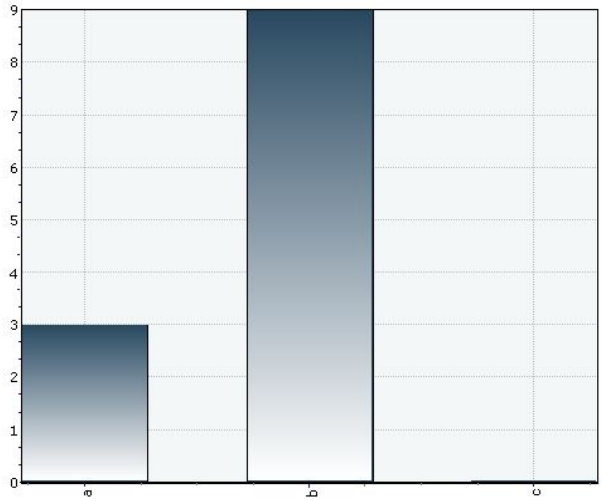
Alternatives	Value	Percent
a Less than 6 months	0	0 %
b 6-12 months	2	16,7 %
c 1-2 year(s)	2	16,7 %
d 2-5 years	5	41,7 %
e More than 5 years	3	25 %
Total	12	

5. When did your organization last buy a software-intensive system?



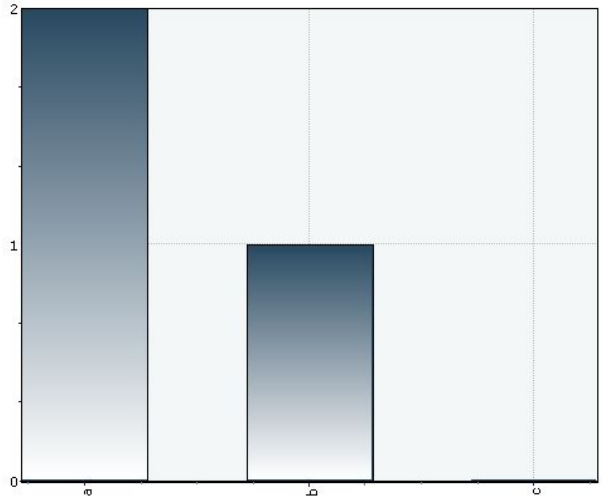
Alternatives	Value	Percent
a Recently	3	25 %
b Less than 6 months	3	25 %
c 6-12 months	2	16,7 %
d 1-2 year(s)	2	16,7 %
e 2-4 years	2	16,7 %
f More than 4 years	0	0 %
g Don’t know	0	0 %
Total	12	

7. Do you have a defined, formalized procurement process in your organization?



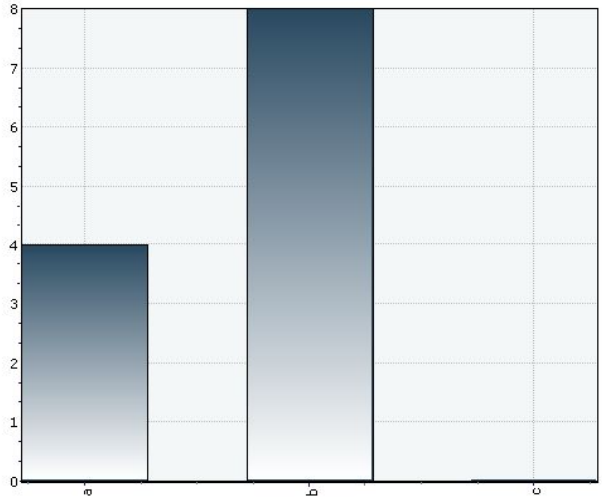
Alternatives	Value	Percent
a Yes	3	25 %
b No	9	75 %
c Don’t know	0	0 %
Total	12	

8. Does this process apply for procurement of software-intensive systems as well?



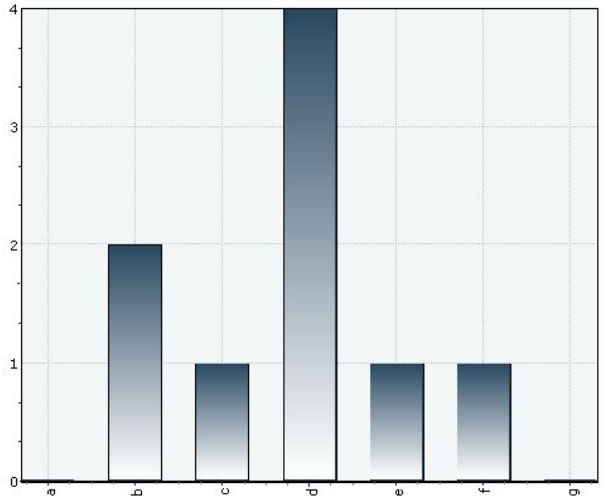
Alternatives	Value	Percent
a Yes	2	66,7 %
b No	1	33,3 %
c Don’t know	0	0 %
Total	3	

11. Is there an appointed team in the organization that is responsible for software procurement?



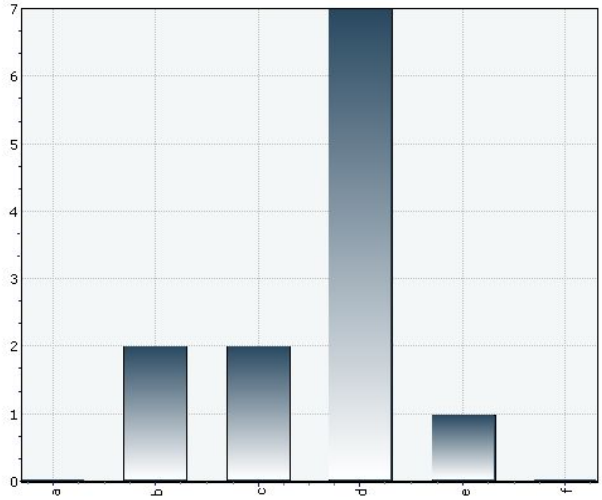
Alternatives	Value	Percent
a Yes	4	33,3 %
b NO	8	66,7 %
c Don’t know	0	0 %
Total	12	

