COPING WITH DECISIONS ON DEVIATIONS IN
COMPLEX PRODUCT DEVELOPMENT PROJECTS

Joakim Eriksson

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School of Innovation, Design and Engineering
COPING WITH DECISIONS ON DEVIATIONS IN COMPLEX PRODUCT DEVELOPMENT PROJECTS

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Akademisk avhandling

som för avläggande av teknologidoktorsexamen i innovation och design vid Akademin för innovation, design och teknik kommer att offentligen försvaras fredagen den 20 januari 2012, 10.00 i Raspen, Smedjegatan 37, Mälardalens högskola, Eskilstuna.

Fakultetsopponent: professor Niels Henrik Mortensen, Danmarks Tekniske Universitet, Institut for Planlægning, Innovation og Ledelse
Abstract

A strong need for resource efficiency within manufacturing companies have been driven extensively through pro-active planning and methods which have naturally resulted in an increased amount of strong couplings between product development projects, their activities, and resources. These strong couplings mean a high level of complexity where deviations are likely to occur on a regular basis which can spread quickly and have far reaching consequences. Praxis related to treatment of such deviations in product development projects has not been widely discussed. The subsequent question is therefore How are decisions on managing deviations made in practice?

A Practice approach has been adopted in this research and led on to the use of context sensitive research methods in order to collect relevant data. The main amount of data has been gathered through one year of participant observations and document retrieval in a product development project. Also, a large amount of interviews have been used as a method for collecting data.

38 deviations have been analysed through the identification of praxis which has been primarily analysed by three theories. The first theory, decision roles, has been used to clarify the different types of uncertainties people within complex product development projects need to manage in practice. The second theory, loosely coupled systems, shows how temporary organizing by loose couplings enables parallel management of both planned and unplanned activities when deviations occur. The third theory, Sensemaking, have been used to characterise processes related to different types of uncertainties.

Conclusions are drawn regarding how people acts related to deviations are directly dependent on the types of uncertainties of the context as well as the situation itself. Uncertainties regarding choices, responsibilities, mobilization, and legitimization combined with the temporary organization leads to certain praxis patterns. The patterns can be used by project managers and other decision makers as a way of discussing temporary organization and how process emerge within the organization today, and how they would like resulting processes to be managed when deviations occur.
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Thank you all!
I dedicate this thesis to my family, friends, and colleagues.

Thank you, for everything.
Coping with decisions on deviations in complex product development projects

Joakim Eriksson
Abstract
A strong need for resource efficiency within manufacturing companies has been driven extensively through proactive planning and methods which have naturally resulted in an increased amount of strong couplings between product development projects, their activities, and resources. These strong couplings mean a high level of complexity, where deviations are likely to occur on a regular basis. These deviations can spread quickly and have far reaching consequences. Praxis related to the treatment of such deviations in product development projects has not been widely discussed. Therefore, the subsequent question is:

How are decisions on managing deviations made in practice?

A practice approach has been adopted in this research and has led to the use of context sensitive research methods in order to collect relevant data. The main amount of data has been gathered during one year of participant observations and document retrieval in a product development project. Also, semi-structured interviews have been used as a method for collecting data. Thirty-eight deviations have been analysed through the identification of praxis, which has been analysed primarily through the application of three theories. The first theory, Decision Roles, has been used to clarify the different types of uncertainties people within complex product development projects need to manage in practice. The second theory, Loosely Coupled Systems, shows how temporary organising by loose couplings enables the parallel management of both planned and unplanned activities when deviations occur. The third theory, Sensemaking, has been used to analyse and characterise processes related to different types of uncertainties.

Conclusions are drawn regarding how people act related to deviations and are directly dependent on the types of uncertainties in the situation. Uncertainties regarding choices, responsibilities, mobilisation, and legitimisation, combined with the temporary organisation, lead to certain praxis patterns. The patterns can be used by project managers and other decision makers as a way of discussing temporary organisation and how processes emerge within the organisation today, and how they would like resulting processes to be managed when deviations occur.
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Sammanfattning (In Swedish)

Ett starkt behov av resurseffektivitet inom tillverkande företag har drivits i stor utsträckning genom proaktiv planering och metoder vilket naturligt resulterat i starka kopplingar mellan produktutvecklingsprojekt och dess aktiviteter samt resurser. Dessa starka kopplingar innebär en hög komplexitet där en avvikelse lätt kan uppstå, snabbt spridas och ha långtgående konsekvenser. Praktik vid hantering av sådana avvielser relativt förväntningar i produktutvecklingsprojekt har dock inte diskuterats i någon större utsträckning. Den följaktiga frågan är därför:

Hur fattas beslut om avvikelsehantering i projekt i praktiken?

En praktikansats har anammats i denna forskning och lett vidare till användning av kontextkänsliga metoder för insamling av data. Den största mängden data har samlats in genom ett års direkta observationer av ett teknikutvecklingsprojekt samt dokumentinsamling. Även en större mängd intervjuer har använts för att samla in data.

38 avvikelser har analyserats genom att praktik identifierats och analyserats primärt genom användning av tre teorier. Den första teorin, beslutsroller, har använts för att tydliggöra de olika osäkerheter som människor inom komplexa organisationer är i behov av att hantera i praktiken. Den andra teorin, löst kopplade system, visar på hur organisering i temporärt löst kopplade system möjliggör en parallell hantering av både planerade och oplanerade aktiviteter i projekt när avvikelser uppstår. Den tredje teorin, Sensemaking1, har använts för att analysera och karaktärisera processer som ett resultat relaterat till olika osäkerheter när avvikelser uppstår i projekt.

Slutsatser handlar om hur människors agerande vid avvikelser i projekt är direkt beroende av olika typer av osäkerheter. Osäkerheter kring frågeställningar, ansvar, mobilisering och legitimitet i kombination av den situerade organiseringen leder till uppkomsten av olika praktikmönster. De olika mönstren kan användas av projektledare och andra beslutsfattare kring projekt som ett sätt att diskutera hur dessa temporära organiseringar och processer uppkommer inom organisationen idag och hur man skulle vilja att resulterande processer skulle hanteras när avvikelser uppkommer.

1 Se teorikapitlet för beskrivning av teorier.
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1 Se teorikapitlet för beskrivning av teorier.
This thesis is based on the following papers, which are referred to in the text by their Roman numerals.


II. Eriksson, J., Brannemo, A. (2009) Decision-focused product development process improvements. International Conference on Engineering Design 2009, August 24 - 27, 2009, Palo Alto, CA, USA. Awarded the "Outstanding Paper Award" at the conference. The paper is based on data collected by Joakim Eriksson. The data was mostly analysed by Joakim Eriksson, with the support of Anette Brannemo. The paper was fully written by Joakim Eriksson.

III. Eriksson, J., Brannemo, A. (2011) Coping with deviation and decision-making. International Conference on Engineering Design 2011, August 15 - 18, 2011, Copenhagen, Denmark. The paper is based on data collected by Joakim Eriksson. The data was mostly analysed by Joakim Eriksson with the support of Anette Brannemo. The paper was fully written by Joakim Eriksson.
List of papers

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CHAPTER 1 - Introduction

In Chapter 1, an introduction and background to the research area and scope of the thesis is presented. First, the background of the research is described, followed by how this research responds to an academic problem which also has industrial relevance. Thereafter, the purpose and objective of the research are described, followed by a description of the stated research questions. Thereafter, the scope and delimitations of the research are described. Finally, the disposition of the remaining chapters is presented and the appended papers summarised.

It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.
-Charles Darwin

1.1 Background

The quote of Charles Darwin points to the fundamental importance of flexibility in order to survive in changing environments. A product development organisation is such an environment, and flexibility is paramount. The concept of flexibility in product development activities has been addressed in both large manufacturing industry and academia for many years. In this thesis, however, I address a flexibility less discussed. Popular forms of flexibility discussed by product development professionals and scholars are embodied in set-based concurrent engineering (Morgan and Liker, 2006), product modularisation (Persson and Ahlstrom, 2006, Shamsuzzoha, 2011, Umeda et al., 2008), as well as product platforms (product families) (Harlou, 2008, Jiao et al., 2007). These approaches have enabled the possibility to strategically standardise product architectures, make informed decisions about product configuration during product development, and offer the customer individualised products at the same time (i.e., mass customisation). This is not the flexibility I have studied. Rather, I will report on studies of the flexibility of the actors, aiming at following a process of developing products within a project. I will describe the flexibility displayed by people when confronted with deviations from the expected processes in product development projects and the flexibility created by actors trying to absorb project deviations.
People operating within large companies developing and manufacturing complex products can be characterised as coping with demanding market, regulatory, and financial requirements. This leads to large and fragmented project portfolios where an extensive amount of projects are executed in parallel. Research has shown how the increased necessity to continuously launch new products has resulted in challenges in managing project portfolios (Engwall and Jerbrant, 2003) and, in combination with complex product systems and the rapid pace, has demanded greater integration of organisations through cross-functional teams (McDonough, 2000). In this highly interrelated and strained project organisation environment, making effective and efficient decisions as prescribed by product development and project management literature is not a trivial thing to do in practice. Making decisions in this context is highly complex, experience-based, and context-dependent. People take into account the most pressing aspects at a certain moment in the project and its social environment and are forced to accept large uncertainties regarding a long range of prescribed downstream performance aspects in order to even be able to move forward in the process (Christiansen, 2009). A vast amount of performance aspects are important to balance when making trade-offs during decision-making, but there is rarely enough time in practice (March, 1994).

Much of the research which prescribes decision practices in product development is based on normative and rational models of decision-making and, in turn, excludes fundamental aspects of how decisions are made in practice. This conclusion has also been expressed by other researchers, such as Jupp et al. (2009, p. 1),

Decision-making is a multifaceted phenomenon. Yet in design, many models describing decision-making and approaches to decision support are based on simplistic process models and assumptions.

Despite an overwhelming amount of research on decision-making, with results that point to people’s inability to make fully rational choices, rationality is still the most prevailing and idealised point of view in product development research (Engwall, 2002, Hälgren, 2009a). In business, rational actions are encouraged to such an extent that actors within corporate organisational systems need to disguise certain decision-making processes as rational processes in order to gain an acceptance of reasoning and actions (Brunsson, 2006). This has led to product development research also adapting that same striving for rationality in order to satisfy industries’ stated needs for more rational behaviour. The thought of people as fully rational dominated research until the 1950s. Since then, scholars have published remarkable results showing that people indeed suffer from a large amount of natural barri-
ers to rational choices. The inability of our minds to handle the complexity of important decisions, our bias towards recent information, risk aversion, political factors, and our emotions are some factors that affect our decision-making behaviour (see for example Gigrenzer and Selten, 2002, Kahneman and Tversky, 1979, March, 1994). Despite all of these findings about the nature of our decision-making, we still aspire to make effective and efficient decisions using rational standards. This has been pointed out by others as well, Engwall (2002) and Hällgren (2009a), for example. The notion of rationality in decision-making influences the aims of product development research efforts in helping industry minimise resource spending and maximise output in activities by behaving more rationally. This notion, in turn, impacts our efforts to improve the way we conduct and support product development activities. Those efforts include, for example, design practice and methodologies, communication methods, and process models.

The practices prescribed by process methodologies, methods, and models within product development do play their part as points of references for people engaged in product development, as a way of planning and communicating responsibilities and resource allocation, for example. This is an important role in organising product development projects. The process methodologies, methods, and models help people identify common current situations and work out plans of activities and responsibilities. However, these supports for rational behaviour are concerned with planning proactive behaviour, not reactive behaviour. Reactive behaviour means that people react to situations which they had not anticipated or planned for, which interferes with their goals or preferences - “Fire fighting” (Repenning, 2001) for example.

Research on the role of situatedness in planning activities (e.g. Suchman, 1987) shows our limitations in the ability to anticipate desired actions. It also illuminates the fact that we generally do not anticipate alternative plans of actions until some course of action is already starting to be realised. By acting in a present situation, possibilities become clear. The emergent actions are interdependent on related activities and actions by other actors throughout the organisation, and are, to a large extent, social processes. The post hoc analyses we perform which make processes of actions seem rational tell more about the nature of the analysis itself than they do about the situated actions taken (Suchman, 1987). We rationalise our actions and decisions to make sense of the environment we act within.

People within product development organisations can also be characterised by their necessary and ambitious aim to manage projects within this complex project organisation environment. They do so by engaging in methodologies such as lean thinking, portfolio management (including resource management), project and product life cycle management, platform and product family management, concurrent engineering, and cross-functional
project teams, for example. The corporate competitive situation regarding launching new products on the market demands high performance ambitions in order for the companies to survive. Further, it puts great demands on the people responsible for developing these products. However, I agree with Smith (2007), who states that best practice in product development is mostly based on improving processes by planning pro-active activities. The prevalent notion in industry is that projects should be planned and that plan followed, despite the numerous industrial and scientific reports that deviation from the plan is a natural part of product development projects. So the subsequent question becomes If the management of a system is built on the notion that project activities should go according to plans and resources optimised accordingly, how do people cope when deviations occur? It is precisely this general kind of flexibility I have explored.

1.2 Academic problem and industrial relevance

Companies’ efforts to maximise output with a minimum of resources demand a great deal of those companies. They experience difficulty in managing higher organisational complexity regarding activities and resources in projects due to shorter lead time, an increased number of stakeholders in the processes, an increased amount of parallel processes, and an increased need for technical advancement. This interrelated and strained environment can be characterised as a complex tightly coupled system. As a result, there is a high probability that unexpected events will occur which have rapid and far reaching consequences for project scope, time, and cost. Indeed, the correlation between tightly coupled systems and deviations has been widely acknowledged since Perrow (1984) published Normal Accident Theory (NAT) in 1984. In it, Perrow states that no matter what organisations do to prevent deviations, they are inevitable in complex tightly coupled systems. Other researchers have published results pointing to specific strategies used by organisations to achieve greater safety (reliability) in tightly coupled systems. These High Reliability Organisations (HRO) achieve reliability through flexibility and the ability to migrate decisions within the organisation depending on contextual factors (Roberts et al., 1994). Strategies of redundancy, decentralised decision-making, centralised decision premises, and conceptual slack (diverging concurrent theories of the same system) are used to ensure the identification of decision situations, the root cause of the situation, and that necessary actions are taken. HROs are organisations where failure is not considered an option (e.g., nuclear facilities or aircraft carriers). They have an extremely low tolerance for risks, which differs from the kind of organisations under study in this research. Nonetheless, the phenomenon of deviations in tightly coupled systems is still the same. If a de-
violation occurs, and no flexibility is built into the system, there are no plans or dedicated resources allocated. Instead, they need to be created (i.e., flexibility is created). I have chosen to illustrate the mechanism of the overall phenomenon of deviations in a product development context as in Figure 1.

![Diagram](https://via.placeholder.com/150)

**Figure 1.** A balancing loop of margins within a complex organisational system.

The left loop is driven by the organisation’s motivation to create predictability, exact planning, and precision in execution by eliminating unnecessary efforts and misused resources (waste) and creating a lean system (Morgan and Liker, 2006a. By doing so, they decrease system margins for deviations. "The right product needs to be developed in the right way” is the idealised thought in the organisation. The decrease of system margins leads to an increase of tight couplings (interdependencies) regarding timing, deliveries, and the responsibility of activities, as well as project organisation resources. An increase in interdependencies makes the system complex, and no single person in the organisation possesses the knowledge of the entire development organisational system; it has to be divided between individuals or groups of people. The division of the system between individuals or groups makes systems dynamics difficult to grasp (complex), and deviations will occur. In this research, deviations in projects are defined as project deviations. Deviations, which can be experienced as both opportunities and problems for people in projects, are symptoms of complex systems. Deviations are managed by loosening the situation from normal operations, thus creating temporary loose margins (a loosely coupled system, which enables flexibility of resources, attention, and action).

The academic problem is that although the phenomenon of deviations in tightly coupled systems has been known for a long time, studies from a mi-
cro-perspective, where the relationship between action and context are considered important, have just started to emerge within research on complex product development. These types of micro-perspective studies have strong roots in social science and have spread to research on strategy (see e.g. Johnson et al., 2003) and from there to project management (see e.g. Hällgren and Söderlund, 2011) where the approach is called project-as-practice. In this research, the challenge is to introduce this approach into research on complex product development within large manufacturing companies and to analyse the findings from three different theoretical perspectives in order to reveal how decisions on managing deviations are made in practice. The academic challenge is also to describe decision-making processes as resulting from emergent praxes, instead of looking at processes as something given and static. Such a perspective was identified as early on as 1969 by Weick (1969) as a productive way of studying processes.

Finally, the industrial relevance of this research comes from creating new knowledge related to finding a balance between control for precision and system margins in order to create an organisation which has the capabilities to proactively work to minimise deviations as well as manage the deviations that still do occur. The issue of process flexibility has been discussed and worked on in industry for a long time from various perspectives and by different methods. Nonetheless, the issue remains problematic to manage. I have addressed this issue from the perspective of building in-depth knowledge of how people create process flexibility in complex organisational systems with low margins when managing deviations. I will describe the way decisions regarding managing deviations are made in tightly coupled project environments. Ultimately, this research aims to contribute to that immense task of creating flexibility where there supposedly is none.

1.3 The purpose and objective of the research

As described in the previous sections, striving for rational and precisely executed processes leads to decreased system margins and an increase of system interdependencies, which in turn leads to an increase in complexity and deviations.

Therefore, the academic purpose of this research is to contribute to knowledge regarding how project managers manage change in complex product development projects.

In this research, the design, characteristics, and resulting knowledge gained from decision processes when managing deviations in practice are in focus in order to provide a rich description of the nature of reactive decision-making in product development projects. When contrasted against the as-
sumptions often underlying prescriptive decision methodologies, methods, and models, it provides a basis for discussing the need for organisational strategies supporting decision-making on deviations in tightly coupled organisational systems in practice.

The academic objective is to analyse and describe how decisions are made on managing deviations in complex product development projects in practice.

The objective is stated in order to place focus on peoples’ practices of making decisions and requires describing the following: praxes (acts) of people, the role these praxes play in practice related to decision-making, the resulting decision processes of peoples’ praxes, and, finally, what characterises the processes of making decisions on managing deviations. More specifically, the intent was to analyse and describe the nature of the practice of making decisions on managing deviations in projects from three theoretical perspectives: Brunsson’s four decision roles, strategies from Orton and Weick’s loosely coupled systems theory (Orton and Weick, 1990), and emergent decision processes from Maitlis’ sensegiving and sensemaking theory (Maitlis, 2005).

The developed in-depth knowledge of the current practices of managing deviations in practice can be used in order to provide a theoretical basis for future studies on reactive decision-making in product development project organisations. The relevance lies in creating in-depth knowledge of the current practices of managing deviations in practice in order to provide realistic and reliable assumptions underlying future decision methodologies, methods, and models. The relevance is also about providing a basis for discussing the need for organisational strategies for managing deviations in complex product development projects.

While most research on decision-making in product development project environments aims at prescribing practices, I want to, instead, give detailed descriptions of emergent situated decision process designs, characteristics, and the resulting knowledge of people when deviations occur in projects which cannot be anticipated and planned for in advance. I am inspired by Suchman's (1987, p. 50) words:

Rather than attempting to abstract action away from its circumstances and represent it as a rational plan, the approach is to study how people use their circumstances to achieve intelligent action.

I wanted to create new knowledge regarding how people actually make decisions on managing deviations in the context of the complex project environments that these decisions are situated within.
1.4 Research questions

In this research, three specific questions have been specified to study and answer, in order to create relevant knowledge related to the research purpose and objective discussed in previous sections. To clarify the objective, the following three questions were stated:

(RQ1) *What roles do decisions play in practice when managing deviations?*

Since decision-making is viewed as an emergent process in this research, where procedure and content determine the decision result, the first question was posed to enable the investigation of what the processes consist of on a micro-level. This was done in order to identify the “building blocks” of decision processes, the praxes and the purposes of the praxes' actors.

(RQ2) *What types of decision strategies are used in practice when managing deviations?*

The second research question was posed in order to investigate the design of decision processes and to compare the results with the rational ideal which is often prescribed in product development management literature.

(RQ3) *What characterises the decision processes when managing deviations in practice?*

Finally, the third research question was posed in order to investigate the characteristics of decision-making when managing deviations. Since decision processes are viewed in this research as being emergent, a result of both content and context, and not following a given process, the ability to control processes, interactions, and the resulting conditions was investigated.

1.5 Scope and delimitations of the research

In order to be able to answer the research questions in this research, it was important to use an approach suitable for the studied phenomenon and suitable methods for collecting data with a focus on the actors’ actions and the circumstances surrounding those actions. Therefore, this research focuses on the project managers’ practice and praxis to a large extent. It also includes interaction with actors in multiple functions and on several levels in the organisation, in order to make sense of the project managers’ actions.

The research does not focus on how well development teams comply with given processes (planned development processes). Instead, the project managers in this research are regarded as highly skilled individuals by their or-
ganisations and were therefore selected. When a deviation occurs, the practices of these skilled project managers result in emergent processes in the projects. It is these processes, this research aims to create new knowledge about, describe, and discuss. The scope of the research is only to create knowledge about the characteristics of current practices of making decisions on managing deviations and not to prescribe practices.

In this research, the focus is on the operational organisational level of the development project (i.e., the team including the project managers). In addition, the interactions with steering committees and other stakeholders are of great importance in order to gain knowledge about actions and purposes.

The product development project life cycle of interest in this research spans from when a project is started until the start of production. This process can be described in different ways, which has been of great interest within product development research (for example Cooper, 1993, Ottosson, 2004, Pahl and Beitz, 1977, Ullman, 2002, Ulrich and Eppinger, 1995). Wheelwright and Clark give an overall detailed and schematically representative description of the process as seen in this research (see Figure 2). The choices to initiate projects, on the other hand, often called product planning, are out of the scope of this research.

**Typical Phases of Product Development**

<table>
<thead>
<tr>
<th>PHASE</th>
<th>Project begins</th>
<th>Months Before Market Introduction</th>
<th>Market introduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept Development</td>
<td>36</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>Product Planning</td>
<td>18</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Product/Process Engineering</td>
<td>18</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Pilot Production/Ramp-Up</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* This development process assumes a thirty-six-month cycle time and four primary phases. Vertical arrows indicate major events; horizontal lines indicate the duration of the activities.

*Figure 2. Generic phases of the development process (Wheelwright and Clark, 1992, p. 7)*
The delimitations regarding the type of companies in this research are limited to one mid-size and seven large international manufacturing companies. The type of technology systems developed by the companies in this research is complex large mechatronic systems. However, results may be applicable to other industrial areas as well.

The scope and research questions necessitated using a longitudinal participant observation method, which (for practical reasons) meant doing observations in Sweden. In other words, no data was collected outside Sweden. This, in turn, meant that no consideration was taken to cultural differences regarding decision-making, and results were only validated in mainly Swedish organisations. However, most data collections involved investigating or observing interactions between international teams where some of the cultural aspects were identified. That notwithstanding, they are not a focus of this research. The same applies to gender, where no consideration was taken during the analysis of data. However, during the collections of data, it appeared that women were a minority within the observed activities.

1.6 Disposition of the thesis

This thesis is structured according to seven main chapters, Introduction, Previous Research, Method, Theory, Case Study A, Case study B, and finally, Discussion and conclusions.

The introduction presents the background of the research, the academic and industrial challenges responded to, the purpose of the research, research questions, and the scope and delimitations of the research. Previous research is described in order to present the research this study in turn is based on and aims to build on and contribute to. The chapter on methods presents the methods used in this research to collect and analyse data. The theory chapter describes the theories chosen in this research to analyse data. The case study chapters (5 and 6) describe the case companies and presents collected data, analysis, and the results. Finally, the discussion on results and conclusions drawn from the results are presented.

1.7 Summary of appended papers

Paper I


Uncertainty is a part of the product development project’s nature, where problems often can be considered ill-structured, explorative and pragmatic. It
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1.7 Summary of appended papers

Paper I

Uncertainty is a part of the product development project's nature, where problems often can be considered ill-structured, explorative and pragmatic. It is the project manager's responsibility to manage this uncertainty in a complex, ever-changing project environment. The purpose of this paper was to report on the current literature regarding decision-making within the area of engineering design methodology and project management, as well as practices in a manufacturing company, in order to characterise this uncertain environment when changes occur.

We investigated decision-making practices and identified the nature of shared understanding, decision processes, shared responsibility, and decision-making behaviour. The literature review shows how most uncertainties are related to the consequences of choice, the context, the concurrent execution of project tasks in multiple organisational department, and organisational learning.

By identifying characteristics of decision-making processes when managing changes in complex product development projects, we propose a mindset for the clarification of decision situations when a change has occurred. Two models of such a mindset are presented. In them, input-output and important elements of consideration when a project change has occurred are illustrated. The proposed mindset is supposed to aid project managers when handling project changes by reducing complexity in project planning and supporting the articulation of uncertainties.

Paper II

The objective of this paper was to investigate what elements characterise an integrated (shared by many stakeholders) decision-making process and environment. In order to support reasoning regarding product development process improvements, it is important to develop knowledge concerning how the integrated decision-making process can be viewed holistically and include its relationship to performance aspects.

This paper investigates these characteristics through a literature review and a case study at a large Swedish manufacturing company. By identifying what decision-making aspects are considered important within prescriptive decision-making literature, as well as in product development governance, we can report on what is considered to characterise a “decision-making system” in a complex product development environment. A rich picture was developed in order to clarify the relationship between fundamental decision-making aspects, performance, the process levels, and the product development organization. By comparing this decision-making system model with empirical findings, the aspects which most characterise a decision-making situation could be generalised. The results show the important elements to be
considered when aiming to manage decision-making in a complex product development project.

Paper III
Eriksson, J., and Brannemo, A. (2011), *Coping with deviation and decision-making*.

Structured models, such as gated models, are used in order to manage complex projects. The aim in following these prescriptive models in turn creates strong interdependencies between activities in the projects. The project system becomes sensitive to deviations that can influence the system. When managing a project in a highly-interrelated project environment, it is not possible to anticipate every possible external influence on the project. Deviations from the planned operations are inevitable. Nonetheless, teams rarely receive credit for the skilled way in which they manage to cope with these unexpected events.

The research in this paper investigates how decisions are made in practice regarding managing these deviations. A project-as-practice approach has been used to study praxes on a micro-level in a project and to capture contextual circumstances.

Results show how these praxes correspond to four different roles of decisions and reveal the decision strategy used to manage the deviation. The characteristics of the decision-making process are described using the garbage can model in order to highlight distinctive features of decision-making regarding managing deviations.

Paper IV

A product development project organisation could be considered as an open system, sensitive to unexpected events that might influence the system. When managing a project in a highly-interrelated project environment, it is not possible to anticipate every potential external influence on the project. Increased complexity and limited buffers in the project system inevitably lead to deviations from planned operations. Deviations are unexpected events that need attention from the project team since they interfere with targets, scope, cost or time.

The project-as-practice approach has been used in this research to capture the situated praxis of the actors, aiming to contextualise, and in this case, observe actors’ praxes of managing deviations in relation to decision mak-
An analysis of the collected data shows how deviations generally are managed by six major categories of decoupling decision strategies: rational, irrational, mixed rational, mixed irrational, rational to irrational, and irrational to rational. Finally, deviating situations demand consideration of not only technical, financial, market, and schedule uncertainty, but also organisational, social, and political uncertainties.

**Paper V**


The aim of this paper is to present the results from a case study aimed at answering the question: *How are decisions regarding managing deviations in a highly interrelated project made in practice?* The results are based on an analysis of a single case study of a complex system development project, interrelated with eight other projects. It reveals the development team’s efforts to make sense of, and decisions made regarding, deviating situations. The analysis reveals the characteristics of the sensemaking processes related to the roles of the decisions. This research contributes enhanced knowledge of how project managers cope with deviation in order to reach informed decisions involving four different types of sensemaking and four types of decision roles. The results of this research can be used by project managers or other decision makers within product development to reflect upon how to manage unexpected deviations, proactively as well as reactively.

**Paper VI**


This paper presents the results of a case study aimed at investigating how decisions are made on managing deviations in complex product development projects. The results are based on the analysis of data collected from participant observations, as well as interviews with project managers from six additional large manufacturing companies. The data is analysed according to four types of sensemaking processes. This research examines why these processes are used in different situations and further explores their characteristics and their relationship with the different roles decisions play in organisations. The factors driving controlled and uncontrolled sensemaking are also examined. This research contributes to knowledge regarding how project managers use different praxes to manage deviations in complex, socially and politically sensitive environments.
CHAPTER 2 – Previous Research

In Chapter 2, an overview of related research areas to this conducted research is presented and discussed. In this chapter, an attempt is made to give the reader a sense of the related research which has been taken into account when conducting this research. The chapter will start by describing theory and studies regarding the overall characteristics and properties of the type of development processes studied. Thereafter, theory and studies related to the planning activities often carried out in order to set up development projects in industrial settings are described. Further, theories and studies carried out to investigate the phenomenon of deviations in tightly coupled systems are presented. Finally, theory and studies on organisational decision-making and related decision-making approaches conclude the chapter.

2.1 Innovation and Design

This conducted research lies within the research subject of Innovation and Design at Mälardalen University and, specifically, the research conducted on product development process governance. It involves research on how product development processes should be governed in order to achieve high performance in product development.

In this research, I have drawn from the external research areas of Decision Sciences in order to be able to investigate how decisions are made in complex environments in practice. Specifically, I have focused on descriptive theories of decision-making in complex environments (see, for example, (Gigerenzer and Selten, 2002, Kahneman and Tversky, 1979, Klein, 2008, March, 1994, Simon, 1997, Simon, 1959).

By combining the theories within the two main research areas, I was able to study the phenomenon of managing deviations from a practice perspective (Hällgren and Söderlund, 2011) with the intent to create knowledge useful for understanding the reactive aspect of product development process governance in a project context. By doing so, I aim to contribute to research such as that of Weick and Sutcliffe (2001), Engwall and Svensson (2004), Söderholm (2008) and Hällgren (2009b), for example.
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2.2 Studies on product development processes

Models of product development processes such as those by Pahl and Beitz (1977) and Ulrich and Eppinger (1995) are common models for planning product development projects in large manufacturing industry companies. These stage and activity-based models are often used in practice to plan project stages and to define the needed activities in order to develop certain types of knowledge within each stage along the process. These process models also prescribe how different organisational functions should be integrated in the product development process, as prescribed by Andreasen and Hein (1987), for example. Over time, the amount of aspects included in these types of planned process models have grown intensely to include change management, quality management, and risk management activities, to name a few. I regard these process plans as representing the organisation’s and the project team’s initial expectations of the project’s future activities and deliveries. The studies conducted in cooperation with the eight companies reported on in this thesis all use this kind of detailed process plan. Therefore, I consider the theories on process models to be relevant for this research in order to understand when plans and expectations are violated and deviations occur.

In product development literature as well as in industry’s planning activities, these process models are often prescriptions of rational processes and often result in gated processes and checklists, for example. A great deal of research on product development process governance is preoccupied with prescriptive, or synaptic, studies on process control and evaluation. However, even if product development project processes can be prescribed on a detailed level, according to, for instance, Cooper’s (1993) stage-gate model (see Figure 3), it does not reveal how plans are executed or revised, nor how corrective actions are carried out in practice, including managing deviations. The actual process is not possible to prescribe in detail. However, if events or actions are studied in detail, underlying processes are made visible, enabling detailed studies of managing deviations in practice.

Figure 3. The Stage-Gate Model (Cooper, 1993, p. 130).
Studies on product development processes

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Figure 3. The Stage-Gate Model (Cooper, 1993, p. 130).

There exists a large amount of descriptive studies on product development processes. However, these studies are often based on the same structural components as the process models (phases, activities, methods) and often aim at producing prescriptive decision support in the end. This is a noble, and in some cases a successful, approach in order to support industry with useful methods. However, the methods aimed at preventing deviations and their impact on the execution of plans in projects often paradoxically add interrelations, couplings, and complexity in project environments, in turn increasing the amount of experienced deviations in projects (Hällgren, 2009a). The lack of understanding in industry and academia of the nature of organising the unexpected presents both challenges regarding managing product development projects and a great opportunity for further research.

2.3 Studies on project planning and deviation

I have found a gap in research on product development process governance where research on decision processes is often viewed as an entity which can be mapped out and improved on in order to produce better results and outcomes. The notion in much of product development literature is that if we consider all relevant performance aspects throughout the project and product life cycle, we can control the outcome of performance aspects. In addition, these outcomes are often thought to be improved by planned actions according to certain methodologies or methods (for instance, Lean Product Development (Kennedy, 2003, Mascitelli, 2007, Morgan, 2002), Concurrent Engineering (Prasad et al., 1998), Systems Engineering (ISO/IEC, 2002), Project Management (PMI, 2008), Critical Chain Concept (Rand, 2000) or Enterprise Resource Planning (cross-functional resource management) (Umblea et al., 2003). These results from research on how to plan and improve performance in product development projects are based on structural and processual studies (Synoptic accounts) (as described by Tsoukas and Chia, 2002, Hällgren, 2009a). Synoptic accounts mean that organisational change processes can be understood by identifying and describing structural components of processes, e.g. phases, tasks, activities, and principles. However, these types of process studies neglect the significance of individual activities and contextual factors on organising, which studies on micro-activities and organising do account for (Performative studies) (as described by Tsoukas and Chia, 2002, Hällgren, 2009a). Synoptic accounts view processes as entities, while Performative accounts view them as emergent flux (Van de Ven and Poole, 2005). In practice, the theoretical process models, derived from synoptic accounts, are used to organise emergent, context dependent processes. Why? I regard the industry's objective of planning product development processes according to these models as obtaining the best possible ini-
tial position from which the project organisation can exercise their skills on which the success of the project depends. The question is how do actors organise project activities when these process models no longer provide detailed guidance? This research is therefore related to the research areas of performative process studies, as well as descriptive organisational decision-making studies.

Product development processes can also be described as change processes. An increasingly used form of organising these processes is in the form of project organisations. Success factors and best practice are investigated to optimise the structure, processes, and prescribed methods. In research on the project form of organising product development, the same approach has been used. For example, in the industry standard for managing projects, the PMBOK (PMI, 2004), processes and methods are prescribed to manage different aspects of the project. These synoptic accounts of product development projects are important in order to understand the overall phenomenon of change. However, as described earlier, they have limitations as to which level of detailed knowledge they provide in practice. Since this conducted research aims only to describe decision-making processes, I have not used this type of prescriptive model to evaluate how well actors adhere to these, for example.