12. Who are represented in this procurement team?



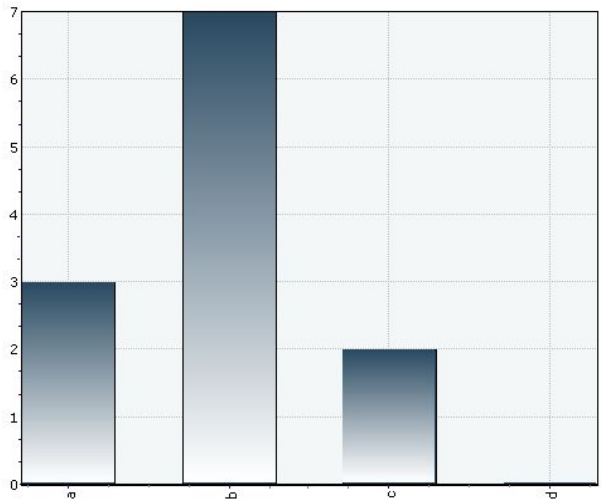
Alternatives	Value	Percent
a Senior management	0	0 %
b ICT-officer	2	50 %
c Technical experts	1	25 %
d System users	4	100 %
e Financial experts	1	25 %
f External consultants	1	25 %
g Other	0	0 %
Total	9	

14. To what extent do you consider software procurement as a risky activity?



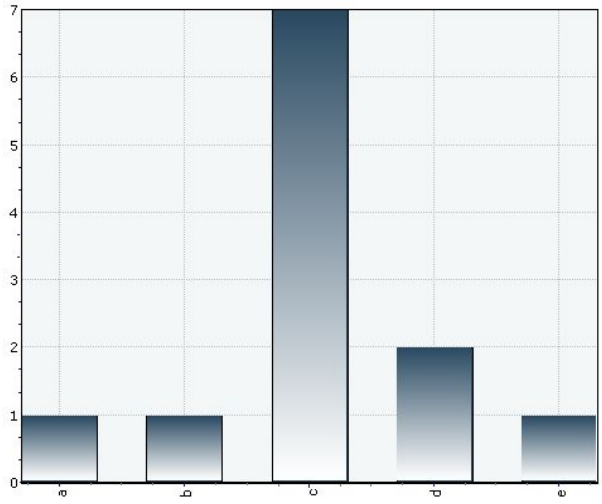
Alternatives	Value	Percent
a No risk	0	0 %
b Very low risk	2	16,7 %
c Low risk	2	16,7 %
d Medium risk	7	58,3 %
e High risk	1	8,3 %
f Very high risk	0	0 %
Total	12	

17. Do you integrate risk management in procurement projects?



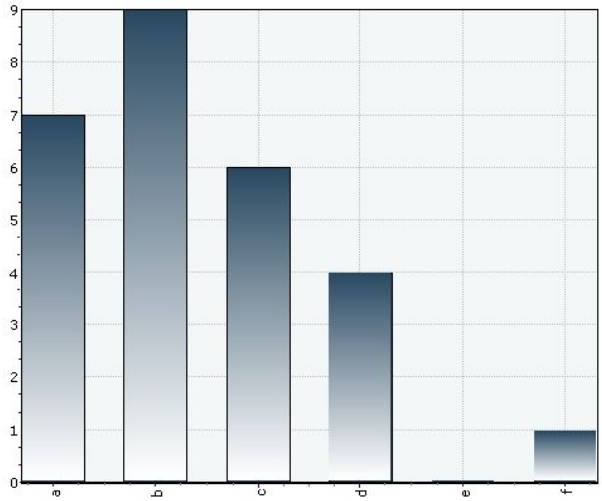
Alternatives	Value	Percent
a Never	3	25 %
b Seldom	7	58,3 %
c Often	2	16,7 %
d Always	0	0 %
Total	12	

18. To what extent have you been satisfied with previous procurements of software-intensive systems, especially the systems critical for the operation of the organization?



Alternatives	Value	Percent
a Dissatisfied	1	8,3 %
b Little satisfied	1	8,3 %
c Fairly satisfied	7	58,3 %
d Satisfied	2	16,7 %
e Very satisfied	1	8,3 %
Total	12	

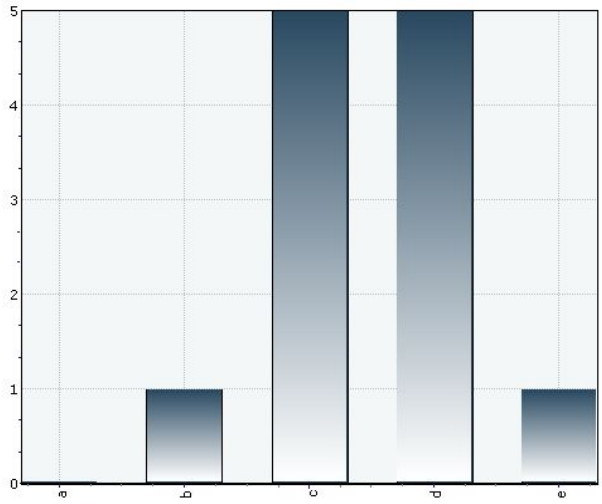
23. How do you gather information about the potential products/suppliers?



Alternatives	Value	Percent
a Send out request for proposal to potential suppliers	7	58,3 %
b Perform own research	9	75 %
c Get recommendations from colleagues/interest groups	6	50 %
d Use external consultants	4	33,3 %
e Don’t know	0	0 %
f Other	1	8,3 %
Total	27	

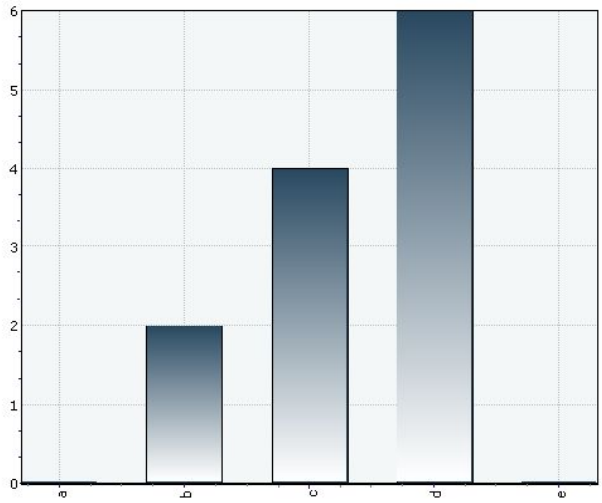
24. To what extent are the following factors emphasized in the evaluation of potential products/suppliers?

24.1 Acquisition cost



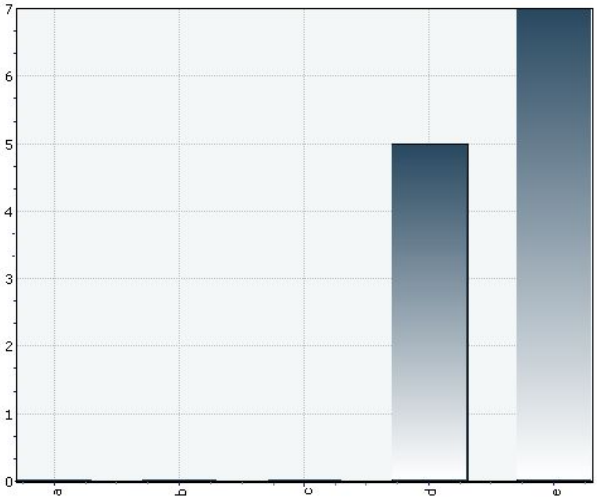
Alternatives	Value	Percent
a Very low	0	0 %
b Low	1	8,3 %
c Medium	5	41,7 %
d High	5	41,7 %
e Very high	1	8,3 %
Total	12	

24.2 Delivery time



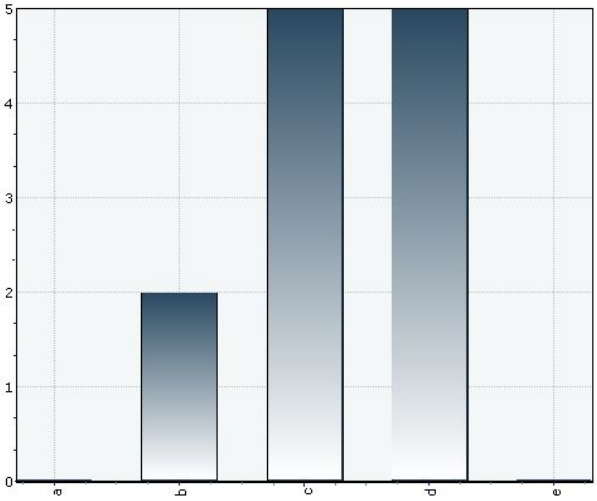
Alternatives	Value	Percent
a Very low	0	0 %
b Low	2	16,7 %
c Medium	4	33,3 %
d High	6	50 %
e Very high	0	0 %
Total	12	

24.3 Functionality



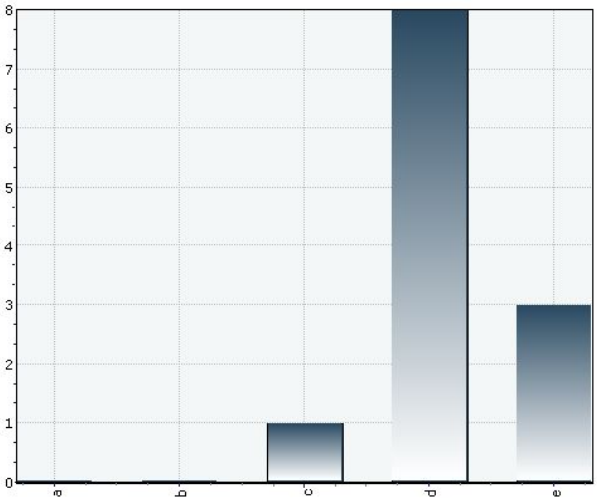
Alternatives	Value	Percent
a Very low	0	0 %
b Low	0	0 %
c Medium	0	0 %
d High	5	41,7 %
e Very high	7	58,3 %
Total	12	

24.4 Licence type



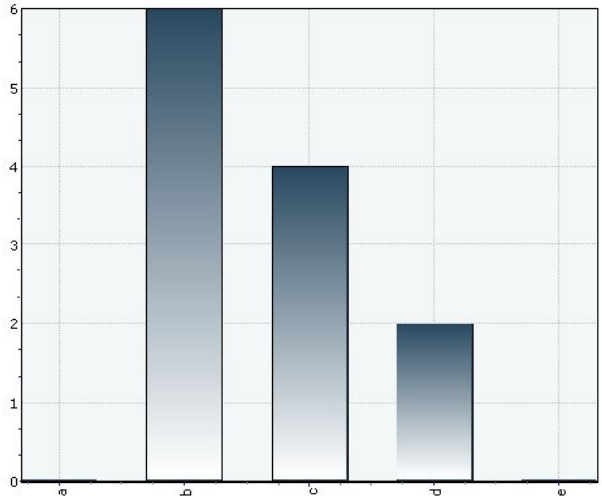
Alternatives	Value	Percent
a Very low	0	0 %
b Low	2	16,7 %
c Medium	5	41,7 %
d High	5	41,7 %
e Very high	0	0 %
Total	12	

24.5 Maintainability



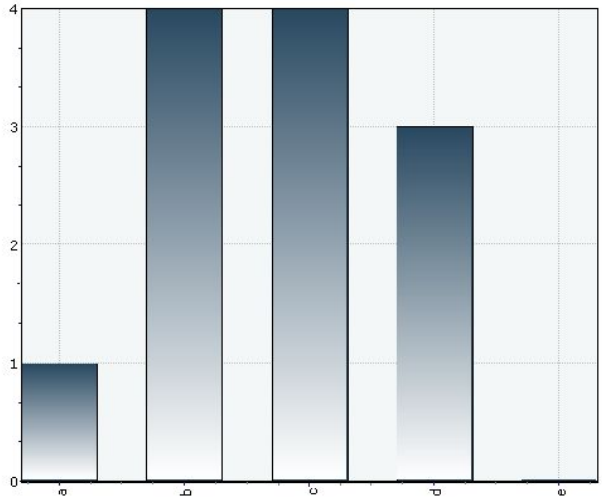
Alternatives	Value	Percent
a Very low	0	0 %
b Low	0	0 %
c Medium	1	8,3 %
d High	8	66,7 %
e Very high	3	25 %
Total	12	

24.6 Market share product



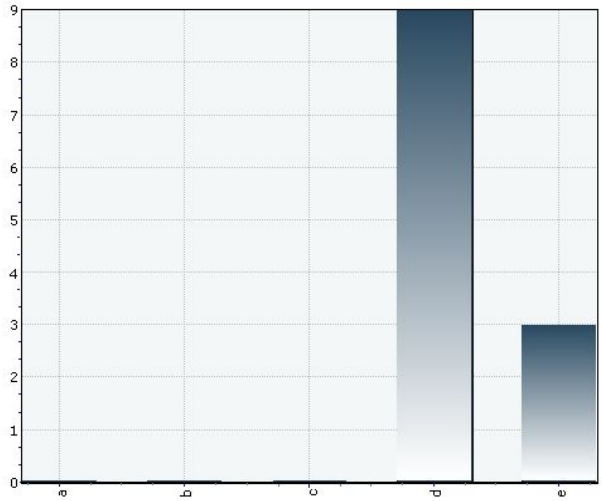
Alternatives	Value	Percent
a Very low	0	0 %
b Low	6	50 %
c Medium	4	33,3 %
d High	2	16,7 %
e Very high	0	0 %
Total	12	