On a more detailed level, research within Engineering Design does, in some cases, present descriptions of design processes as a series of steps, leaps, loops, or meta-processes (for example Badke-Schaub and Gehrlicher, 2003) resulting in tentative decisions (for example López-Mesa and Chakrabarti, 2007, Hansen and Andreasen, 2004). These results have given insights into how design choices are made within design processes. Most studies have been carried out in lab experiments with students, or in short observations of a few design activities, and do not reveal the influence of contextual circumstances. Nonetheless, the descriptions of processes, revealing that tentative decisions play a crucial part as emergent entities in processes, are used in this research. For example, Lopez-Meza and Chakrabarti’s (2007) model of tentative decisions can be compared to sensemaking processes, a type of alternative decision-making model in organisational research developed by Weick (1969). I relate the focus of my studies to these theories since they are practice related.

Sensemaking theory describes how, while actors try to make sense of their environment and act logically in their organisation, they organise their world by acting according to agreed upon constructs and in turn change the organisational environment. “Organisation is the attempt to order the intrinsic flux of human action, to channel it towards certain ends by generalising and institutionalising particular cognitive representations” (Tsoukas and Chia, 2002). At the same time, “organisation is a pattern that is constituted,

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2 See description of Sensemaking theories in the Theory chapter.
shaped, and emerging from change” (Tsoukas and Chia, 2002). Weick (1993) calls it enactment, which is a part of sensemaking processes where social interactions are key. I regard experienced actors within organisations as the most valuable assets in organising emergent processes and that these actors’ cognitive maps play a crucial role in these activities. In this view of organisational decision-making and change, research needs to be focused on micro-activities as well as social and contextual circumstances in order to create new knowledge. In this type of approach to change process studies, a practice approach3 (Jarzabkowski and Paul Spee, 2009, Whittington, 2007) has been used. In it, planned processes were not noted in favour of emergent actions resulting from a wide range of individual, social, contextual, and process related factors. The practice approach has spread from social sciences to research on strategy, and further to project management research. Research on project organising with a practice approach is called project-as-practice (Hällgren and Söderlund, 2011).

Few studies have been made regarding managing deviations in product development projects with a practice approach. However, I consider the findings from Söderholm (2008) and Hällgren (2009a) to be the dominating authors within the research area. Söderholm (2008) for example, identified four practices of dealing with deviations in projects. They are the following:

- innovative action,
- applying detachment strategies,
- setting up intensive meeting schedules,
- and negotiating project conditions

With “innovative action”, Söderholm (ibid) means that project managers creatively design sequences of action to deal with unexpected changes, including re-allocating resources and planned activities. “Innovative action is problem solving on-site and short term” (Söderholm, 2008, p. 84). I want to build on this theory and to describe in detail these innovative (or skilful) actions. “Detachment strategies” mean that project managers isolate the consequences of adjusting actions as much as possible in order to minimise consequences on other parts of the project system. An “Intensive meeting schedule” is used by project managers to closely monitor problematic episodes in the project in order to assure “continuous information flow and commitment-building between team members working on the problem” (Söderholm, 2008, p. 85). “Negotiation project conditions” are when project managers negotiate with other project managers, functional departments, steering committees, or other stakeholders to have more resources assigned to the project or to change some of the deliverables (time, functionality, etc.), as well as “to ensure project status” (Söderholm, 2008, p. 85). I consid-

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3 See description in the method chapter for the practice approach used in this research.
er these results to be an initial foundation for conducting in-depth studies on managing deviations in practice. Further, they have inspired this conducted research to dig deeper into practices and to find links to a decision-making view on managing deviations in practice.

In another closely related example, Hällgren (2009a) investigated detachment strategies of project managers when managing project deviations in practice. Eight practice patterns were found to be used by project managers to detach deviating situations from planned operations. They are the following:

- identify and get to know the boundaries,
- interpret the goal in an advantageous way,
- mobilisation of network,
- displacement of responsibility,
- concentration of organising,
- acceptance of responsibility,
- situated use of resources,
- and creation and maintenance of space for actions

These practice patterns were used to identify the nature of the deviation and circumstances (becoming distinctive), as well as enabling actions to be taken (becoming responsive) in the tightly coupled project systems. (Hällgren, 2009b) The research of Hällgren (ibid) also identified twenty-eight praxes used by project managers to manage deviations. Even though these findings were found in power plant construction projects, the identified praxes were used as a preliminary template for observations and analysis in this research. That was because I wanted to investigate if these were suitable for observing and analysing the context studied in this research as well.

In these studies based on the project-as-practice approach, episodes are viewed as to include the intertwined constructions of praxis, practice, profession, and actor which are described in detail in the theory chapter of this thesis.

2.4 Decision-making in organisations

I do not regard decision-making in product development to be only about the choice of product design and manufacturing processes related to technical and financial aspects. Rather, it is an overall organisational decision-making process. A range of research areas deal with decision-making in organisational settings. In this conducted research, parts of the results from descriptive decision sciences which draw upon theories from, for instance, Psychology, Sociology, and Political Science are built upon.
During the 1950’s, research on organisational decision behaviour was focused on both producing sophisticated mathematical models and on social sciences, which had been an inactive area in decision sciences earlier. Barnard (1968), March (1994), Simon (1959), and Mintzberg (1976) established the research area of managerial decision-making in organisations, which looks into risk and organisational behaviour. Even though results from the research area have been used to improve decision processes for actors in organisations, the aim of the research area is not to obtain results that enable perfect rationalism. Results instead show how we as human beings have limitations regarding contextual and psychological aspects that constrain us from making optimal choices. March (ibid) and Simon (ibid) calls these circumstances Bounded rationality.

March (1994) describes the human limitations of attention, memory, comprehension, and communication. Further, time is a limited resource and constitutes a constraint on the search and attention to information related to the identification and retrieval during decision-making. In product development project organisations, information stored by one stakeholder is often not easily retrieved by another stakeholder. Other researchers argue that with the constraints of limited time and knowledge in decision-making, it is more effective and efficient to use simple heuristics, including tentativeness and delay (Gigerenzer and Selten, 2002). In this research, bounded rationality is considered part of the fundamentals of human decision-making and no attempt is made to overcome that fact.

Further, research on decision-making in product development often assumes that the purposes of decisions and main results are choices. This has been criticised by Brunsson (2007). Brunsson (ibid) argues that the general notion of the equivalence between decision and choice is based on a series of false assumptions. The decision maker is assumed to be searching for the best alternative of action, and uncertainty then relates to alternatives. As described earlier, we as human beings possesses limitations which constrain us from finding the best alternative in practice; what is more, even if normative mathematical models exist for making the best alternative that acknowledges the constraints, they do not always provide support in practice. Decisions may forego the recognition of preferences or consequences when we decide to find out the consequences of an alternative (a trial and error approach) (Brunsson, 2007). Further, in order to enable action in organisations with multiple stakeholders involved, it is important to build in the commitment to the decision from involved actors during the process (Hammond et al., 2002). This influences the resulting design of decision processes. Uncertainty in terms of commitment is treated rather than alternatives. Brunsson (ibid) shows how different types of uncertainties can be related to the role decisions play in processes, and this is described in greater length in the Theory chapter in this thesis. I regard Brunsson’s theory that a decision may
play different roles in an organisation to be productive in describing the different types of uncertainties that actors within product development activities cope with on a daily basis. I have therefore used Brunsson’s suggestion of four different decision roles in organisations in order to analyse what role micro-decisions play in the 38 overall decision-making episodes identified in the conducted studies described in the case study chapters of this thesis.

2.5 Decision-making approaches

In order to choose appropriate theoretical foundations for analysing and describing observed decision-making approaches, I spent most of the first two years of the conducted research searching and reviewing decision-making literature, including numerous decision approaches within organisational as well as product development literature. I grouped these approaches in three categories: (1) Normative (2) Descriptive, and (3) Prescriptive. This exact categorisation has been made earlier by other scholars as well (for example Bell et al., 1988), and is sometimes called schools of decision-making.

First, normative decision approaches are theories on how an optimal decision can be calculated in theory. I have made no attempt to contribute to this specific field of research, and do not consider these approaches to be useful in describing decision-making on a micro-level in practice.

Secondly, descriptive decision-making approaches, on the other hand, are theories addressing how decisions are made in practice, within different contexts. This area of research is often divided into two types of studies of thinking processes: System One and System Two. System One is an automatic and heuristic-based system of rapid cognition which has been popularised as blink by Gladwell (2007) in his book Blink. Heuristics are studies of the effective and fast shortcuts our minds take when making decisions. The studies of System One also include the downside of using heuristics - the many types of biases we as humans suffer from when making decisions (pioneered by Kahneman and Tversky, 1979, for example). System Two is a slow, effortful, and conscious system. System Two can override System One if time allows for it and the actor is convinced that the provided intuitive answer is not appropriate. System two shares characteristics with decision-making models created within economic theories (rationality, for example). However, these economic models do not correspond to human decision-making, since the existing biases, such as the fact that humans are more sensitive to loss than gain (loss aversion), distort our judgments. I have made no attempt to separate the two different systems when collecting data or conducting analysis since it was not required in order to describe the decision episodes observed in this conducted research. The episodes originate from the intersection between actor, praxis, practice, and profession, according to
the project-as-practice approach (Hällgren, 2009a). Furthermore, they are only observed through the acts by actors where the distinction between their cognitive systems was not relevant in this research. Therefore, I regard the observed decision-making approaches used by actors to be a mix of rational, heuristic-based, and bias-prone processes.

Finally, prescriptive decision approaches closely resemble the normative approaches with which an optimal decision is calculated, but with regard to human limitations (bounded rationality). One example of such an approach is the even swap method (see for example Hammond et al., 1998, Luo and Cheng, 2006), where subjective values are used to judge appropriate alternatives.

Reviewing product development literature has led to the conclusion that most research within product development process governance rests on the normative and prescriptive decision-making approaches. Meanwhile, I aim to contribute to the descriptive decision-making approaches.

Several models of complex naturalistic decision-making have been proposed by researchers of organisational and behavioural decision-making to describe decision-making in complex organisational environments. The most renowned models are satisficing (Simon, 1959), muddling through (Lindblom, 1959), the garbage can (Cohen et al., 1972), and the mixed scanning model (Etzioni, 1967). The Satisficing model describes how objectives are often defined before generating alternatives. The process is a search for alternatives until a reasonable alternative is identified which falls within the established boundary conditions. Further, the search for alternatives and evaluation is a means-end analysis where the end might change during the process (Simon, 1959). The muddling through model of decision-making describes the search for objectives and alternatives as being made at the same time. Alternatives are considered and compared to the current situation if the current situation poses a problem and single identified alternatives are tried out according to a trial-and-error approach (Lindblom, 1959). The garbage can model states that objectives emerge during the process and are not defined before alternatives are started to be generated. The process is a successive search for issues and matching alternatives which can be independent and spontaneously connect (Cohen et al., 1972). Finally, the mixed scanning model describes how policy guidelines of the organisation are identified before generating alternatives. The process is focused on broad ends and tentative means, and a decision is made when a satisfactory alternative is found consistent with the organisation’s policy. The search for alternatives is limited, and consequences are evaluated in terms of the policy guidelines (Etzioni, 1967).

All these models of decision-making in naturalistic settings highlight different strategies resulting in different processes and results. Choo (2004, p. 80) divided organisational decision-making into four modes: boundedly ra-
tional mode, process mode, political mode and anarchy mode. The four decision models described above can be placed within these four modes where satisficing is closely related to the boundedly rational mode, the muddling through model is closely related to the process mode, the mixed scanning model is closely related to the political mode, as well as sensegiving (Maitlis, 2005) which will be described later, and finally the garbage can model is closely related to the anarchy mode. “Organisations engage in all four decision-making modes, with different decision situations calling for different decision approaches” (Choo, 2004).

These models with different characteristics and uses further spawned more in-detail research on decision-making behaviour with a focus on cognitive aspects and decision-making performance - NDM. Naturalistic Decision-Making (NDM) focuses on cognitive aspects of decision-making behaviour, and results have identified requirements of effective decision makers to be flexibility, speed, resilience, adaptation, risk taking, and accuracy (Zsambok and Klein, 1997). Flexibility means managing ill-structured, dynamic and complex environments. Speed means that quick decisions are required due to high time pressure. Resilience to ambiguity, stress, high stakes, and high workload is important in order not to have these factors impact the decision in a negative way. Adaptation in turn means that decision makers need to know which decision strategies to apply, as well as how to modify these strategies to suite the demands of the situation. Risk taking is vital as actors judge possible consequences of error and the benefits of payoffs when taking action based on uncertain information. Finally, accuracy means having the aim of being successful more often than unsuccessful over a longer period of time and not dwelling on single bad outcomes. (Zsambok and Klein, 1997) Researchers within NDM aim to provide guidelines for training decision makers in effective decision-making practices. The NDM research also shares the focus of “macro cognitive” functions (in other words, cognitive adaptations to complexity) with other research areas on decision-making, such as situation awareness (SA) (Endsley and Connors, 2008) and sensemaking (Weick et al., 2005).

If these most common decision approaches are reviewed (the optimizing model (Howard, 1968, Howard, 1988), the satisficing model (March, 1994), the muddling through model (Lindblom, 1959), the mixed scanning model (Etzioni, 1967), the contingency model (Beach and Mitchell, 1978), and the garbage can model (Cohen et al., 1972)), one approach in particular stands out as suitable for understanding human decision-making when managing deviations in an unpredictable environment: the garbage can model. When coping with a deviation, the activities are decoupled and that part of the project system becomes temporarily and loosely coupled with normal operations.
Loosely coupled parts of organisations are most likely to resemble the garbage-can decision model. That is because of the display of problematic preferences, a great deal of ambiguity, no clear cause and effect relationships, and members passing through the decision process briefly. Problems are issues of frustration that need attention. In such situations, according to the garbage-can model, objectives emerge spontaneously and are not set in advance. Ideas for solutions and problems may exist independently, and chance may connect them. A satisfying decision occurs when a problematic situation matches a remedy in a satisfying way. According to the model, decision makers search for existing solutions, problems, participants, and opportunities to connect (Cohen et al., 1972).

Regarding studies on decision-making, Langley et al. (1995) reviewed different models of organisation decision-making and provided five suggestions for studying organisational decision-making processes in detail (Langley et al., 1995, p. 276). They are:

- Trace “issues” forward, not “decisions” backward.
- Try new perspectives: zoom in and out.
- Follow processes in real time, as well as retrospectively.
- Focus on people and personalities, not just events.
- Reanalyse previously analysed decision processes, not just new ones.

The suggestion to use “issues” (deviations, in this research) as units of analysis was adopted in this research in order to be able to describe the purposes of acts made by project managers and other team members. I consider decisions not to be the primary driver of actors in the project. Ensuring progress in the project is. Langley describes it best by stating:

> Longitudinal studies of how and why groups of issues develop, get refined, and interact over time could enrich theories of organizational decision making. Here, “decisions” would be viewed, not as the constructs that drive methodology, nor necessarily as the ultimate point of destination, but as events that punctuate and modify the flow of issues. (Langley et al., 1995, p. 276)

Further, when following and observing praxes of actors, processes are the resulting descriptions which emerge along the way; emergence through sequences of situated acts. Situated acts mean that where actors are located when they act matters. “Thus, Situatedness is concerned with locating everything in a context so that the decisions that are taken are a function of both the situation and the way the situation is constructed or interpreted” (Gero, 1998). The observation of emergence of action strategies as a response to contextual circumstances is emphasised and described by Langley (1995) as riding a wave wherever it might go, instead of picking out a braking wave at the shore, and tracing it backward. In order to do so in this research, the third
suggestion of Langley (ibid) was also adopted. It enables researchers to follow decisions in the making and trace flows of issues forward in order to draw conclusions regarding the resulting processes. I regard decision-making processes as a series of micro-decisions, tightly connected to related actions, which are situated. This means that actors take into account not only the issue at hand, but also contextual, organisational, social, and political aspects.
CHAPTER 3 - Method

In Chapter 3, the research approach used in this research will be described, followed by a description of the research process carried out. Thereafter, descriptions of the methods used to collect and analyse the data in Case study A and B will conclude the chapter.

3.1 Research Approach

The phenomenon of decision-making regarding managing deviations in practice is a complex process which entails identifying contextual factors, actions, and purposes. Also, there is no single right answer as to how deviations should be managed, and many paths may lead a project forward when deviations occur. In some cases, the actors might not even know themselves that they are acting in a certain manner.

In order to answer the research questions stated, I have been dependent on access to industrial settings where I could collect qualitative data in order to perform qualitative data analysis. This type of research is often referred to as qualitative research (Yin, 2010). A qualitative research approach enables capturing the important contextual richness of actors’ everyday activities. Further, the use of a qualitative research approach in order to collect data about contextual factors has been considered important by many scholars. For example, Yin stated that “in many ways, these contextual conditions may strongly influence all human events” (Yin, 2010, p. 8).

In order to answer the stated questions of this research, a case study approach employing observations and descriptions of the phenomenon is a logical approach. Therefore, I have used the inductive approach to study, describe, characterise, and explain the purposes behind the identified decision-making processes. Induction means that new knowledge is possible to develop based on observations of real-world settings (industrial settings in this research) and abstracted to theoretical concepts. An alternative would have been deduction, which means that theoretical concepts are used to describe and make predictions about real-world settings. A constant search for knowledge based on observations has been a big part of the effort. At the same time, the knowledge has been compared to theory to find suitable models to use when describing the practices used by actors in a meaningful way.
This process was not planned out in the beginning of the research; rather, it is the result of an iterative search for insights, explanations, and appropriate representations of the obtained knowledge.