24.7 Market share supplier



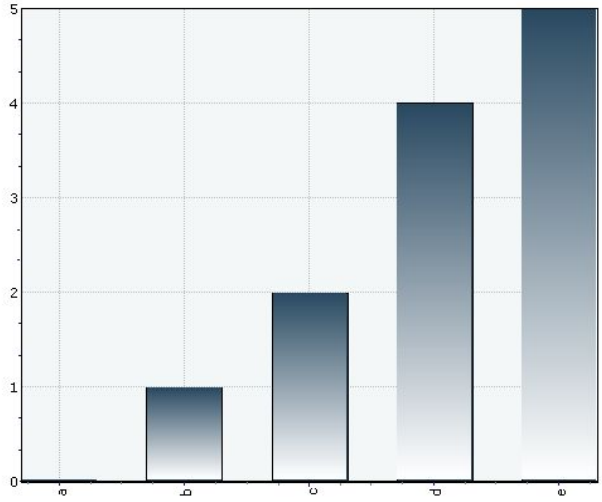
Alternatives	Value	Percent
a Very low	1	8,3 %
b Low	4	33,3 %
c Medium	4	33,3 %
d High	3	25 %
e Very high	0	0 %
Total	12	

24.8 Reliability



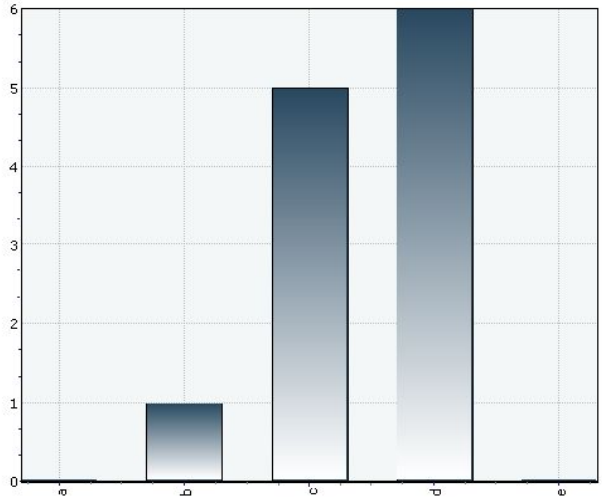
Alternatives	Value	Percent
a Very low	0	0 %
b Low	0	0 %
c Medium	0	0 %
d High	9	75 %
e Very high	3	25 %
Total	12	

24.9 Return on Investment (ROI)



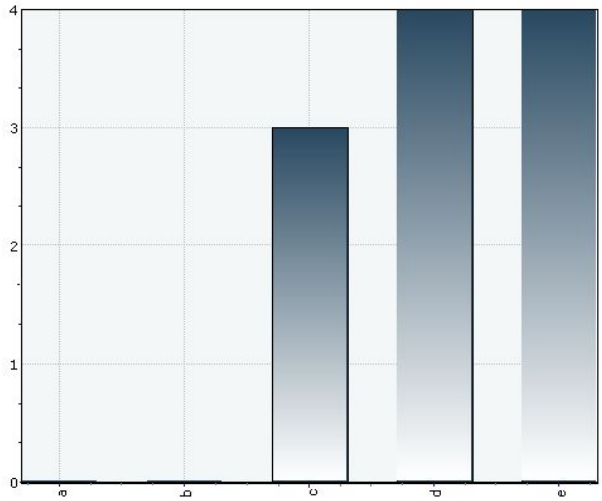
Alternatives	Value	Percent
a Very low	0	0 %
b Low	1	8,3 %
c Medium	2	16,7 %
d High	4	33,3 %
e Very high	5	41,7 %
Total	12	

24.10 Supplier’s reputation



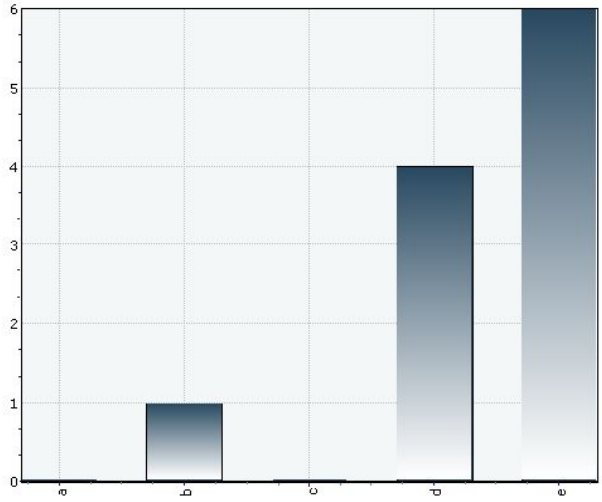
Alternatives	Value	Percent
a Very low	0	0 %
b Low	1	8,3 %
c Medium	5	41,7 %
d High	6	50 %
e Very high	0	0 %
Total	12	

24.11 Total cost of ownership (TCO)



Alternatives	Value	Percent
a Very low	0	0 %
b Low	0	0 %
c Medium	3	27,3 %
d High	4	36,4 %
e Very high	4	36,4 %
Total	11	

24.12 Usability

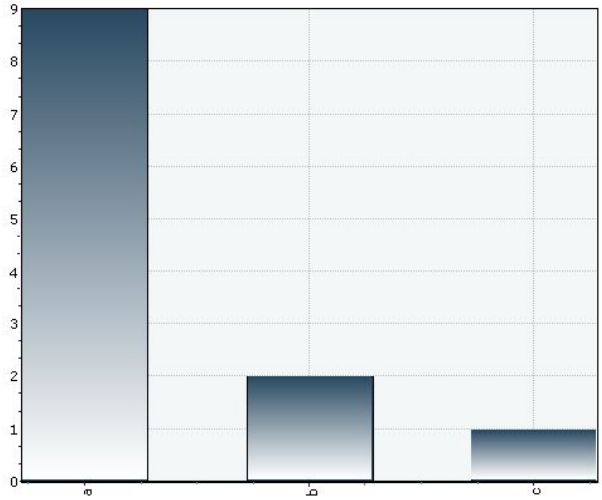


Alternatives	Value	Percent
a Very low	0	0 %
b Low	1	9,1 %
c Medium	0	0 %
d High	4	36,4 %
e Very high	6	54,5 %
Total	11	

27. How do you investigate the feasibility of the supplier's approach/proposal?

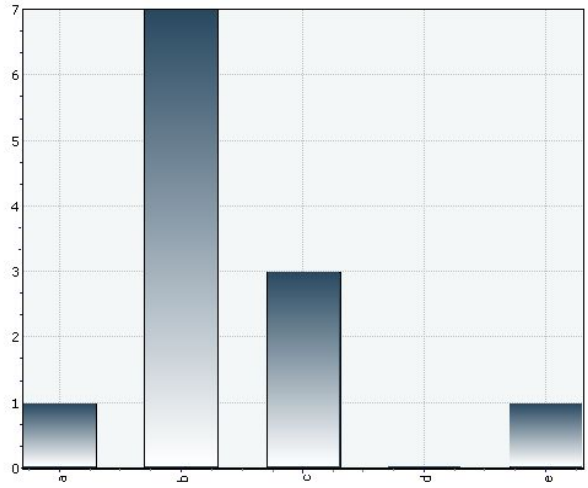
Alternatives	Value	Percent
a Get references	8	72,7 %
b Use prototyping	3	27,3 %
c Close collaboration with the supplier	7	63,6 %
d Use external evaluator	4	36,4 %
e Don't know	0	0 %
f Other	1	9,1 %
Total	23	

28. Do you include a contract change clause in the contract between you and the supplier, whcih allows changes to be made on certain conditions?



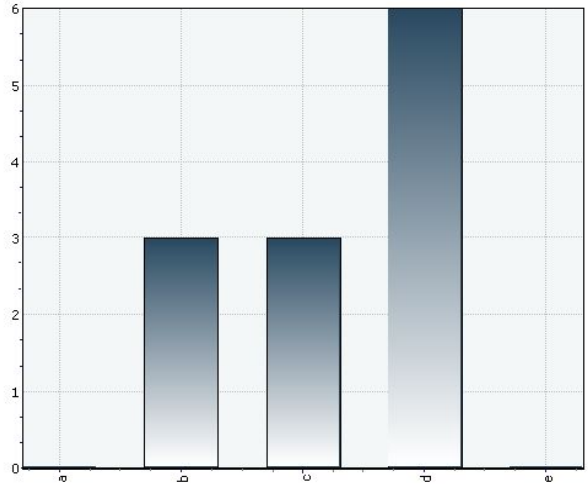
Alternatives	Value	Percent
a Yes	9	75 %
b No	2	16,7 %
c Don't know	1	8,3 %
Total	12	

29. How often are there changes to the initial contract?



Alternatives	Value	Percent
a Never	1	8,3 %
b Seldom	7	58,3 %
c Often	3	25 %
d Always	0	0 %
e Don't know	1	8,3 %
Total	12	

30. To what extent do you find the documentation and information from the suppliers regarding products, satisfactory?



Alternatives	Value	Percent
a Dissatisfied	0	0 %
b Little satisfied	3	25 %
c Fairly satisfied	3	25 %
d Satisfied	6	50 %
e Very satisfied	0	0 %
Total	12	

A4 Statistical analysis in detail

This section contains the statistical analysis conducted in the investigation. First, Table 19, 20 and 21 shows the combination of different factors characterizing the participating organizations. Then the statistical work conducted in Minitab is presented.

The factors are:

A. Organizations with a defined, formalized procurement process
B. Organizations with respondents having long working experience related to SIS, i.e. 6 years or longer
C. Organizations integrating risk management in procurement projects, i.e. often or always integrates risk management
D. Organizations having an appointed procurement team

Legend for Table 19, 20 and 21: The left column indicates the related row in Table 16. The numbers in each cell indicates which of the participating organizations satisfying the given combination of factors.

	A	B	C	D
1	1,2,3,4,5,6,7,8,10,12	1,4,6,7,11	1,2,3,4,5,6,8,10,11,12	2,5,7,8,9,10,11,12,13
2	1,2,3,4,5,6,7,8,10,12	1,4,6,7,11	1,2,3,4,5,6,8,10,11,12	1,3,4,6
3	1,2,3,4,5,6,7,8,10,12	1,4,6,7,11	7,9,13	2,5,7,8,9,10,11,12,13
4	1,2,3,4,5,6,7,8,10,12	1,4,6,7,11	7,9,13	1,3,4,6
5	1,2,3,4,5,6,7,8,10,12	2,3,5,8,9,10,12,13	1,2,3,4,5,6,8,10,11,12	2,5,7,8,9,10,11,12,13
6	1,2,3,4,5,6,7,8,10,12	2,3,5,8,9,10,12,13	1,2,3,4,5,6,8,10,11,12	1,3,4,6
7	1,2,3,4,5,6,7,8,10,12	2,3,5,8,9,10,12,13	7,9,13	2,5,7,8,9,10,11,12,13
8	1,2,3,4,5,6,7,8,10,12	2,3,5,8,9,10,12,13	7,9,13	1,3,4,6
9	9,11,13	1,4,6,7,11	1,2,3,4,5,6,8,10,11,12	2,5,7,8,9,10,11,12,13
10	9,11,13	1,4,6,7,11	1,2,3,4,5,6,8,10,11,12	1,3,4,6
11	9,11,13	1,4,6,7,11	7,9,13	2,5,7,8,9,10,11,12,13
12	9,11,13	1,4,6,7,11	7,9,13	1,3,4,6
13	9,11,13	2,3,5,8,9,10,12,13	1,2,3,4,5,6,8,10,11,12	2,5,7,8,9,10,11,12,13
14	9,11,13	2,3,5,8,9,10,12,13	1,2,3,4,5,6,8,10,11,12	1,3,4,6
15	9,11,13	2,3,5,8,9,10,12,13	7,9,13	2,5,7,8,9,10,11,12,13
16	9,11,13	2,3,5,8,9,10,12,13	7,9,13	1,3,4,6

Table 19: Organizations satisfying one factor

	AxB	AxC	AxD	BxC	BxD	CxD
1	1,4,6,7	1,2,3,4,5,6,8,10,12	2,5,7,8,10,12	1,4,6,11	7,11	2,5,8,10,11,12
2	1,4,6,7	1,2,3,4,5,6,8,10,12	1,3,4,6	1,4,6,11	4,6	1,3,4,6
3	1,4,6,7	7	2,5,7,8,10,12	7	7,11	7,9,13
4	1,4,6,7	7	1,3,4,6	7	4,6	
5	2,3,5,8,10,12	1,2,3,4,5,6,8,10,12	2,5,7,8,10,12	2,3,5,8,10,12	2,5,8,9,10,12,13	2,5,8,10,11,12
6	2,3,5,8,10,12	1,2,3,4,5,6,8,10,12	1,3,4,6	2,3,5,8,10,12	3	3,4,6
7	2,3,5,8,10,12	7	2,5,7,8,10,12	9,13	2,5,8,9,10,12,13	7,9,13
8	2,3,5,8,10,12	7	1,3,4,6	9,13	3	
9	11	11	9,11,13	1,4,6,11	7,11	2,5,8,10,11,12
10	11	11		1,4,6,11	4,6	3,4,6
11	11	9,13	9,11,13	7	7,11	7,9,13
12	11	9,13		7	4,6	
13	9,13	11	9,11,13	2,3,5,8,10,12	2,5,8,9,10,12,13	2,5,8,10,11,12
14	9,13	11		2,3,5,8,10,12	3	3,4,6
15	9,13	9,13	9,11,13	9,13	2,5,8,9,10,12,13	7,9,13
16	9,13	9,13		9,13	3	

Table 20: Organizations satisfying the combination of two factors

	AxBxCxD	AxBxC	AxBxD	AxCxD	BxCxD
1		1,4,6	7	2,5,8,10,12	11
2	1,4,6	1,4,6	1,4,6	1,3,4,6	1,4,6
3	7	7	7	7	7
4		7	1,4,6		
5	2,5,8,10,12	2,3,5,8,10,12	2,5,8,10,12	2,5,8,10,12	2,5,8,10,12
6	3	2,3,5,8,10,12	3	1,3,4,6	3
7			2,5,8,10,12	7	9,13
8			3		
9	11	11	11	11	11
10		11			1,4,6
11			11	9,13	7
12					
13			9,13	11	2,5,8,10,12
14					3
15	9,13	9,13	9,13	9,13	9,13
16		9,13			

Table 21: Organizations satisfying the combination of three and four factors

Statistical calculations conducted in Minitab:

Mean satisfaction and risk level for each group of organizations identified in Table 19, Table 20 and Table 21.