In product development research and literature, the aim for rationality is often present. Processes and methods prescribed are assumed to be used in order to obtain rational choices. However, I believe that that may not be the only intent or nature of the practitioners' practices. This idea is based on research results from a range of research areas including organisational behaviour (March, 1994, Simon, 1997), psychology (Weick, 1969), and neuro-science (Damasio, 1995). Even though the research results from these areas point to the inability of people to act in accord with rational decision models, it is still the most valued ideal for practice, not only in organisations but also in western society. This also holds true for actors in product development projects. I agree with researchers such as Söderlund (2004) and Packendorff (1995) who have questioned normative research on product development projects which does not consider contextual factors, focuses on models and methods, and is based on a non-existent rationality.

Several scholars have proposed an alternative approach for investigating the issue from a micro-organisational perspective (for example Cicmil, 2006, Cicmil et al., 2006, Hällgren, 2009b): the project-as-practice approach. I have adopted the approach of project-as-practice since it supports the objective of this research to capture the praxes of project managers and other parties involved when managing deviations, as well as how specific, local circumstances of the project shape and are shaped by praxis - in other words, practice (Hällgren, 2009a). This approach also supports the founding idea of this research, as it views activities within projects as socially skilful and contextually connected, where actors respond to the actions and interactions of parties at multiple levels of the organisation (as argued by Paroutis and Pettigrew, 2007).

Hällgren’s (2009a, p. 25) words describe what I consider to be the most important aspect of the approach: “Contrary to the process perspective, a practice perspective means that existing processes are not noted in favour of studies of how the processes arise”. In this research, Hällgren's statement provides an important distinction between viewing a process as given or emergent. If decisions are to be understood, it is not a point in time or a pre-determined set of decision activities which need to be investigated; instead, it is the emergent process of considering a range of uncertainties and reaching a satisfying resolution. This view of processes has had a substantial impact on the choices I have made regarding methods for collecting data and for analysis. The collection of data was less about formal and official processes and more about expectations, informal actions, and emergent processes. Analysis was focused less on adherence to planned activities and more on observed actions and purposes. Vaughan (1996) spent 15 years researching a
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The project-as-practice approach is closely related to the actors approach (see Arbnor and Bjerke, 1997) and shares the aim of obtaining in-detail knowledge of purposes behind actions and the view of the real world as a manifestation of human interpretation. In Figure 4, the relativity of the most common research approaches is presented and the project-as-practice approach has been mapped out.

In order to describe the focus, or main aspect, of this research, which is the study of work processes aimed at developing products, I use the illustration by Arbnor and Bjerke (1997, p. 62). In it, they positioned research approaches on a spectrum, from positivism to hermeneutics. The relative position of the project-as-practice approach has been placed within the actors approach. Further, in order to clarifying the focus of the data collected, I illustrate this as an intersection between organisation and the process of projects. The process perspective is the main focus, in order to identify what praxes are used and what the resulting process is. The organising perspective is partly also of interest in order to identify who is involved in managing deviations, and how they organise activities. Also, the product perspective is also partly relevant as a contextual entity since the actors' knowledge of the product is an extensive part of their reasoning when making decisions on managing deviations (see Figure 4).

![Figure 4. The research approach and the main focus on processes and organisation.](image-url)
In order to create new knowledge in this research, a multi-case study design was chosen since it is appropriate in order to investigate relationships within companies. A case study is described as: “...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” (Yin, 1994, p. 13). Two case studies (A and B) were carried out, involving eight international companies with major parts of their development activities based in Sweden.

The multi-case study I have designed and mainly carried out through observations and semi-structured interviews can be seen in Figure 5 below. The phenomenon studied guided the choices of methods. The contexts are the project organisations, where projects are initiated in a mid-size and seven large international manufacturing companies in order to develop complex products. The unit of analysis in Case A (UoA A) includes the general elements of consideration in decision-making processes and environments when managing changes (including deviations) in complex product development projects. The unit of analysis in Case B (UoA B) is the actual praxes of actors when managing project deviations.

![Case study design, inspired by Yin (1994).](image)

### 3.2 Selection of theories

I have selected different theories for different purposes throughout the research process. In order to clarify the different purposes for choosing specific theories, I use Eisenhardt (1989). She discusses the use of theory in case study research, and distinguishes between three distinct uses: (1) an initial guide to design and data collection, (2) a part of an iterative process of data collection and analysis, and (3) a final product of the research (Eisenhardt, 1989) in (Walsham, 1995). In this research, I have used theory as an initial
guide to the case study design and data collection, which has been developed iteratively throughout the process. By constructing an overall theory of the mechanisms behind the phenomenon (balance of margins) as well as the phenomenon itself (managing deviations), I could use these as a guide for selecting a suitable industrial context and the type of data to collect within that context. Theory has also been used as a part of an iterative process of data collection and analysis. I did not, however, use the role of theory as a final product of the research, since descriptions of design and characteristics of the phenomenon were the main aim of the research, not producing another theory.

The theories finally selected to be used for the analysis of data were selected on their merits to explain observed and outspoken practices of managing deviations in a complex project environment. Throughout the research process, different theories have also been considered and compared with what I saw and heard in industrial settings (in other words, product development project organisations) regarding the phenomenon. Interactions with companies, besides those who are a part of the two case studies described in this thesis, have provided further insights regarding choice of theories. Examples of such companies include ABB Robotics, and Uponor. Examples of theories that were considered but not chosen in the end include: the decision-making model of “muddling through” (Lindblom, 1959), since it proved to be too abstract for the analysis, “decision quality” (Matheson and Matheson, 1998), since it was not a good fit with observed practice, and “robust decision-making” (Ullman, 2001), since it was too limited to formal procedures and design choices. Even though these theories present valuable aspects of decision-making processes, they do not provide a good basis for analysing decision-making on managing project deviations in practice.

The theories found useful in order to aid in fulfilling the objective of this research, to analyse and describe praxes, were chosen and are discussed in the Theory chapter of the thesis. The basis of the research is the mechanisms behind the phenomenon which presents a challenge in both industry and academia. The basis for analysis was identified elements to be considered, practices, and praxes, and therefore related concepts, such as profession, practice, and actor, were also used. Also, the concepts of decision processes and roles of decisions were used for analysis. Further, in order to analyse the design of decision strategies and how flexibility is enabled, the theory of loosely coupled systems was employed. Finally, in order to analyse the characteristics of the emergent processes resulting from praxes when managing deviations, the theories of Sensegiving and Sensemaking were used.
3.3 The Research Process

First, an initial interview study took place. In it, interviews in Company α, a mid-size manufacturing company, were carried out in order to find an initial scope for the research, and it resulted in a general focus on decision-making processes. In order to narrow down the scope and find an objective, as well as specific research questions, a research clarification stage (Case study A) was planned and carried out. In it, I searched for what is considered the major elements to be considered when making decisions on project changes and parts of the complex product development project environment in general. I continuously searched for indications and evidence supporting or contradicting the assumptions on which the research scope and purpose are based (Blessing and Chakrabarti, 2009). Two companies (X and A) were visited (see Figure 6) and interviews were made with actors participating in product development activities from various departments on multiple organisational levels. The data collections during Case study A in Company X are called data collection one (DC1). In Company A, they are called data collection two (DC2).

The conclusions drawn and assumptions made have been a part of constructing my current view of the overall phenomenon of decision-making, flexibility and, specifically, managing deviations in product development projects described in the Introduction and Previous research chapters.

![Figure 6](image_url)  
Figure 6. The research process with data collection 1-3 and the literature review.

At the end of the research clarification stage, the research purpose and objective and the questions were clarified. A plan of Case study B was developed, and a third data collection was initiated, in Company A (DC3). In total, two data collections were carried out in Company A (DC2 and DC3), and the results were validated by collecting data in a fourth stage, DC4. The research process has been an iterative process between literature reviewing, clarification activities and the case study work. This is visible in the width of the reports written, which have been presented at conferences and in a journal
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3.4 Methods Used for Collecting Data

The two case studies were carried out by collecting data in four phases through the use of participant observations, a workshop, semi-structured interviews, and document reviews. With the objective of this research to develop knowledge which considers the context in which the studied phenomenon is situated, it was paramount to gain access to, and to be able to collect, relevant data. This was made by first getting permission to gather data through semi-structured interviews and presenting the initial results. The process then led the managers at Company A to trust my research abilities and allowed me to make further studies and to collect data through more direct methods (observations) over a longer period of time. The complexity of the field settings and the need to validate the in-depth findings warranted the use of participant observations, review of documents, as well as interviews. In order to ensure the quality of results and conclusions, triangulation by collecting data from several sources was used in the case study; interviews, observations, and documents.

3.4.1 Data collection 1

At the beginning of the research, in the research clarification stage, Company X was visited, a workshop held, and interviews made, as described earlier, in order to investigate decision-making on project change in complex product development projects in general.

DC1 was initiated by a workshop with 9 people from different departments. The goal was to create an overall understanding of their product development process, including communication, areas of responsibilities, and
decision-making. A total of 12 interviews were held with people from the board of directors, market management, project management, engineering design, logistics, and production. Two specific projects were investigated, one successful and one not successful (according to the Company). The interviewees also commented upon a second unsuccessful project during the interviews.

An extensive literature review on decision-making in the area of engineering design methodology and project management was carried out. The literature review was carried out by searching for literature in several databases online via search engines or directly in the databases, as well as in libraries. The search engines used for search were Google Scholar, Academic Search Elite, and ELIN@Mälardalen. The databases directly searched were ABI/INFORM Global (ProQuest), Emerald, IEEE Xplore, Inderscience, IngentaConnect, JSTOR, Oxford University Press, SAGE Journals Online, SpringerLink, and Wiley Online Library. Examples of search words used separately or in combination were the following:

- Decision
- Decision-making
- Decision processes
- Decision quality
- Decision analysis
- Product development
- Technology development
- Deviation
- Project deviations
- Project deviation management
- Project management
- Change management
- Project change management

During DC1, a plan emerged to dig deeply into the areas of unexpected project changes and the related decision-making processes. The result of the research clarification activities at that time was knowledge regarding what type of data was necessary to collect, and by which methods, in order to gain in-depth knowledge of managing deviations and related decision-making processes in projects in order to answer the research questions. The first obstacle to overcome was to select and gain access to the industrial setting in which such data could be collected. I developed a list of criteria in order to search for alternative organisations to collect data within:
1. Medium size or large international company in Sweden.\(^4\)
2. Complex (in-house) product development organised in projects.
3. To be or newly started project, managed by an experienced project manager.

A list of industrial organisations was formed and the ability to gain access was assessed together with the supervisors. After some consideration, the list was reduced to a small number of companies. By chance, a PhD student colleague suggested an opportunity to conduct the planned case study in an organisation which the colleague had worked with before. The organisation proposed was one of the companies still on the list of alternatives, and the decision was made to select the company for the case study: Company A.

3.4.2 Data collection 2

The first data collection in Company A (DC2) began in 2008, investigating a project deviation which had taken place in the early phases of a project, and the study was focused on that single decision episode. The decision episode involved a deviation in which the project steering committee had made a decision which the project team members felt was unexpected and not appropriate given the situation in the organisation at that time. The decision episode starting with, and following that decision, was studied in detail.

The data collection was carried out by conducting eight semi-structured interviews with seven actors in the organisation (a project manager, an engineer, a manufacturing representative, a financial controller, a process manager, a market representative, and a quality manager). The project manager was interviewed twice in order to clarify details. Each interview lasted between 50 and 90 minutes and was recorded as well as summarised.

To achieve a wide perspective on the decision-making process, interviews were made in different departments and with people on different organisational levels who had dissimilar backgrounds and experiences regarding the deviation under study. During the data collection, the researchers had full access to the documents connected to the project (the project organisation, the time schedule, the meeting minutes, the decision log, the administrative documentation, and the product documentation, for example). I also had help collecting data by a manager at the company\(^5\) who had an active part in the project in which the project deviation took place.

\(^4\) A medium sized company is defined as a company which employs between 50 and 250 people, and with an annual turnover between € 10 and € 50 million, or a balance sheet total exceeding € 43 million per year. (http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm, entered 2011-06-13 )

\(^5\) I would like to give my warm regards and thanks to the manager at Company A for the support.
3.4.3 Data collection 3

In a second step of data collection within the same organisation (Company A), which began in October 2009, participant observations in an additional project, adhering to the stated case company selection criteria, were carried out over a period of thirteen months. The aim was to identify and analyse several deviations and related decision episodes. Data was collected through observations, conversations, document reviews, and taking field notes. Observations took place in, and between meetings, sitting at a desk outside or in the project managers’ offices. The desks I sat at during the one year of observations (I moved around between empty desks) are illustrated (1-5) in Figure 7 below. One to 3 marks the desks outside the project managers’ offices where I had my place when there were no meetings or other activities to observe. Four and 5 mark the desks where I sat five weeks in total (2.5 in each) and made observations of the project managers’ day-to-day activities. Most observations of project work were made in conference rooms, offices, the lunch rooms, and in the corridors of the company.

![Figure 7. The office landscape layout in which I sat in Company A during DC3.](image)

During the first month, it was critical to study the internal language, abbreviations, company structure, and the technology system of the organisation being developed in the project in order to be able to understand what was being said in conversations in, and outside, meetings. Access to relevant parts of the intranet was provided, and during the first month I studied company internal presentations of the organisation, systems, and processes. Engineers at the company took their time on several occasions to show prototypes and older versions of the technology system, describing the systems’ parts and functions. The engineers gave me tours of the workshops and labs, where they described the work processes related to developing the technological system. In the same way, managers described the organisational environment and processes used in Company A. All these conversations gave an invaluable background description and understanding of the context within which the project team operated. The understanding included agreed upon rules, expectations, norms, and values of the actors in the organisation acting in and around the project.
rules, expectations, norms, and values of the actors in the organisation acting in and around the project. After a month it was possible to grasp the overall meaning of, and the implications resulting from, conversations. During the second data collection at Company A, day-to-day conversations over coffee or lunch presented a good opportunity to learn about the current situation in the project, technology, organisation, and processes. Field notes were written down and chronologically ordered in a notebook when deviations occurred, conversation by conversation, day by day, and month by month. Conversations were not noted word for word, which was not possible, but summarised continuously during conversations. Citations were sometimes written down word for word when the opportunity was given to show evidence of a specific purpose or action of an actor. It was also noted who were present to be able to capture interactions taken place. Field notes were made of all types of observations regarding deviations in conversations, meetings, and day-to-day work. An example of the type of field notes taken can be seen in Figure 8. The risk with participant observations is that the observer can affect the process of the actors. Therefore, my role when collecting data by observations has been as a passive observer to minimise the risk. However, in the beginning of the study, I noted a certain caution from the team members regarding discussing sensitive opinions. This changed over time as the team grew to accept my presence. Though valuable, the task of observation was time-consuming and, to some extent, stressful, since other work activities were not put on hold, and resulted in me being present approximately half of the time during the thirteen months at Company A.

<table>
<thead>
<tr>
<th>Date, time, end time, participants, the amount actors spoke, purpose of the activity.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Initials of actor) Summary of what the actor said and/or did.</td>
</tr>
<tr>
<td>(Initials of actor) Summary of what the actor said and/or did. “Citation of the actor”.</td>
</tr>
<tr>
<td>(Initials of actor) Summary of what the actor said and/or did.</td>
</tr>
<tr>
<td>(Initials of actor) Summary of what the actor said and/or did.</td>
</tr>
<tr>
<td>(Initials of actor) Summary of what the actor said and/or did. “Citation of the actor”.</td>
</tr>
</tbody>
</table>

Figure 8. Example of the type of field notes taken during observations.
In meetings, when PowerPoint slides were presented for the present actors, it was almost always possible to download the presentation. It was printed and placed next to the written notes from that specific meeting. Document retrieval and review was an important task that took place at the same time as the observations in Company A. Since the team members continuously worked on different documents placed on the team's database (Team Site), I downloaded the entire database once a month on an intranet folder provided by the company. The folder could be accessed remotely by logging in via a company computer with a secure internet connection. These downloaded documents provided a good opportunity to follow changes in the project work as it progressed. From a methodological viewpoint, using documents as information in a case study is not considerably different from how observations or interviews are used (Merriam, 1988). In addition, the Head Project Manager (HPM) and the Project Manager representing Engineering (EPM) provided access to their emails (in and outbox). In total, approximately 600 hours of observations were made, and 5,000 emails and 5,000 project documents were collected and studied.

To verify that the data collected was relevant, semi-structured interviews were held with the HPM, EPM, and the product development manager for that particular technology system developed. Each interview lasted between 40 and 60 minutes, and all interviews were recorded as well as summarised. Questions were asked about what deviations had occurred in the project and the interviewees’ experiences of the deviations clarified.