———————— ~A ————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	10	2,800	0,249	0,789	3,000
	1	3	4,667	0,333	0,577	5,000
Risk level	0	10	3,600	0,221	0,699	4,000
	1	3	4,00	1,00	1,73	5,00

———————— A ————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	3	4,667	0,333	0,577	5,000
	1	10	2,800	0,249	0,789	3,000
Risk level	0	3	4,00	1,00	1,73	5,00
	1	10	3,600	0,221	0,699	4,000

———————— ~B ————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	8	3,375	0,324	0,916	3,000
	1	5	3,000	0,632	1,414	3,000
Risk level	0	8	4,250	0,164	0,463	4,000
	1	5	2,800	0,374	0,837	3,000

———————— B ————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	5	3,000	0,632	1,414	3,000
	1	8	3,375	0,324	0,916	3,000
Risk level	0	5	2,800	0,374	0,837	3,000
	1	8	4,250	0,164	0,463	4,000

———————— ~C ————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	3	4,000	0,577	1,000	4,000
	1	10	3,000	0,333	1,054	3,000
Risk level	0	3	4,333	0,667	1,155	5,000
	1	10	3,500	0,269	0,850	4,000

———————— C ————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	10	3,000	0,333	1,054	3,000
	1	3	4,000	0,577	1,000	4,000
Risk level	0	10	3,500	0,269	0,850	4,000
	1	3	4,333	0,667	1,155	5,000

——————————— ~D ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	4	2,500	0,500	1,000	3,000
	1	9	3,556	0,338	1,014	3,000
Risk level	0	4	3,250	0,479	0,957	3,500
	1	9	3,889	0,309	0,928	4,000

——————————— D ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	9	3,556	0,338	1,014	3,000
	1	4	2,500	0,500	1,000	3,000
Risk level	0	9	3,889	0,309	0,928	4,000
	1	4	3,250	0,479	0,957	3,500

——————————— ~Ax~B ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	9	3,556	0,338	1,014	3,000
	1	4	2,500	0,500	1,000	3,000
Risk level	0	9	4,000	0,289	0,866	4,000
	1	4	3,000	0,408	0,816	3,000

——————————— ~AxB ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	7	3,429	0,528	1,397	3,000
	1	6	3,000	0,258	0,632	3,000
Risk level	0	7	3,429	0,481	1,272	3,000
	1	6	4,0000	0,000000000	0,000000000	4,0000

——————————— Ax~B ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	12	3,083	0,288	0,996	3,000
	1	1	5,0000	*	*	5,0000
Risk level	0	12	3,833	0,241	0,835	4,000
	1	1	2,0000	*	*	2,0000

——————————— AxB ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	11	3,000	0,302	1,000	3,000
	1	2	4,500	0,500	0,707	4,500
Risk level	0	11	3,455	0,247	0,820	4,000
	1	2	5,0000	0,000000000	0,000000000	5,0000

——————————— ~Ax~C ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	4	4,250	0,479	0,957	4,500
	1	9	2,778	0,278	0,833	3,000
Risk level	0	4	3,750	0,750	1,500	4,000
	1	9	3,667	0,236	0,707	4,000

——————————— ~AxC ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	12	3,250	0,329	1,138	3,000
	1	1	3,0000	*	*	3,0000
Risk level	0	12	3,750	0,279	0,965	4,000
	1	1	3,0000	*	*	3,0000

——————————— Ax~C ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	12	3,083	0,288	0,996	3,000
	1	1	5,0000	*	*	5,0000
Risk level	0	12	3,833	0,241	0,835	4,000
	1	1	2,0000	*	*	2,0000

——————————— AxC———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	11	3,000	0,302	1,000	3,000
	1	2	4,500	0,500	0,707	4,500
Risk level	0	11	3,455	0,247	0,820	4,000
	1	2	5,0000	0,000000000	0,000000000	5,0000

——————————— ~Ax~D ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	7	3,429	0,528	1,397	3,000
	1	6	3,000	0,258	0,632	3,000
Risk level	0	7	3,571	0,481	1,272	4,000
	1	6	3,833	0,167	0,408	4,000

——————————— ~AxD ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	9	3,556	0,338	1,014	3,000
	1	4	2,500	0,500	1,000	3,000
Risk level	0	9	3,889	0,309	0,928	4,000
	1	4	3,250	0,479	0,957	3,500

——————————— Ax~D ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	10	2,800	0,249	0,789	3,000
	1	3	4,667	0,333	0,577	5,000
Risk level	0	10	3,600	0,221	0,699	4,000
	1	3	4,00	1,00	1,73	5,00

——————————— ~Bx~C ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	9	3,333	0,289	0,866	3,000
	1	4	3,000	0,816	1,633	3,000
Risk level	0	9	4,111	0,200	0,601	4,000
	1	4	2,750	0,479	0,957	2,500

——————————— ~BxC ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	12	3,250	0,329	1,138	3,000
	1	1	3,0000	*	*	3,0000
Risk level	0	12	3,750	0,279	0,965	4,000
	1	1	3,0000	*	*	3,0000

——————————— Bx~C ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	7	3,429	0,528	1,397	3,000
	1	6	3,000	0,258	0,632	3,000
Risk level	0	7	3,429	0,481	1,272	3,000
	1	6	4,0000	0,000000000	0,000000000	4,0000

——————————— BxC ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	11	3,000	0,302	1,000	3,000
	1	2	4,500	0,500	0,707	4,500
Risk level	0	11	3,455	0,247	0,820	4,000
	1	2	5,0000	0,000000000	0,000000000	5,0000

——————————— ~Bx~D ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	11	3,091	0,315	1,044	3,000
	1	2	4,00	1,00	1,41	4,00
Risk level	0	11	3,909	0,251	0,831	4,000
	1	2	2,500	0,500	0,707	2,500