### 3.4.4 Data collection 4

The fourth and final collection of data in the case study was made within six companies (B-G) fulfilling the case company selection criteria stated earlier, with the exception of “To be or newly started project”. Access was gained via connections held by myself and a supervisor with actors within companies which met the criteria for suitable organisations. Semi-structured interviews were used for this data collection. They were held with one experienced and highly regarded project manager (by their organisations) in each of the six companies (Companies B to G). Six people were interviewed in total. Interviews were held at the site of each company and lasted between 60 and 120 minutes. Each was recorded and summarised. Questions were asked regarding the project managers’ project organisations and practices of managing deviations in practice. The project managers were encouraged to speak about deviations they had been a part of managing and to describe the characteristics of the processes. I also presented the results obtained at Company A and asked the project managers to comment on similarities and differences between the results and behaviour within their respective organisation.
3.4.5 Discussion of the chosen methods

The choices of methods to use in the case studies were guided by the research objective and research questions posed, which framed the choices. Each choice of method was made between several alternatives of methods, and pros and cons were investigated by reading about the methods or discussing their uses with colleagues to be able to make the necessary trade-offs. As described earlier, an influencing factor when making choices of methods was the organisations from which I needed commitment to the methods of choice. If the organisation did not approve, the method was not a feasible alternative. However, most of the suggestions I made of methods to use in the case studies were accepted by the eight organisations. I did suggest to a manager at Company A to video-record steering committee meetings. However, that was not accepted as a way of collecting data due to the invasive nature of the method. In Table 1, the methods used and data coverage in the case study are presented.

Table 1. Methods used and data coverage.

<table>
<thead>
<tr>
<th>Data collection phase</th>
<th>Data collection method</th>
<th>Data coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collection 1</td>
<td>Workshop</td>
<td>Statements on posed questions and illustrations of the company’s processes</td>
</tr>
<tr>
<td>(Company X)</td>
<td>Semi-structured interviews</td>
<td>Statements on posed questions</td>
</tr>
<tr>
<td>Data collection 2</td>
<td>Semi-structured interviews</td>
<td>Statements on posed questions</td>
</tr>
<tr>
<td>(Company A)</td>
<td>Reviewing documents</td>
<td>Personal documents, shared documents, printed material</td>
</tr>
<tr>
<td>Data collection 3</td>
<td>Participant observations</td>
<td>Peoples’ social interactions and actions</td>
</tr>
<tr>
<td>(Company A)</td>
<td>Semi-structured interviews</td>
<td>Statements on posed questions</td>
</tr>
<tr>
<td></td>
<td>Reviewing documents</td>
<td>Personal documents, shared documents, printed material (technical systems)</td>
</tr>
<tr>
<td></td>
<td>Day-to-day conversations</td>
<td>Discussions on multiple related topics</td>
</tr>
<tr>
<td>Data collection 4</td>
<td>Semi-structured interviews</td>
<td>Statements on posed questions, descriptions of work practices</td>
</tr>
<tr>
<td>(Company B - G)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

During DC1, a workshop gave the opportunity to collect data which provided a broad understanding of the company’s product development processes, communication patterns, and decision-making behaviour. During DC1 to DC4, semi-structured interviews presented the opportunity to gain insight into the thoughts and minds of actors regarding expectations and experiences. By being asked questions, the interviewees were given the opportunity to express views on the issues. The interviewees were encouraged to give descriptions of issues. If another related issue was expressed, the interviewee was given the opportunity to elaborate on that as well. This was done in or-
der to gain a broader view on issues, rather than a view based solely the ones addressed by the prepared questions. The risk with semi-structured interviews is that interviewees giving their view on situations make subjective statements that may contradict other actors’ views and statements. This might result in distorted conclusions if not treated in a proper manner by the researcher. In this research, this risk has been met by conducting several interviews with actors on each phenomenon from different departments and different companies. In Company X, the interviewees were selected by who was responsible for each department or expert activity. In Company A, the interviewees were handpicked by who was the most central (the responsible actors) and observed actors in the project. The interviewees in Company B to G were selected by their own organisations as representing highly skilled project managers. Each interview was digitally recorded and afterward listened to several times in order to write down a summary of each interview. Statements not considered relevant to the phenomenon being studied were not included in the written summaries.

To summarise this section, Table 2 below presents the methods described and the sources of data.

Table 2. Summary of the methods used and sources of data.

<table>
<thead>
<tr>
<th>Org.</th>
<th>Unit of Analysis</th>
<th>Method</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>Elements of consideration</td>
<td>- Semi-structured interviews</td>
<td>- Managers, Project Managers, team members, and stakeholders.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Document reviews</td>
<td>- Intranet, Team Site, printed material.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Participant observations (field notes)</td>
<td>- HPM, Project Managers (PMs), team members, decision body members, and other stakeholders in the organisation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Document reviews</td>
<td>- Intranet, Team Site, printed material, and photos.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Conversations</td>
<td>- Experts on the technical system and managers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Semi-structured interviews</td>
<td>- Managers, HPM, EPM, team members, and stakeholders</td>
</tr>
<tr>
<td>A</td>
<td>Praxis</td>
<td>- Semi-structured interviews</td>
<td>- PMs</td>
</tr>
<tr>
<td>B-G</td>
<td>Praxis</td>
<td>- Semi-structured interviews</td>
<td>- PMs</td>
</tr>
</tbody>
</table>
3.5 Methods for Analysis

In Case study A, two sets of data were included in the analysis: the data from DC1, and DC2. In the analysis of data collected during DC1, two steps of analysis were carried out.

First, the extensive literature review regarding decision-making in the area of engineering design methodology and project management was used by categorising the findings in the literature regarding input, the process, and the output from project change situations (see Table 3).

Table 3. The analysis filter for categorizing findings from the literature review.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>PROCESS</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identified elements</td>
<td>Identified elements</td>
<td>Identified elements</td>
</tr>
</tbody>
</table>

The second step here was to categorise the empirical data according to the theoretical framework, thereby summarising the important elements of consideration when making decisions on project changes. Statements made by the interviewees were analysed by searching for elements related to the categories in the theoretical framework.

In the analysis of data collected during DC2 in Case study A, three steps of analysis were carried out with the support of the PhD colleague. An initial analysis of the different data sources (summaries of interviews, notes, and documents) was made individually, and then once again, together.

First, the extensive literature review on decision-making in the area of engineering design methodology and project management was used by categorising the findings in the literature regarding seven major elements of decision-making in large organizations: structures, performance aspects, organising, decision-making processes, groups, methods, and individuals. Second, a timeline of the decision-making process was created, and the empirical data was categorised according to the theoretical framework, thereby identifying the important elements to be considered when making decisions in complex product development projects when a deviation has occurred. Third, and finally, the identified important elements were compared to a classical decision-making process (identification, objectives, alternatives, evaluation, and decision) to identify which decision-making activities had actually taken place and been considered during the decision-making process. The results from Case study A was reported in Paper I and II.

In Case study B, as described earlier, three sets of data were included in the analysis: DC2 (reanalysed), DC3, and DC4. For each of the steps, theories were used for identification and interpretation of decision episodes in order to answer the research questions (see Figure 9).
During the reanalysis of data from DC2, a PhD student colleague (Anette Brannemo) once again participated in the analysis. Parts of the collected data were transferred to a qualitative data analysis software, NVivo8. An analysis filter was developed and used in NVivo8 to categorise the data according to the input, process, and output (see Table 4). This gave the data a chronological order, and I identified and separated out critical activities by comparing statements of the process made by the eight interviewees. The time line from the first analysis was reused. Further, factors driving the decision-making process under study were analysed in order to clarify which factors were contextual and which were process-related.

Table 4. Analysis filter used in NVivo8 to categorise data related to episodes.

<table>
<thead>
<tr>
<th>Input: Source event &amp; circumstances</th>
<th>Internal project</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>External project</td>
</tr>
<tr>
<td>Process: Events &amp; Praxes</td>
<td>Internal project</td>
</tr>
<tr>
<td></td>
<td>External project</td>
</tr>
<tr>
<td>Output: Output events &amp; Praxes</td>
<td>Resulting internal practices</td>
</tr>
<tr>
<td></td>
<td>Resulting decisions</td>
</tr>
</tbody>
</table>

In NVivo, a second filter was developed and applied to the data. This was performed to identify praxes used by actors and to relate these praxes to four types of decision roles in order to describe the emergent decision process in detail (see Table 5). The four roles of decisions have been defined by Bruns-son (2007) and described in the theory chapter of this thesis.
Conclusions were stated and then discussed together with the colleague, and iteratively modified according to the joint conclusions. The first part of Case study B (DC2 reanalysed) was reported in Paper III, included in this thesis.

The second part of Case study B (DC3), where observations were made, was analysed through a three stage process. In it, (1) praxes used when deviations occurred were identified, (2) the praxes were related to theories of decision roles, decision models, loosely coupled systems, and sensemaking, and (3) theoretical implications on managing deviations in projects were identified. The theoretical models used for analysis were selected through an iterative process during the collection of data in order to find alternative theories and select the most purposeful theories related to the research questions. The theories were considered purposeful if these could be used to characterise and describe meaningful aspects of the studied phenomenon. The selected theories are described in detail in the theory chapter of this thesis.

The third data collection (DC3) resulted in the identification of 37 decision episodes, and a timeline was produced in order to identify critical events, activities, and circumstances (see Figure 10). The time line was used as a project map in order to understand and describe the “story” of the project and organise data and notes on an overall level of analysis. Even though it cannot be made out in detail in the picture, the timeline was noted and circumstances, events, and praxes were noted and positioned on the timeline by drawing a line from the note. I used these notes and timeline to construct the narrative of the observed activities and praxes used by actors within the project.

Table 5. Analysis filter used in NVivo8 to make cross-references between praxes and decision roles.

<table>
<thead>
<tr>
<th>Decision episode</th>
<th>Decision roles (consequences)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Praxis</td>
<td>Choice</td>
</tr>
<tr>
<td>n</td>
<td></td>
</tr>
<tr>
<td>n+1</td>
<td></td>
</tr>
</tbody>
</table>

Figure 10. The timeline of the project observed during DC3 in Company A.
These timeline notes were related to specific sets of highlighted data in field notes and documents (see Figure 11 for examples of highlighted data in field notes). The field notes were further used throughout the analysis to provide data on contextual circumstances and praxes.

Figure 11. Highlighted data in field notes related to the time line notes.

Over 600 pages of field notes were analysed and data highlighted before being transferred into NVivo8 for further detailed analysis. The same filter use in the previous stage (see Table 5) (to relate praxes to decision roles) was used as a basis for further analysis. The pattern of use of decision roles was analysed and compared to previous research on decision approaches. The characteristics of the resulting decision episodes were categorised according to four sensemaking process types. In addition, the related use of decision roles for each sensemaking type was analysed (see the theory chapter for description). The results from the second part of Case study B were reported in Papers IV to VI, which are included in this thesis.

Finally, the data collected in Companies B to G (DC4) was analysed in order to conduct an initial validation of results obtained at Companies X and A. Once again, the theoretical models of decision roles and sensemaking types were used to relate the interviewees’ statements about behaviour in their respective organisations regarding managing project deviations. The results from the final stage of the case study were reported in Paper VI and are included in this thesis.
CHAPTER 4 - Theory

In Chapter 4, specific theories will be described in detail and their relationship to the conducted research. Theories which have been used to define the mechanism behind the phenomenon are theories about loosely coupled systems, complexity, and unexpected events. Theories used for the analysis of data are related to the project-as-practice approach, i.e. praxis, as well as decision roles, loosely coupled system mechanisms, sensegiving, and sensemaking.

4.1 Project deviations

A deviation is defined in the Oxford Online Dictionaries ("deviation", 2011) as “The action of departing from an established course or accepted standard; deviation from a norm”. In product development projects, a deviation from the norm would mean deviating related to several possible entities. Among them are: process prescriptions (a gated model, for example), project plans, risk analyses (process FMEA, for example), project budgets, and requirement lists. What guide the content of these planning methods are expectations of actors in the organisation. I view the nature of plans in the same way as Söderholm, who states that “Plans codify those expectations that are desirable, necessary and likely if actions are carried out in a correct way without any unexpected disturbances” (Söderholm, 2008, p. 81). I view the role of plans to be a resource for an actor’s internal and external discussions regarding which actions to take, and not as static models of action (even if treated as such on occasion in product development literature). Further, there exist two opposite views on the role of plans related to action: projected versus situated actions. The first view regards plans as a projected alternative to action which should be carried out accordingly. I do not agree with this view, and regard it to be unfit for describing practice. However, the practice of using plans as a carrier of expectations has been included in the case study. I regard the relationship between plans and action to be as Suchman (1987, p. 52) describes it, a “resource for situated action", but it does not "determine its course”.

Expectations are the basis for planning activities, and they guide thought as well as action. Over time, actors sharing the same environment and relat-
ed work activities develop an understanding of how organising activities work and guide day-to-day activities. However, in some cases, the expectations do not match shared practices and formal procedures may be disregarded in order to manage issues in practice (Hällgren, 2009a). I regard such occasions to be more common in practice than literature within product development often portrays them to be.

In research on product development process governance, little has been explicitly written about the concept of deviation, and the texts that have been written often deal with deviations related to something negative that needs to be eliminated from processes by more exact planning procedures or intensified information search and processing. Deviation is often treated as “failure” (White, 2006), “error” (Busby, 2001), “unwanted consequences” (Ensici et al., 2008), or “disposition problems” (Olesen, 1992), for example. I agree that deviations may pose critical problems as they impact cost, time, and/or scope goals. Nonetheless, these deviations might also present opportunities for improving product quality, time, and cost.

Engwall and Svensson (2004) view deviations or “unanticipated problems” as a natural part of temporary organisations. They also explore how temporary task teams, or “Cheetah teams”, are used to manage large and urgent project deviations related to technical challenges that have emerged. Their research spawned more in-depth project management studies of the mechanisms of managing deviations in temporary organisations, as mentioned earlier (see Hällgren, 2009a, Söderholm, 2008). The research I have conducted falls into that area of research.

In traditional research on organising product development activities (e.g., systems engineering), deviations fall under “change control”, or “risk management”, but there are differences. Change control processes are formal requests for changes, often regarding product design, and are often not considered unexpected by involved actors. If the change is controlled, it is not unexpected. Risk management is proactive activities where different failure modes are predicted and acted upon. However, while I regard that a deviation can include risks when these are realised, all deviations are not risks because these might be all too improbable, too expensive or just impossible to predict, as also stated by Hällgren (2009a).

In research on organising, deviations are often associated with “unexpected events” (Weick and Sutcliffe, 2001, p. 1) and “the everyday struggle to keep projects on track and on schedule” (Söderholm, 2008, p. 81). For purposes of this research, I consider the definitions of deviation used in most research on product development to be insufficient to describe the phenomenon I have studied, and to be in need to be further development to include other aspects as well. For that reason, I have searched for a definition which is focused on practice and can aid in identifying deviations in an industrial setting. The definition closest to my view on deviation was found in the re-
Deviations are simply unexpected events that need attention from the project team because they interfere with cost, time or scope goals. (Hällgren, 2009b, p. 613)

Deviations are therefore not associated with magnitude (can be small or crises) or escalation (can be abrupt or cumulative) (Hällgren, 2009a). I chose to adopt this definition since it provided a good basis for the identification of deviations in practice. Further, I include product features and quality aspects in the concept of scope goals, important aspects in product development projects.

In Figure 12, an illustration of the concept of managing a deviation can be seen. I developed this illustration to clarify my view of the phenomenon. This illustration represents the mechanism of managing deviations in practice. Since deviations are unexpected, there are no plans or dedicated resources for managing these. This means that management needs to be detached from planned operations and activities managed in parallel, taking into account the situated nature of the issue. The praxis used has consequences in the organisational system and originates from the intent of the actors. The consequences are the actual consequences following actions which some are planned and anticipated, while others are unplanned and unexpected. These consequences are a part of the ecological change of the organisation. The praxes are used with the intent to produce consequences which advance the work in the project and return it to normal operation.

Figure 12. A model of managing deviations in practice.

The actions taken by actors in order to manage a deviation in a complex, uncertain environment are neither rational nor optimal; rather, these are “satisficing” (March, 1994, Simon, 1997). The decision approach used by actors managing deviations in practice is described by Levitt (1999) as following satisficing rules. According to such rules, solutions to issues are investigated
until an alternative that is good enough is found, and the search thereafter stops. I actually questioned this theory at the beginning of the research since literature on product development advocates using methodologies which encourage multiple parallel alternatives (Set-based Concurrent Engineering (Ward et al., 1995), for example). Such approaches aim at finding the best solution possible within a given timeframe. These approaches to concept decisions have increased in industrial use and are concepts included in Lean Product Development (LPD). However, my view of decision processes resulting in “satisficing” has strengthened since observations has confirmed it to be typical. While alternatives might be considered, once an alternative proves viable, that alternative is tried out and the remaining alternatives discarded if the chosen alternative works. Further, the observations I have made of concept selection in industrial settings are often not about finding the best product solution. Instead, they are about the search for a solution that actually works according to stated minimal requirements. It has become highly complex to meet even minimal requirements of products and projects which are driven by, for example, legal, environmental, and customer demands. These findings are discussed in detail in the case study chapter in this thesis. This also means that decision processes are not about finding the best way to manage deviations, but a way that works well enough in a particular situation (balance projected consequences or trade-offs) in a project related to the project itself, the context, and the stakeholders.

4.2 Constructions of the Project-as-Practice approach

I wanted to approach the studied phenomenon from a micro-perspective, describing in detail activities and practices as well as how these came about. Therefore, this research is based on the project-as-practice approach (Blomquist et al., 2010, Häggren and Söderlun, 2011), which displays these specific characteristics of a detail-focused, bottom-up approach. The Project-as-practice approach rests on five interrelated key constructions:

- actor (practitioner),
- praxis,
- practice,
- profession,
- and episode

The actor is the person acting (praxis) in the project organisational system. “Praxis refers to actual activity, what people do in practice” (Whittington, 2006, p. 619). Practice is the aggregated praxis that has become standard procedure related to specific situations (Häggren, 2009a). Practices “refer to
shared routines of behaviour, including traditions, norms and procedures for thinking, acting and using “things” (Whittington, 2006, p. 619). When managing deviations in projects, an example of praxis could be “gathering information” and practice could be “structuring information according to a QFD\textsuperscript{6}. Profession, or “institutional field” (Whittington, 2007, p. 1580), refers to the role an actor is assumed to play in the organisation which is conventional even outside the organisation (engineering or project management, for instance). During data collections, I observed, as well as interviewed actors, regarding praxes and practices of actors within projects and surrounding organisations. Their professions were related to their specific role in the organisation and project which I used in order to understand why certain arguments or viewpoints were presented during meetings, for example.

\textbf{Figure 13.} The project-as-practice approach’s four cornerstones and episodes (Hällgren, 2009a, p. 37).

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\textsuperscript{6} Quality Function Deployment
In Figure 13 above, the four cornerstones of the project-as-practice approach (Actor, Praxis, Practice, and Profession) are illustrated. The cornerstones which enable an episode make it possible to discuss where the four cornerstones come together and how. “The single episode thereby reveals something about the content of the work instead of development over time” (Hällgren, 2009b, p. 37). Since I regard these concepts to be useful in identifying and describing characteristics of episodes when actors are managing deviations in practice, it provided further arguments for choosing the project-as-practice approach for my research. What is important to note is that it is impossible in reality to separate, or single out, the four cornerstones’ influence on acts made by actors. An episode contains all four cornerstones, and observing actors and their praxis means that practice and professions are also a part of the observed.

Therefore, in this research, these concepts have been used as a basis for analysis in order to identify actors involved in decision episodes and the praxes used in order to manage deviations. The actors’ professions are noted by describing their role in the organisation (PM for Project Manager, for example) and practice is described through the analysis of the design of decision strategies.

Further, in this research, Häggren’s identified praxes (see Table 6) were used as a guide during observations and analysis in order to label (categorise) praxes used by actors. Further, the relationship to Häggren’s praxis patterns and characteristics (ibid) were also used to compare results in the discussion and conclusion chapter.

Table 6. Praxis, praxis pattern, and characteristics of action (Hällgren, 2009a, p. 234, translated from Swedish).

<table>
<thead>
<tr>
<th>Praxis</th>
<th>Praxis description</th>
<th>Praxis pattern</th>
<th>Characteristics of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of experience</td>
<td>Use of experience to identify a solution</td>
<td></td>
<td>Identify and get to know the boundaries</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Create identity</td>
</tr>
<tr>
<td>Information gathering</td>
<td>Gather information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Control status of issue</td>
<td></td>
<td>反思评估提供初步身份</td>
</tr>
<tr>
<td>Assessments</td>
<td>Assessments provide preliminary identity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Define</td>
<td>Efforts to delimit the event</td>
<td></td>
<td>在有利的方面解释目标</td>
</tr>
<tr>
<td>Down prioritising</td>
<td>Prioritise among events</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normalisation</td>
<td>Give the illusion of normality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobilisation</td>
<td>Assemble actors</td>
<td></td>
<td>动员网络</td>
</tr>
<tr>
<td>Create responsiveness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsibility allocation</td>
<td>Actively reject responsibility</td>
<td></td>
<td>拒绝责任</td>
</tr>
<tr>
<td>Requirement formalisation</td>
<td>Pre-determined routine in order to clarify requirement</td>
<td></td>
<td>正式要求的格式化</td>
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<tr>
<td>Meeting formalisation</td>
<td>Formalised meeting in order to clarify requirement</td>
<td></td>
<td>正式会议的格式化</td>
</tr>
<tr>
<td>Report</td>
<td>Formally notify status</td>
<td></td>
<td>报告的格式化</td>
</tr>
<tr>
<td>Change formalisation</td>
<td>Formalised change management</td>
<td></td>
<td>变更的格式化</td>
</tr>
<tr>
<td>Demand assurance</td>
<td>Demanding verbal assurance</td>
<td></td>
<td>需求保证</td>
</tr>
<tr>
<td>Reminder</td>
<td>Reminder of responsibility for an activity</td>
<td></td>
<td>提醒活动的责任</td>
</tr>
<tr>
<td>Increased activity</td>
<td>Dedicate time and resources</td>
<td></td>
<td>组织的时间释放</td>
</tr>
<tr>
<td>Replace</td>
<td>Arrange new material</td>
<td></td>
<td>安排新的材料</td>
</tr>
<tr>
<td>Accept responsibility</td>
<td>Implement earlier solution</td>
<td></td>
<td>接受责任</td>
</tr>
<tr>
<td>Routine management</td>
<td>Use of simple routine</td>
<td></td>
<td>常规管理</td>
</tr>
<tr>
<td>Redesign</td>
<td>Change design</td>
<td></td>
<td>重新设计</td>
</tr>
<tr>
<td>Reorganising</td>
<td>Change order of activities</td>
<td></td>
<td>重新组织活动</td>
</tr>
<tr>
<td>Resource reallocation</td>
<td>Reallocate resources</td>
<td></td>
<td>资源的重新分配</td>
</tr>
<tr>
<td>Create alternative</td>
<td>Enable more alternatives</td>
<td></td>
<td>创造更多的替代</td>
</tr>
<tr>
<td>Create and maintain</td>
<td>Create responsiveness</td>
<td></td>
<td>保持响应力</td>
</tr>
<tr>
<td>Create goodwill</td>
<td>Accept less optimal solution in order to create goodwill</td>
<td></td>
<td>接受不太理想的解决方案用于创建良好的声誉</td>
</tr>
<tr>
<td>Create resources</td>
<td>Release resources</td>
<td></td>
<td>释放资源</td>
</tr>
<tr>
<td>Create time</td>
<td>Release time</td>
<td></td>
<td>释放时间</td>
</tr>
<tr>
<td>Hide information</td>
<td>Hide information</td>
<td></td>
<td>隐藏信息</td>
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</tbody>
</table>
In Figure 13 above, the four cornerstones of the project-as-practice approach (Actor, Praxis, Practice, and Profession) are illustrated. The cornerstones which enable an episode make it possible to discuss where the four cornerstones come together and how. "The single episode thereby reveals something about the content of the work instead of development over time" (Hällgren, 2009b, p. 37). Since I regard these concepts to be useful in identifying and describing characteristics of episodes when actors are managing deviations in practice, it provided further arguments for choosing the project-as-practice approach for my research. What is important to note is that it is impossible in reality to separate, or single out, the four cornerstones' influence on acts made by actors. An episode contains all four cornerstones, and observing actors and their praxis means that practice and professions are also a part of the observed.

Therefore, in this research, these concepts have been used as a basis for analysis in order to identify actors involved in decision episodes and the praxes used in order to manage deviations. The actors' professions are noted by describing their role in the organisation (PM for Project Manager, for example) and practice is described through the analysis of the design of decision strategies.

Further, in this research, Hällgren's identified praxes (see Table 6) were used as a guide during observations and analysis in order to label (categorise) praxes used by actors. Further, the relationship to Hällgren's praxis patterns and characteristics (ibid) were also used to compare results in the discussion and conclusion chapter.

<table>
<thead>
<tr>
<th>Praxis</th>
<th>Praxis description</th>
<th>Praxis pattern</th>
<th>Characteristics of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of experience</td>
<td>Use of experience to identify a solution</td>
<td>Identify and get to know the boundaries</td>
<td>Create identity</td>
</tr>
<tr>
<td>Discuss</td>
<td>Discuss to create a common view</td>
<td>Identify and get to know the boundaries</td>
<td></td>
</tr>
<tr>
<td>Information gathering</td>
<td>Gather information</td>
<td>Identify and get to know the boundaries</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Control status of issue</td>
<td>Identify and get to know the boundaries</td>
<td></td>
</tr>
<tr>
<td>Assess</td>
<td>Assessments provide preliminary identity</td>
<td>Identify and get to know the boundaries</td>
<td></td>
</tr>
<tr>
<td>Define</td>
<td>Efforts to delimit the event</td>
<td>Identify and get to know the boundaries</td>
<td></td>
</tr>
<tr>
<td>Down prioritise</td>
<td>Prioritise among events</td>
<td>Identify and get to know the boundaries</td>
<td></td>
</tr>
<tr>
<td>Normalisation</td>
<td>Give the illusion of normality</td>
<td>Identify and get to know the boundaries</td>
<td></td>
</tr>
<tr>
<td>Mobilisation</td>
<td>Assemble actors</td>
<td>Mobilisation of network</td>
<td></td>
</tr>
<tr>
<td>Responsibility allocation</td>
<td>Actively reject responsibility</td>
<td>Rejection of responsibility</td>
<td></td>
</tr>
<tr>
<td>Requirement formalisation</td>
<td>Pre-determined routine in order to clarify requirement</td>
<td>Rejection of responsibility</td>
<td></td>
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<tr>
<td>Meeting formalisation</td>
<td>Formalised meeting in order to clarify requirement</td>
<td>Rejection of responsibility</td>
<td></td>
</tr>
<tr>
<td>Report</td>
<td>Formally notify status</td>
<td>Rejection of responsibility</td>
<td></td>
</tr>
<tr>
<td>Change formalisation</td>
<td>Formalised change management</td>
<td>Rejection of responsibility</td>
<td></td>
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<tr>
<td>Demand assurance</td>
<td>Demanding verbal assurance</td>
<td>Rejection of responsibility</td>
<td></td>
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<tr>
<td>Remind</td>
<td>Reminder of responsibility for an activity</td>
<td>Rejection of responsibility</td>
<td></td>
</tr>
<tr>
<td>Increased activity</td>
<td>Dedicate time and resources</td>
<td>Focus the organisation</td>
<td>Create responsiveness</td>
</tr>
<tr>
<td>Margin reduction</td>
<td>Reduce margins in order to focus efforts</td>
<td>Focus the organisation</td>
<td></td>
</tr>
<tr>
<td>Replace</td>
<td>Arrange new material</td>
<td>Accept responsibility</td>
<td></td>
</tr>
<tr>
<td>Implement</td>
<td>Convert earlier solution</td>
<td>Accept responsibility</td>
<td></td>
</tr>
<tr>
<td>Routine management</td>
<td>Use of simple routine</td>
<td>Accept responsibility</td>
<td></td>
</tr>
<tr>
<td>Redesign</td>
<td>Change design</td>
<td>Accept responsibility</td>
<td></td>
</tr>
<tr>
<td>Reorganising</td>
<td>Change order of activities</td>
<td>Situated use of resources</td>
<td></td>
</tr>
<tr>
<td>Resource reallocation</td>
<td>Reallocate resources</td>
<td>Situated use of resources</td>
<td></td>
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<tr>
<td>Create alternative</td>
<td>Enable more alternatives</td>
<td>Situated use of resources</td>
<td></td>
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<tr>
<td>Create goodwill</td>
<td>Accept less optimal solution in order to create goodwill</td>
<td>Situated use of resources</td>
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<tr>
<td>Create resources</td>
<td>Release resources</td>
<td>Situated use of resources</td>
<td></td>
</tr>
<tr>
<td>Create time</td>
<td>Release time</td>
<td>Situated use of resources</td>
<td></td>
</tr>
<tr>
<td>Hide information</td>
<td>Hide information</td>
<td>Situated use of resources</td>
<td></td>
</tr>
</tbody>
</table>
4.3 Decision processes and decision roles

Studies of the way project managers manage deviations in practice from a micro-perspective have focused on creating knowledge by observations of actors' actions (praxes) and working practices. The use of praxes enables the project managers to progress beyond deviating situations. This focus on praxis corresponds well with the focus on tentative micro-decisions in descriptive studies of design decision-making (see for example Hansen and Andreasen, 2004, López-Mesa and Chakrabarti, 2007).

Inspired by this view of decision-processes, I also focused on studying both decision-processes in detail and in an industrial product development project setting over a long period of time, which is rare. Further, as Langley et al. (1995, p. 276) suggest, instead of focusing on decisions (choices) made, issues should be observed and followed. I agree and argue that observations of decision-making processes need to be carried out with a wider perspective than simply observing the choices that result from the decision-making process. The final choices made tell us little about the intents of the actors to create commitment, for example. The role that micro-decisions play during the overall decision-making process should also be observed in order to determine the intent of the decision praxes used.

The intent of actors is revealed by responses to different types of uncertainties during the process, and not only uncertainties about the product during development. In order to describe the different types of uncertainties that actors need to consider during decision-making in practice, I searched for a theory which could show nuances of such processes.

A review of the product development literature provides a unanimous answer regarding the role a decision plays; it is a choice made between two or more alternatives. Further, a decision is often viewed as the final choice at the end of a process, “a conclusion or resolution reached after consideration” (OxfordDictionaries.com, "decision", 2011). However, I view choice to manage uncertainty related to alternatives, and that there exist types of uncertainties not included in that specific concept of decision-making. Some literature on decision-making (Hammond et al., 2002, Roberto, 2009, for example) argue for managing uncertainty regarding the implementation of decisions (commitment) by creating commitment by actors during the process. However, Brunsson (2007) suggests an alternative, a more extensive theory which I find both revealing and useful. Brunsson (ibid) states that decisions in organisations may have four different roles in treating uncertainty as to alternatives, commitment, decision makers, and legitimacy (See Table 7).
Table 7. Four roles of decisions (adapted from Brunsson, 2007, p. 27).

<table>
<thead>
<tr>
<th>Handle uncertainty as to:</th>
<th>Alternatives</th>
<th>Commitments</th>
<th>Decision makers</th>
<th>Organisational legitimacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design:</td>
<td>Rationality</td>
<td>Irrationality</td>
<td>Irrationality for responsibility acceptance</td>
<td>Rationality in environments of inconsistent norms</td>
</tr>
</tbody>
</table>

As Brunsson states (2007, p. 27):

Decision-making can reduce uncertainty related to alternatives, actors, decision-makers, or legitimacy. Decision-makers may adapt the design of decision-making processes to these different roles and to what the decision-makers want to achieve within the role.

The four roles of decisions enabled me to describe a more nuanced picture of decision-making processes within organisations since it clarifies major uncertainties managed, as well as how alternatives are decided.

The extent to which those involved follow rational norms of standard decision theories varies according to the decision makers’ role and objective. Decision as choice, or decision as legitimation, is considered to have a rational design. A high degree of rationality can be viewed as an attempt to manage choice, hinder action (by requesting more rational procedures), escape responsibility, or legitimise events in an environment where inconsistent norms are important (in a political situation, for instance). On the other hand, decision as mobilisation, and decision as responsibility allocation, is considered to have an irrational design. A high degree of irrationality does not always mean irrational actions. Instead, it should be viewed as behavioural decision-making which considers other roles besides choice alone. In this research, the roles have been used as a means to identify and determine the intent of praxis. Further, the design of decisions (rational or irrational) has been used to identify the design and strategies used in decision episodes. (Brunsson, 2007)

Brunsson’s (ibid) theory has mostly been focused on macro activities of organisations, a decision on a reform and consequences of the decision, for example. However, Brunsson (ibid) shows how the construction of decision-making can be extended, and I have used the theory to provide useful illustrations of the struggles employees within large organisations make to identify, understand situations, and get things done. To better understand the intent of the used praxes of project managers, the four different decision roles (Table 7) were adopted. They were used to codify data and analyse how deci-
sions regarding managing deviations were made in practice. In this research, the four roles are used to investigate micro-decisions, which may add to an extension of the theory.

Finally, in order to describe general activities and characteristics of loosely coupled decision-making processes observed in the case study, I searched for a decision-making model which contained the appropriate concepts and definitions. As described in the previous research chapter, I reviewed different decision-making approaches and models before coming to the conclusion that the garbage can model of decision-making (Cohen et al., 1972) was the most appropriate one. I deem the model appropriate since it describes decision-making as activities where objectives may emerge spontaneously, which means that they are not defined in advance. This corresponds well with the view of managing deviations as an emergent process. Further, the model states that during decision-making the issue may have cause and effect relationships which are too complex to identify and understand. I regard this as a major characteristic of making decisions regarding managing deviations in practice. Finally, the model also characterises decision-making as processes where actors search for issues, and existing solutions which match. When a match is found between these, a decision is made. This characteristic is descriptive of decision-making in practice, where I have observed actors searching for problems, opportunities, and even existing solutions. The existing solutions can be found by involving experienced actors who have experienced both similar and dissimilar situations.

4.4 Loosely Coupled Systems

Organisations are often described as a means to achieve the common goal of creating value, and are considered “goal-seeking systems” (Koskinen, 2011). In order to achieve these goals, the organisational system is designed using logical structures where processes, including activities, are connected in such a way that they should result in the common goals of the organisation (Choo, 2004). However, if organisations and projects are analysed more in detail, a picture of more loosely coupled activities within organisations emerges. Such activities are a necessity in order to manage activities in practice, which means that these activities are not necessarily governed by processes, plans, or methods (Hällgren, 2009b). I share this view of organising, and have used this as a basis for understanding the mechanisms behind the studied phenomenon in this research. Temporary loose couplings allow deviations in tightly coupled systems to be isolated and acted upon, preventing them from spreading throughout the entire project organisation, as well as allowing the organisation to retain its identity (as argued by Weick, 1976). I searched for a theory which could be used for categorising praxes related to
loosely coupled activities, and Orton and Weick (1990) describe how the ability of a system to manage a deviation is determined by “responsiveness” and “distinctiveness”. Responsiveness describes the ability to absorb change. Distinctiveness, meanwhile, describes the ability to retain logical or physical distance (separating the deviation from the regular organisation).