——————————— ~BxD ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	11	3,273	0,359	1,191	3,000
	1	2	3,0000	0,000000000	0,000000000	3,0000
Risk level	0	11	3,909	0,251	0,831	4,000
	1	2	2,500	0,500	0,707	2,500

——————————— Bx~D ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	6	3,000	0,516	1,265	3,000
	1	7	3,429	0,369	0,976	3,000
Risk level	0	6	3,000	0,365	0,894	3,000
	1	7	4,286	0,184	0,488	4,000

——————————— BxD ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	12	3,250	0,329	1,138	3,000
	1	1	3,0000	*	*	3,0000
Risk level	0	12	3,667	0,284	0,985	4,000
	1	1	4,0000	*	*	4,0000

——————————— ~Cx~D ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	7	3,143	0,459	1,215	3,000
	1	6	3,333	0,422	1,033	3,000
Risk level	0	7	3,714	0,421	1,113	4,000
	1	6	3,667	0,333	0,816	4,000

——————————— ~CxD ———————————

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	9	3,556	0,338	1,014	3,000
	1	4	2,500	0,500	1,000	3,000
Risk level	0	9	3,889	0,309	0,928	4,000
	1	4	3,250	0,479	0,957	3,500

Cx~D

Descriptive Statistics: Satisfaction level; Risk level

Variable	Include	Total Count	Mean	SE Mean	StDev	Median
Satisfaction lev	0	10	3,000	0,333	1,054	3,000
	1	3	4,000	0,577	1,000	4,000
Risk level	0	10	3,500	0,269	0,850	4,000
	1	3	4,333	0,667	1,155	5,000

Statistical tests conducted in Minitab

Mann-Whitney Test: Satisfaction level - orgs. with procurement procedure vs. orgs without procurement procedure

```
                                        N  Median
Satisfaction level without procedure   10   3,000
Satisfaction level with procedure       3   5,000


Point estimate for ETA1-ETA2 is -2,000
96,5 Percent CI for ETA1-ETA2 is (-3,000;-1,000)
W = 55,5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0090
The test is significant at 0,0049 (adjusted for ties)
```

Two-Sample T-Test: satisfaction level by procurement procedure

```
Include                                 N   Mean  StDev  SE Mean
Satisfaction level without procedure   10  2,800  0,789     0,25
Satisfaction level with procedure       3  4,667  0,577     0,33


Difference = mu (0) - mu (1)
Estimate for difference:  -1,86667
95% upper bound for difference:  -0,97911
T-Test of difference = 0 (vs <): T-Value = -4,48  P-Value = 0,005  DF = 4
```

Mann-Whitney Test: Satisfaction level – orgs. with procurement team vs. orgs. without procurement team

```
                  N  Median
Orgs with team    4   3,000
Orgs without team 9   3,000


Point estimate for ETA1-ETA2 is -1,000
96,3 Percent CI for ETA1-ETA2 is (-2,000;-0,000)
W = 19,0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0948
The test is significant at 0,0763 (adjusted for ties)
```

Two-Sample T-Test: Satisfaction level by procurement team

```
Include             N  Mean  StDev  SE Mean
Orgs without team   9  3,56   1,01     0,34
Orgs with team      4  2,50   1,00     0,50


Difference = mu (0) - mu (1)
Estimate for difference:  1,05556
95% upper bound for difference:  2,27161
T-Test of difference = 0 (vs <): T-Value = 1,75  P-Value = 0,930  DF = 5
```

Mann-Whitney Test: Satisfaction level – orgs. integrating risk management vs. orgs. not integrating risk management

```
Include                                          N  Median
Satisfaction level without risk integration     10   3,000
Satisfaction level with risk integration         3   4,000


Point estimate for ETA1-ETA2 is -1,000
96,5 Percent CI for ETA1-ETA2 is (-2,999;0,999)
W = 62,0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,1024
The test is significant at 0,0834 (adjusted for ties)
```

Two-Sample T-Test Satisfaction by risk integration

```
Include                                          N  Mean  StDev  SE Mean
Satisfaction level without risk integration     10  3,00   1,05     0,33
Satisfaction level with risk integration         3  4,00   1,00     0,58


Difference = mu (0) - mu (1)
Estimate for difference:  -1,00000
95% upper bound for difference:  0,56891
T-Test of difference = 0 (vs <): T-Value = -1,50  P-Value = 0,115  DF = 3

------------------------------------------------------------------------------
```

Mann-Whitney Test: Frequency of contract changes – orgs. with contract change clause vs. orgs. without clause

```
Include              N  Median
Orgs without clause  3   2,000
Orgs with clause     8   2,000


Point estimate for ETA1-ETA2 is 0,000
96,8 Percent CI for ETA1-ETA2 is (-2,000;1,000)
W = 16,0
Test of ETA1 = ETA2 vs ETA1 > ETA2


Cannot reject since W is < 18,0
```

Two-Sample T-Test Contract change by contract clause

```
Include             N   Mean  StDev  SE Mean
Orgs without clause 3   2,00   1,00     0,58
Orgs with clause    8   2,250  0,463    0,16


Difference = mu (0) - mu (1)
Estimate for difference:  -0,250000
95% upper bound for difference:  1,502281
T-Test of difference = 0 (vs <): T-Value = -0,42  P-Value = 0,359  DF = 2
------------------------------------------------------------------------------
```

Mann-Whitney Test: Risk level – orgs. with experienced procurers vs. inexperienced procurers

```
                                N  Median
Risk level unexperienced proc.  5   3,000
Risk level experienced proc.    8   4,000


Point estimate for ETA1-ETA2 is -1,500
95,2 Percent CI for ETA1-ETA2 is (-2,000;-1,000)
W = 18,0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0079
The test is significant at 0,0042 (adjusted for ties)
```

Regression Analysis: Risk level versus experience

```
The regression equation is
Risk level = 1,58 + 0,457 experience


Predictor            Coef  SE Coef     T      P
Constant           1,5828   0,6825  2,32  0,041
Experience         0,4571   0,1416  3,23  0,008


S = 0,709076   R-Sq = 48,6%   R-Sq(adj) = 44,0%


Analysis of Variance

Source          DF       SS      MS      F      P
Regression       1   5,2386  5,2386  10,42  0,008
Residual Error  11   5,5307  0,5028
Total           12  10,7692


Unusual Observations

Obs  Experience  Risk level   Fit  SE Fit  Residual  St Resid
 11       4,00    2,000     3,411   0,215    -1,411     -2,09R

R denotes an observation with a large standardized residual.
```

Mann-Whitney Test: Satisfaction level – orgs. factor combination Bx~C vs. BxC

```
                          N  Median
Satisfaction level Bx~C   6   3,000
Satisfaction level BxC    2   4,500


Point estimate for ETA1-ETA2 is -1,500
93,3 Percent CI for ETA1-ETA2 is (-3,000;0,000)
W = 21,5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0478
The test is significant at 0,0369 (adjusted for ties)
```