Hällgren (2009b) has used these two mechanisms of creating loosely coupled systems in order to manage deviations. The decoupling patterns (see Table 6) were identified by Hällgren (ibid), and show how actors managing a deviation create both distinctiveness and responsiveness. Hällgren (ibid) showed that management action is initially dominated by one of the processes, while attending to the other dominates in the later stage. This creates two different action patterns. In other words, the two different strategies can be acted out in different sequences. The carefully assessed actions can be described as a strategy of planning and acting, while good enough actions can be described as a strategy of acting and reflecting. The studies of Hällgren (ibid) were made in power plant construction projects, and I wanted to investigate the strategies within the context of complex product development projects in the manufacturing industry. Further, I aimed to investigate the strategies from a decision-making perspective. Therefore, I related these two strategies (see Figure 14) to different types of decision-making episodes and used these strategies to investigate and describe decision process (episode) design in detail. To compare results, I related “carefully assessed actions” and “good enough actions” to related praxes and, in turn, decision roles.

Figure 14. The two decoupling processes (Hällgren, 2009a).
4.5 Sensemaking and Sensegiving

Product development project processes are about learning, acting, and making decisions. This process can also be described according to a sensemaking process (Weick, 1995) as follows: project managers continuously working to understand the current situation and taking step by step actions and reflecting on suitable responses based on the feedback received from the organisational environment. Each step represents a decision which may play several different roles, not only choice, which is a part of the evolving environment.

In contrast to Satisficing, Muddling Through, the Garbage Can, and the Mixed Scanning models, Sensemaking views the first step towards making a decision to be gaining a sense of the current organizational environment in order to develop an understanding that can be used as a context for organizational action (Choo, 1996). Weick argues, “The basic idea of sensemaking is that reality is an on-going accomplishment that emerges from efforts to create order and make retrospective sense of what occurs” (Weick, 1993, p. 635). Sensemaking focuses on how those involved construct meaning in a constructed reality. I also share this view of sensemaking, which focuses on how actors construct meaning in a constructed reality.

A sensemaking approach views human behaviour as an unfolding process, which is in contrast to the typical assumption that decisions are the triggers for action. Contrasting this view of sensemaking with classical decision-making, Chia (1994, p. 794) describes decision-making as imposing order on streams of events and as a “product of a post-hoc rationalisation process”. Decision-making is also seen as “our projection of purposive and intentional behaviour onto those we observe and analyse” (Chia, 1994, p. 795). Sensemaking theory de-emphasises people as rational actors and argues that much of what we do is articulated and understood only in retrospect (Weick, 1995). Therefore I have observed actors’ praxes (acts) and described them as emergent processes.

Choo (2004) proposed a model of sensemaking on a macro-level in organizations which views sensemaking processes as a continuous process of making sense of the environmental input of organizations which in turn is the input to organizational knowledge creation and decision-making processes. Vlaar et al. (Vlaar et al., 2006) also showed how actors in inter-organizational interactions use formalization as a means to make sense of their partners. Vlaar et al. (ibid) identified the mechanisms of how formalization assists sensemaking by focusing actors’ attention, provoking articulation, deliberation and reflection, instigating and maintaining interaction, reducing judgement errors and individual biases, and diminishing the incompleteness and inconsistency of cognitive representations. Since product development projects in large manufacturing companies often involve interactions with external stakeholders, these findings are considered important in order to understand the nature of Sensemaking in such project activities.
Sensemaking theory also show that projects are not simply the execution of well-developed plans but are, “Weickian sensemaking activities, as the project management team copes with ambiguity, uncertainty, and complexity” (Weick, 1995) in (Williams and Samset, 2010).

Besides viewing and analysing Sensemaking as an emergent process, it can be approached as a structure, or network, of more or less connected parts. Pooled interdependence, Sequential interdependence, and Reciprocal interdependence between parts are suitable for different types of problems solved by, routine, heuristic, or emergent actions. (Weick, 2005) This means that different types of organizational structures can cope better with different types of problems and again adds to the complex balance between reactive and controlled actions.

The amount of dependencies of interrelated projects and activities in large product development organizations means that even small deviations most likely require management attention called on by project managers (Hällgren, 2009b). Further, since consequences of deviations can have far reaching consequences and spread rapidly throughout the product development organization, the project managers often need to involve project external actors and stakeholders. The amount of actors involved in decision-making processes when managing deviations therefore often involve not only individual sensemaking but also interactions with other actors in order to communicate and influence other’s evolving view of a deviating situation, i.e. Sensegiving.

Sensegiving is a related construction which focuses on how people intentionally try to influence how other people interpret and perceive situations. Weick et al. (2005, p. 416) have described sensegiving as “a sensemaking variant undertaken to create meanings for a target audience.” Maitlis (2005) identified four different types of sensemaking processes in a study of leader and stakeholder interaction while managing issues together (see Figure 15).
Figure 15. Four types of organisational sensemaking (Maitlis, 2005).

The four types of sensemaking correspond to observations made in this research early on in case study B, and were therefore chosen as a basis for analysis and descriptions of practices. The project team developing the complex product system was observed to be constantly engaged in multiple sensegiving and sensemaking processes in order to create a common understanding together with stakeholders. This was critical for the team in order to be able to take action. Commitment and support from management members was also often vital when manoeuvring a project through a deviating situation.

**Guided organisational Sensemaking**
- Process characteristics
  - High animation
  - High control
- Outcomes
  - Unitary, rich account
  - Emergent series of consistent actions

**Restricted organisational Sensemaking**
- Process characteristics
  - Low animation
  - High control
- Outcomes
  - Unitary, narrow account
  - One-time action or planned set of consistent actions

**Fragmented organisational Sensemaking**
- Process characteristics
  - High animation
  - Low control
- Outcomes
  - Multiple, narrow accounts
  - Emergent series of inconsistent actions

**Minimal organisational Sensemaking**
- Process characteristics
  - Low animation
  - Low control
- Outcomes
  - Nominal account
  - One-time compromise action

**High Sensegiving**

**Low Sensegiving**

**Stakeholder Sensegiving**

Guided organisational sensemaking processes is described by Maitlis (2005) as the systematic and confidential approach of leaders used to interact with multiple stakeholders which is often planned in advance and provides high control of processes. The processes are also often highly animated, which means that the processes involve a high level of interaction between leaders and stakeholders. The outcome of guided sensemaking processes
leads to a deep, common understanding of the current situation (Maitlis, 2005). In product development projects, guided sensemaking relates to structured processes guided by the project team or a stakeholder. Guided sensemaking also related to Häggren’s (2009a) concept of “carefully assessed actions” and the link to a more rational design of decision processes.

*Fragmented organisational sensemaking* results when the process is *animated* but not *controlled*, which leads to issues not being settled between parties. These sensemaking processes also often remained active over a long period of time. (Maitlis, 2005) In product development, this type of process is often meant to be overcome by the use of different structured methods, clear responsibilities, and clear roles. However, as this research aims to highlight, the use of such structured methods may also increase the amount of deviations.

*Restricted organisational sensemaking* occurs when processes are *highly controlled* but not very animated. Leaders communicated general solutions to issues that stakeholders often accepted with few alternative suggestions (Maitlis, 2005). In a product development project, such a process is related to situations where project managers and the team are given the opportunity to act as they see fit.

Finally, *minimal organisational sensemaking* results from processes that are neither *controlled* nor *animated*. The process is characterised by leaders and stakeholders engaging in low levels of sensegiving. In these processes, parties tended to await the other’s solutions to issues, which was often a response to external triggers (Maitlis, 2005). This kind of process reflects day-to-day work in product development projects. This is because many issues arise in the organisations the project managers need to quickly manage or disregard in order to have time to focus on the most important issues inside and outside the project. In some cases, it might be that an issue is thought to be someone else's responsibility (and therefore no actions are taken, or a compromise is made to manage the issue). Due to the fact that these processes receive short attention from project managers, they are also difficult to observe in practice.
CHAPTER 5 – A Study on Decision-Making

Characteristics

In Chapter 5, which concerns the research clarification stage, I will start by describing Companies X and A. Thereafter, the data collected in DC1 and DC2 are presented. Next, the analysis of the data is presented. Finally, the results are also presented. The overall process of data collection, the analysis of Case study A, and the overall disposition of the chapter is illustrated in Figure 16.

Figure 16.
The overall process of collecting data and the analysis in the case study.

5.1 Company "X"

Company X is a mid-size international company which owns two other mid-size manufacturing companies in Sweden and North America. The company also owns two sales organizations in central Europe, one in Asia, and one in Sweden. Company X operates in a market which includes competitors with products of similar capacity, quality, and functionality. Therefore, the product development activities are increasingly focused on bringing innovative technology and products to the market at an increasingly rapid pace. The company's core competence is within heavy machinery development. No machinery components except for electronics and software are produced at the main location in Sweden by the company. Instead, they are delivered by sub-suppliers, and assembled, tested, and shipped to retailers as a whole product. The company is successful, which is shown by the presence on the
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![Figure 16. The overall process of collecting data and the analysis in the case study.](image)

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2003 list for greatly growing businesses in Sweden, which means they have grown by 25% per year for at least five years in a row. The company employs 66 people in Sweden and 16 in North America, with a turnover of 20 million € per year. They sell approximately 300 products per year on the global market, all of which are individually configured, with regard to mechanics and electronics, for individual customer needs.

Company X has a product development project governance structure with decision bodies, as seen in Figure 17.

![Figure 17. Decision body structure of Company X.](image)

At Company X, the Steering Committee (SC) includes the CEO and the Product development senior manager, who oversees the different project activities in the company. The project managers report to the SC, which in turn oversees the project team members’ work. Team members vary over time in projects and can represent Market, Engineering, Production, Aftermarket, and logistics functions in the company.

A development project at the company always starts with a client need or request. They come from the international sales organisation, an email directly from a client, or a personal meeting with a client in the field. Depending on the type of change considered, one of three types of projects are initiated. Company X uses a gated governance model in order to govern their three types of development projects, called Revision of Component, New Component, and New Product (see Figure 18).
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At Company X, the Steering Committee (SC) includes the CEO and the Product development senior manager, who oversees the different project activities in the company. The project managers report to the SC, which in turn oversees the project team members’ work. Team members vary over time in projects and can represent Market, Engineering, Production, Aftermarket, and logistics functions in the company.

A development project at the company always starts with a client need or request. They come from the international sales organisation, an email directly from a client, or a personal meeting with a client in the field. Depending on the type of change considered, one of three types of projects are initiated. Company X uses a gated governance model in order to govern their three types of development projects, called Revision of Component, New Component, and New Product (see Figure 18).

The type of projects in which the company can take full advantage of the gated governance model is in the New Project processes. The New Product process means developing a new product, and includes reusing the latest product architecture to a large extent, as well as technologies. This is the kind of project investigated in this research.

5.2 Company “A”

Company A is owned by an Industrial Group which owns several large international manufacturing companies with headquarters and main development activities in Sweden. The Industrial Group senior management team includes CEOs from the individual companies. Each company, such as Company A, has its own senior management team which oversees the respective company’s activities. In Company A, the product development organisation contains several decision bodies which decide on various issues depending on the amount of investment related to the issue. The decision bodies are divided into a strategic and an operational council. These two management councils are higher decision bodies for a technology platform council, as well as a product platform council. They oversee steering committee (SC) activities and decisions. The steering committees monitor and support the Head Project Managers (HPM), who manage the individual projects (see Figure 19).
In Company A, all projects carried out are required to use a common company-wide gated process model in order to guide and organise project phases, decisions, gates, and activities. In the introduction of the booklet describing the overall process, the following is stated: “The ability to execute projects in a structured way is critical to success. The [Process] defines such a structure and is the basis as well as the minimum requirement for product development at [Company A]”. I have illustrated the company’s development processes which are divided into gates, phases, and gate decisions (see Figure 20). Gates are stop/go checkpoints where project management confirms that different criteria are met, presents plans for the next phase and gate, and updates the project prediction of final delivery and eventual risks. A steering committee decides if the project is allowed to pass the gate. Gate decisions are made by decision bodies in the organisation about project funding, and funding requests are prepared by project management in cooperation with the steering committee.
Figure 19. Decision body structure of Company A.

In Company A, all projects carried out are required to use a common company-wide gated process model in order to guide and organise project phases, decisions, gates, and activities. In the introduction of the booklet describing the overall process, the following is stated: “The ability to execute projects in a structured way is critical to success. The [Process] defines such a structure and is the basis as well as the minimum requirement for product development at [Company A].” I have illustrated the company’s development processes which are divided into gates, phases, and gate decisions (see Figure 20). Gates are stop/go checkpoints where project management confirms that different criteria are met, presents plans for the next phase and gate, and updates the project prediction of final delivery and eventual risks. A steering committee decides if the project is allowed to pass the gate. Gate decisions are made by decision bodies in the organisation about project funding, and funding requests are prepared by project management in cooperation with the steering committee.

Figure 20. The process model used in projects at Company A.

According to Company A’s model, before the Pre-Study phase, there are two additional phases conducted in order to assess the business opportunity and the feasibility of the planned project. These two phases are used to plan activities aimed at ensuring, “product quality, shorten product development lead time and reduce business risks” (Company booklet). The organisation of projects is carried out with four integrated roles in the company. First, a decision body overviews projects from a strategic profitability perspective and authorises project funds. Second, a steering committee (SC) ensures the project progress from a quality perspective (product and process). Third, project management is the operational driver of the project. And finally, line organisations support the project with resources, methods, and infrastructure. When the concept study phase is concluded, a final concept choice is expected to have been made in the project.

5.3 Characteristics of project decision-making (DC1)

During the interviews in DC1 (Company X), four areas of discussions emerged as dominant regarding the characteristics of the project managers’ and the team members’ decision-making processes. The areas of discussions concerned how the organization viewed their common processes, what situa-
tions were viewed as important for decision-making, the responsibilities for making decisions, and their decision-making behaviour.

For the most part, the actors’ statements regarding their views of their common processes were expressed differently depending on the interviewee’s role in the company. One would say that a project was successful in some regard, while someone else considered it a total failure. “It did not turn out right, but it wasn’t a total loss. We learned quite a lot and could use that [acquired] knowledge in later projects.” (A mechanical engineer) “…we developed expensive components and untested technologies when it was to be produced, but we just carried on. It probably went wrong in every possible way. It was a technical failure, and did not sell either.” (A steering committee member)

Since the projects in Company X were governed by the company’s gated model, the projects were expected to follow the process accordingly. But this was not the case in the investigated projects, not even the successful project. Different actors were active in the project at different times during the project, and decisions made and aspects considered changed meaning when team members entered or exited the project. This was expressed as synchronisation problems in the organisation. “We could definitely synchronise our process more in the light of the handovers in the projects”. Several project team members also expressed how the ability of the project managers to communicate the overall state of activities in the projects in turn impacts the team members’ ability to react to evolving issues and changes. “…the overall state of the project is not discussed in general during the project.” (A mechanical engineer)

The team members viewed the design process to be run according to the gated model, with some exceptions in later gates. "When the [detailed] design work is initiated, it is a matter of getting the product to the market within our timeframe. After that [the finalized design], it is about feeling content with what we got." (A mechanical engineer) According to a project manager, the process was not as simple as earlier stated. “It was a total surprise that the prototype became so expensive [component costs], and that it became even more expensive in series production. In summary, it took a long time between finished design and series production, and it became very expensive.” (A project manager)

The different actors viewed performance aspects of the project and the product differently given their role and what had occurred in the project. For team members who were coping with technical problems, time became less important. Meanwhile, for management, it became even more important. Also, the focus on certain performance aspects changed during the project lifecycle for the project managers and team members. Although steering committee members viewed priorities for projects to be cost, quality, and
time, the project members tended to focus on quality in the early phases, cost in late phases, and time after the project was finished.

Regarding the interviewees’ statements regarding decision-making situations of importance, there were two kinds of meetings expressed, planning and reviewing meetings. In these meetings, different types of uncertainties were expressed to be managed. First, the planning meetings can be considered to be the gate meetings of the project where the attending actors from management and the project manager discussed and decided about directing and organising activities and resources. Second, the review meetings were weekly meetings where actors from management, project managers, and functional experts gathered and discussed current and relevant activities, short term plans and changes that had occurred impacting the project activities and assessed product performance at that time. These review meetings gave input to a weekly priority list which the team members used to prioritise between activities in the project. "It is really good for everyone to see when it is updated and redirects work. It informs the team what is to be prioritised at that time in the project." (A project manager)

Regarding the interviewees’ statements concerning the responsibilities for making decisions, three levels of responsibilities with different characteristics were discussed: management, project management, and functional experts. On a management level, the responsibilities were of a market strategic character. However, they also involved detailed technical choices. "The output from the strategic level also involves detailed knowledge regarding design." (An electronics engineer) On a project management level, the responsibilities expressed were all related to managing the overall state of the project. "One hopes for having an overall view when looking at consequences, but if someone does, it is the project manager." (A mechanical engineer)

And finally, on a functional expert level, the responsibility was directly associated with the role each team member had in the company. The team members were expected to contribute detailed knowledge and suggestions on decisions related to their area of expertise.

The overall view in the company was that there was too little focus on efficiency in projects and that it was the management's responsibility to emphasise this aspect's importance in order to balance the performance focus in the project teams.

Finally, interviewees’ statements regarding their decision-making behaviour involved detailed descriptions of how decisions were made, or sometimes how time had become the ruling criteria.