Mann-Whitney Test: Satisfaction level – orgs. factor ~C vs. C

```
         N  Median
Sat ~C  10   3,000
Sat C    3   4,000


Point estimate for ETA1-ETA2 is -1,000
96,5 Percent CI for ETA1-ETA2 is (-2,999;0,999)
W = 62,0
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,1024
The test is significant at 0,0834 (adjusted for ties)
```

Two-Sample T-Test: Satisfaction level – orgs. with procurement team vs. orgs. without procurement team

```
Two-sample T for Satisfaction level

Org                        N  Mean  StDev  SE Mean
Without procurement team   9  3,56   1,01     0,34
With procurement team      4  2,50   1,00     0,50


Difference = mu (0) - mu (1)
Estimate for difference:  1,05556
95% upper bound for difference:  2,27161
T-Test of difference = 0 (vs <): T-Value = 1,75  P-Value = 0,930  DF = 5
```

Regression Analysis: Risk level versus Satisfaction level

```
The regression equation is Risk = 3,71 - 0,005 Sat


Predictor                   Coef  SE Coef      T      P
Constant                  3,7097   0,8885   4,18  0,002
Satisfaction level       -0,0054   0,2616  -0,02  0,984


S = 0,989436   R-Sq = 0,0%   R-Sq(adj) = 0,0%


Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   0,0004  0,0004  0,00  0,984
Residual Error  11  10,7688  0,9790
Total           12  10,7692


Unusual Observations

Obs   Sat   Risk    Fit  SE Fit  Residual  St Resid
 11  5,00  2,000  3,683   0,538    -1,683     -2,03R

R denotes an observation with a large standardized residual.


Normplot of Residuals for Risk


Residuals vs Fits for Risk
```

One-way ANOVA: Risk level versus experience

```
Source              DF      SS     MS     F      P
Experience           4   7,569  1,892  4,73  0,030
Error                8   3,200  0,400
Total               12  10,769

S = 0,6325   R-Sq = 70,29%   R-Sq(adj) = 55,43%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level  N    Mean   StDev  -----+---------+---------+---------+----
2      1  3,0000       *          (-----------*-----------)
3      3  3,0000  1,0000              (------*------)
4      1  2,0000       *  (-----------*-----------)
5      3  4,0000  0,0000                       (------*------)
6      5  4,4000  0,5477                            (-----*----)
                          -----+---------+---------+---------+----
                             1,2       2,4       3,6       4,8

Pooled StDev = 0,6325


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of experience
```

```
Individual confidence level = 99,14%


Experience = 2 subtracted from:

Experience       Lower   Center   Upper
3              -2,5252   0,0000  2,5252
4              -4,0927  -1,0000  2,0927
5              -1,5252   1,0000  3,5252
6              -0,9956   1,4000  3,7956

Experience     ---------+---------+---------+---------+
3                      (---------*---------)
4                   (-----------*-----------)
5                         (---------*---------)
6                           (---------*--------)
               ---------+---------+---------+---------+
                     -2,5       0,0       2,5       5,0


Experience = 3 subtracted from:

Experience       Lower   Center   Upper
4              -3,5252  -1,0000  1,5252
5              -0,7856   1,0000  2,7856
6              -0,1971   1,4000  2,9971

Experience     ---------+---------+---------+---------+
4                   (---------*---------)
5                         (------*------)
6                           (------*-----)
               ---------+---------+---------+---------+
                     -2,5       0,0       2,5       5,0


Experience = 4 subtracted from:

Experience       Lower  Center   Upper
5              -0,5252  2,0000  4,5252
6               0,0044  2,4000  4,7956

Experience     ---------+---------+---------+---------+
5                        (---------*---------)
6                          (---------*--------)
               ---------+---------+---------+---------+
                     -2,5       0,0       2,5       5,0


Experience = 5 subtracted from:

Experience       Lower  Center   Upper
6              -1,1971  0,4000  1,9971

Experience     ---------+---------+---------+---------+
6                       (------*-----)
               ---------+---------+---------+---------+
                     -2,5       0,0       2,5       5,0
```

Kruskal-Wallis Test: Risk level versus Experience

```
Kruskal-Wallis Test on Risk level

                          Ave
Experience      N  Median  Rank      Z
2               1   3,000   3,5  -0,94
3               3   3,000   4,3  -1,35
4               1   2,000   1,5  -1,47
5               3   4,000   8,0   0,51
6               5   4,000   9,8   2,05
Overall        13           7,0

H = 6,99  DF = 4  P = 0,136
H = 8,34  DF = 4  P = 0,080  (adjusted for ties)

* NOTE * One or more small samples
```

Regression Analysis: Risk integration versus Experience

```
The regression equation is
Risk integation = 1,82 + 0,040 Experience



Predictor                        Coef  SE Coef     T      P
Constant                       1,8160   0,7085  2,56  0,026
Experience                     0,0399   0,1470  0,27  0,791


S = 0,736091   R-Sq = 0,7%   R-Sq(adj) = 0,0%


Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  0,0399  0,0399  0,07  0,791
Residual Error  11  5,9601  0,5418
Total           12  6,0000
```

Kruskal-Wallis Test: Satisfaction level versus experience

```
Kruskal-Wallis Test on Satisfaction level

Working experience     N  Median  Ave Rank      Z
2                      1   3,000       6,0  -0,27
3                      3   3,000       4,3  -1,35
4                      1   5,000      12,5   1,47
5                      3   3,000       4,7  -1,18
6                      5   4,000       9,1   1,54
Overall               13               7,0

H = 6,00  DF = 4  P = 0,199
H = 7,13  DF = 4  P = 0,129  (adjusted for ties)

* NOTE * One or more small samples
```

Mann-Whitney Test: Experienced Satisfation level vs Inexperienced Satisfaction level

```
                       N  Median
Experienced Sat.lev    8   3,000
Inexperienced Sat.lev  4   3,000


Point estimate for ETA1-ETA2 is -0,000
96,6 Percent CI for ETA1-ETA2 is (-2,000;2,001)
W = 54,5
Test of ETA1 = ETA2 vs ETA1 > ETA2 is significant at 0,3670
The test is significant at 0,3579 (adjusted for ties)
```

Mann-Whitney Test: Satisfaction level Bx~C vs. Satisfaction level BxC

```
                          N  Median
Bx~C Satisfaction level   6   3,000
BxC Satisfaction level    2   4,500


Point estimate for ETA1-ETA2 is -1,500
93,3 Percent CI for ETA1-ETA2 is (-3,000;0,000)
W = 21,5
Test of ETA1 = ETA2 vs ETA1 < ETA2 is significant at 0,0478
The test is significant at 0,0369 (adjusted for ties)
------------------------------------------------------------------------------
```