The management in the company was always involved in projects through the project managers and influenced what performance aspects were prioritised during the process. In different meetings, the management organisation as a whole discussed what the current situations in the different projects were, and what the plans were. The project managers brought these priorities
into their respective weekly project review meetings, where the team discussed the current state of the project, what changes had occurred, and what suggestions there were on actions and decisions. Each team member, representing an organisational function, was responsible for giving suggestions which they synthesised during the week, between review meetings. “We discuss something on one meeting, solve it between, and nail it down on the next meeting. I do not think we make any detailed decisions on the short time during the meetings...”

Statements were also about the changing organisation of decision-making in the organisation, as a response to a need for developing more innovative products and taking bigger leaps in development projects (in other words, managing a higher level of uncertainty). The organisation of decision-making processes changed from a centralised management level to a decentralised expert level in order to enable flexibility in managing evolving processes and circumstances in projects. “It has changed a lot during the last couple of years. Management is releasing more and more responsibility on different levels. That change is still going on.” (A project manager)

5.4 Characteristics of a decision on a deviation (DC2)

In this section, I will describe the data collected during the deviation episode investigated in DC2. The project was initiated by Company A to investigate and realise potential efficiency improvements in two product systems. The deviation related to one of these two systems (called System 1, see Figure 21).

![Diagram](figure-21.png)

*Figure 21.* The system developed in the project to be included in Machines 1 and 2.
By conducting semi-structured interviews with actors involved in the management of the deviation episode, I was able to construct the timeline which represents the main decision activities stated in interviews. When asked about the decision-making process, the interviewees’ answers could be illustrated as a classical decision-making process, such as the models taught in most engineering design methodology books. The responses involved identifying the opportunity to make a decision and clarifying the current situation, identifying options, evaluating the options, and making a decision. The interviewees gave statements about the process and which factors had influenced the process.

The project was a typical project at the company, with team members from different functional departments, who sat in different offices, different buildings, and in different countries around the world. In the deviating situation, project external actors were also involved from different functions and levels in the global organisation. Different stakeholders were affected and involved in the investigated decision-making process – the project team members, management, market, manufacturing, and aftermarket. “A decision must be made with input and with regard to all these [stakeholders].” (A project manager)

Integration was a major factor which influenced the way in which the decision-making process was managed. The integration of temporary actors meant that different views were introduced in the team work. ”There exists a “we and them” way of thinking between different functions, groups, and stakeholders, which makes it difficult to have an understanding of each other’s areas.” (A project manager)

Processes grew out of following plans, as well as adaption to changes in the project, to which this investigated decision-making process was no exception. The company did not have any outspoken practices for managing changes in the early phases of projects. ”In early phases, there are many changes, and we do not have any structured way of managing these. We document as much as possible and as good summaries as possible”. (A mechanical engineer)

During the management of the deviating situation, the project manager had a hard time evaluating consequences of the strategic decision which triggered the whole situation, since it was not always obvious who was responsible for different aspects of the decision. The decision organisation was not a given when a deviation occurred. “Unfortunately, the decision hierarchy is not clear”. (A project manager) In order to clarify who was influenced and responsible for different aspects of the situation, the project manager used a practice in which the task of assessing consequences was split between the project team members. “When one is to investigate consequences within the whole (of the project) and in detail, the first thing is to bring them up (the alternatives) in the project team so all get to go home and look at the
impacts they have on their specific area, and bring the conclusions back. Otherwise, it is easy to miss something that will impact on a certain aspect."

It was not only the consequences that were identified by such practices, but also the criteria by which alternatives were judged. “We checked the cost and necessary resources and took it to the steering committee, who said that it was too much money right now and also that it was too much risk with the "new content". These types of decision criteria were introduced along the decision-making process. In addition, criteria in general tended to be flexible depending on what the team learned along the way and was shown in changing goals. “The time plan is the most obvious guiding means also when it comes to goals. That is, the goals and requirements we put up are relevant as long as we can reach them within the time frame set in the project." This way of making decisions was seen by management as an inappropriate decision culture that was hard to manage. “I want to make decisions with care and with facts on the table, but my experience is that that is not the culture of making decisions here.” (A quality manager)

The wish to work with facts expressed itself as a tendency by management to overvalue the accuracy of early information delivered by the project team. Team members expressed that communication was a delicate matter. This was because what was said or written about an assessment could be seen by management as hard facts and held against the team later on. "Depending on where we are in a project, in relation to the development model, information means different things. That fact can definitely be an explanation for why the management level in the organization writes [early developed] things in stone too early."

Regarding uncertainty in general, a manager stated, "We make decisions with great uncertainties but act as if we are sure. I think that the decisions we are uncertain about, and where we risk taking decisions on uncertain grounds, we get to regret in the form of quality deficiencies later on in the process and thereby lose market shares and all that follows with competitive advantage and profits." There were several sources of uncertainty in the deviating situation. One was due to the fact that the project team could not understand on what premises three volume scenarios were based. “We put together data, but, market for example, does not tell us on what grounds the scenarios are based and what levels of revenue the different scenarios will result in. Different organisational functions lack knowledge about other functions' work practices, which makes it difficult to interpret the data without knowing what lies behind it”. (A manufacturing engineer)

Statements by interviewees were also about how goals were uncertain in early phases and made managing the deviating situation difficult. “The related projects, which are our customers, want our project to run on full speed, but they have not decided specifically what they want delivered from us. We should let the [customer projects] decide what they want before we begin,
instead of fiddling around with the requirement for a long time.” (A project manager) The project team needed to resolve the deviating situation without having specific goals to meet, and needed to assess what the goals could be in the end of the project. The involvement of the customer projects was an issue that the company was working hard to improve at that time.

Coordination was stated as a major influencing factor on the decision-making process by several interviewees. “There is no efficiency in that process because we risk little or much of the work to end up in the garbage can [if the customer changes the requirements]. However, the common schedule is so tight that the reasoning is that we have to accept the situation and take any changes that come our way.” (A project manager)

The evolving nature of requirements was stated by most interviewees as an influencing factor on the decision-making process since it presented a major uncertainty for the project team to manage during the process. “An issue that has been ever-present is the management of requirements, which is not structured, including the management of requirement changes in the project.” (A mechanical engineer) The changing requirements presented a challenge for the project team when managing the deviation since it was not clear what the current state was of the requirements. “We need a structured way of managing [requirement] changes. It cannot enter requirements into the project from the side. If we agree on a changed requirement, it requires certain things [to be agreed upon] as we act on the knowledge we have obtained regarding the consequences of that change.” (A project manager)

The project managers did use certain methods and support systems in order to structure and analyse the vast amount of information produced and gathered by the project team, and a new tool for change management processes was on the way.

5.5 Analysis of data collected in DC1

To be able to analyse the data collected in Company X, a literature review was made and a theoretical framework developed. By identifying what is considered to be input, the process, and output from changes in projects, a categorisation of major objects of consideration were developed and used for analysing the empirical data (see Table 8).

Table 8. The theoretical framework used for analysis of empirical data of DC1.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>PROCESS</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>Process of management</td>
<td>Planning</td>
</tr>
<tr>
<td>Circumstances (of the change)</td>
<td>Content of process</td>
<td>Performance aspects</td>
</tr>
<tr>
<td></td>
<td>Goals</td>
<td>Unresolved uncertainty</td>
</tr>
<tr>
<td></td>
<td>Resources</td>
<td></td>
</tr>
</tbody>
</table>
By categorising empirical data according to the theoretical framework, I identified major elements to be considered when making decisions regarding project changes in practice when planning and deciding on a course of action after a change has occurred in a product development project. The summarised interviews were printed, and the data categorised by colour markers. Each colour was summarised and put as one category in a table (see Table 9).

Table 9. Analysis by categorisation of empirical data of DC1.

<table>
<thead>
<tr>
<th>INPUT</th>
<th>ELEMENTS TO BE CONSIDERED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisation</td>
<td>Complexity of multidisciplinary cooperation and the concurrent execution of activities,</td>
</tr>
<tr>
<td></td>
<td>four parties: reference group, project manager, experts in team, and project external</td>
</tr>
<tr>
<td></td>
<td>experts or stakeholders.</td>
</tr>
<tr>
<td>Circumstances (of the change)</td>
<td>Initiated internal or external a project, caused by complex interactions in the organisation.</td>
</tr>
<tr>
<td>PROCESS</td>
<td>ELEMENTS TO BE CONSIDERED</td>
</tr>
<tr>
<td>Process of management</td>
<td>Tentative decisions, clarification, identification of consequences and impact, proposals of actions to meet changes, governed by a reference group and other influential stakeholders in the organisation; project managers govern the overall state of the project.</td>
</tr>
<tr>
<td>Content of process</td>
<td>Uncertainties of different aspects –including the process itself.</td>
</tr>
<tr>
<td>Goals</td>
<td>Progression, costs, quality, time, and requirements.</td>
</tr>
<tr>
<td>Resources</td>
<td>Financial, people, and time.</td>
</tr>
<tr>
<td>OUTPUT</td>
<td>ELEMENTS TO BE CONSIDERED</td>
</tr>
<tr>
<td>Planning</td>
<td>Planning enables improvisation when changes occur, synchronisation of concurrent activities, and critical line considerations.</td>
</tr>
<tr>
<td>Performance aspects</td>
<td>Effectiveness and efficiency, input, output, goals, resources, validation and verification loops.</td>
</tr>
<tr>
<td>Unresolved uncertainty</td>
<td>Downstream considerations, displacement effects, performance aspects, requirements, and plans.</td>
</tr>
</tbody>
</table>

5.6 Analysis of data collected in DC2

The analysis of data collected in Company A during DC2 was made in a manner similar to the analysis of data from DC1. By constructing a theoretical frame, the data was analysed using categorisation and important elements to be considered were identified. The theoretical framework was constructed
by summarising major aspects to be considered in literature on decision-making in product development projects (see Table 10).

Table 10. The theoretical framework used for analysis of data of DC2.

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>DECISION PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>Framing performance aspects</td>
</tr>
<tr>
<td>Planning</td>
<td>Process of decision-making</td>
</tr>
<tr>
<td>PERFORMANCE</td>
<td>GROUP ASPECTS</td>
</tr>
<tr>
<td>Aspects</td>
<td>Communication</td>
</tr>
<tr>
<td>Measures</td>
<td>Interactions</td>
</tr>
<tr>
<td>Links to decision-making</td>
<td>Group decision-making aspects</td>
</tr>
<tr>
<td>ORGANISATION</td>
<td>METHODS</td>
</tr>
<tr>
<td>Levels involved</td>
<td>Use of methods</td>
</tr>
<tr>
<td>Functions involved</td>
<td>INDIVIDUAL ASPECTS</td>
</tr>
<tr>
<td>Validation and verification processes</td>
<td>Individual decision-making</td>
</tr>
</tbody>
</table>

The aspects were illustrated as a model of collaborative decision-making (see Figure 22). The illustration was made to give an overall view of the theoretical framework and to show the links between the important elements to be considered that were included.

Figure 22. A model of decision-making in product development projects.

A commonly used governance model in manufacturing industries is some variant of a gated process. These models are broken down into planned activities and tasks in order to plan for the stated deliveries. The tasks are related to performance, as the difference between the input and output is a measure of the amount of knowledge created. By comparing the output with stat-
ed goals, effectiveness can be assessed. Further, by comparing the output with the input and the amount of resources spent, efficiency can be assessed. The three overall elements of performance of a task (input, goals, and resources) are related to decision-making by the answers they give when clarified. Input (current knowledge) provides answers to what we know at the start of a task. Goals give answers to what we want to achieve (do), and resources provide answers to what the limitations are, what we can do. These are the three pillars on which decisions rest. These are not given before a task is carried out; rather, they need to be clarified through a process of decision-making. Each activity is a part of a web of tasks which contribute to the overall performance of a project. The activities are often divided on different organizational levels in order to manage strategic planning, portfolio management, and project management including the project team. Between these levels, there are feedback loops which enable verification and the validation of project work. In the decision-making process, communication and interactions between actors (individuals) are paramount. In product development, it is often vital to integrate organisational functions and organisational levels in order to coordinate the expertise each of these possesses and create knowledge about the complex product being developed. In the process of communicating, the production of knowledge and information is facilitated by different practices and methods. A major factor in this decision-making process is also the human aspects brought in by individuals which affect the process and results in a large extent.

The single deviation episode was investigated by first mapping activities considered by actors to be critical for the decision-making process (See Figure 23). The process was identified and described in detail in order to investigate what factors had influenced the decision-making process when managing the deviating situation. (In the figure, “A” stands for Alternatives and “Eval.” for Evaluation).
Further, by categorising empirical data according to the theoretical framework, major elements to be considered and specific influencing factors when making decisions on project changes in a product development project were identified. The summarised interviews were printed and the data categorised by colour markers. Each colour was summarised and put as one category in a table (see Table 11).
Table 11. Analysis by categorization of empirical data of DC2.

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>ELEMENTS TO BE CONSIDERED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>Formal processes, decision hierarchy, decision bodies, steering committees, organisational rules, and stakeholders of the project.</td>
</tr>
<tr>
<td>Planning</td>
<td>A holistic view in planning activities (main time plan), continuous meeting agenda (gates, reference meetings, team meetings, and functional meetings), enterprise resource management, and the manning of project.</td>
</tr>
<tr>
<td>PERFORMANCE</td>
<td></td>
</tr>
<tr>
<td>Aspects</td>
<td>Input (current knowledge), output (new knowledge), goals (market needs, for example), and resources (e.g., budget).</td>
</tr>
<tr>
<td>Measures</td>
<td>Effectiveness, efficiency, efficacy, productivity, and competitiveness.</td>
</tr>
<tr>
<td>Links to decision-making</td>
<td>Input-knowledge, goal-wishes, and resource-capability.</td>
</tr>
<tr>
<td>ORGANISATION</td>
<td></td>
</tr>
<tr>
<td>Levels involved</td>
<td>Decision bodies, Steering Committees, Project managers, project team members, and line organisations.</td>
</tr>
<tr>
<td>Functions involved</td>
<td>Functional integration, the line organisations</td>
</tr>
<tr>
<td>Validation and verification processes</td>
<td>Feedback loops between levels.</td>
</tr>
<tr>
<td>DECISION PROCESS</td>
<td></td>
</tr>
<tr>
<td>Framing</td>
<td>Evolving criteria, evolving objectives, knowledge of uncertainties, trade-offs due to limited resources and knowledge.</td>
</tr>
<tr>
<td>Process of decision-making</td>
<td>Identification, objectives, alternatives, evaluation, and choices.</td>
</tr>
<tr>
<td>GROUP ASPECTS</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Organisational integration, functional integration, involvement of expertise areas, understanding of other groups tasks, information, and shared information systems.</td>
</tr>
<tr>
<td>Interactions</td>
<td>Coordination of tasks, temporary interactions between the project and stakeholders or experts.</td>
</tr>
<tr>
<td>Group decision-making aspects</td>
<td>Decision culture, communication of premises, sharing of information, common views on situation, common view on information, common views on goals, shared strategies, political aspects of issues, and authority.</td>
</tr>
<tr>
<td>METHODS</td>
<td></td>
</tr>
<tr>
<td>Use of methods</td>
<td>Financial analysis, consequence analysis, volume scenarios, Product specifications, change management, Gant schedules, QFD, FTA, FMEA, and information systems.</td>
</tr>
<tr>
<td>INDIVIDUAL ASPECTS</td>
<td></td>
</tr>
<tr>
<td>Individual decision-making</td>
<td>Roles, preferences, decision heuristics, decision-making styles, rationality, and intuition (experience based knowledge).</td>
</tr>
</tbody>
</table>
From these categories, the identified factors were compared to a classical
decision-making process in order to identify the elements of such a process
in this case. Out of the identified elements, there were eight that directly
related to the classical decision model.

- Goals (management of goals on different levels in the organization).
- Alternatives (alternative generation and selection).
- Criteria (in order to select alternatives).
- Consequence analysis (decision analysis).
- Uncertainty (of information, environment, and the decision situation).
- Trade-offs (between performance aspects).
- Information (uncertainty, and communication).
- Decision-making praxis (the steps the actors took to carry out decisions).

5.7 Results from DC1 and DC2. A research clarification

The analysis of data from DC1 provided the results which show what ele-
ments are thought to be important to consider when making decisions re-
garding changed situations in product development projects. Three overall
clarifying questions were used to guide the design of a mindset. The first
question was: *Who are included in the decision-making process of a project
manager?*

By abstracting the detailed findings of the analysis, the elements of input,
process, and output was selected in order to illustrate these. The selected
elements of planning situations when a project change has occurred were
found to be the parties which communicate regarding the occurrence. The
parties were simplified to include a project reference group, the project man-
ager, the experts in the team, and external experts. The deviating situation
can be initiated by any of these parties. Two types of external changes were
identified, requests or imposed. A request for a change may be denied by the
project manager and team, while an imposed change needs to be addressed
regardless of whether the project manager and team agree.

The perceived impact of a change determines if the reference group,
stakeholders, and experts should be involved in the process of resolving the
deviating situation. The project managers discuss the change with the in-
volved actors. They also evaluate and plan for the change with the team in
order to determine the impact on different expert areas and the project as a
whole.

The second question posed to guide the design of the mindset illustration
was: *What do project managers decide about in planning and reviewing
situations?*
A suggestion of actions to meet a project change needs to be developed and formulated to provide a basis for future decisions in the project. This suggestion of action needs to be validated within the group and the stakeholders, depending on the impact of the change on the project organisation. The decisions made during planning and reviewing aimed at adapting to a change involves the aspiration to still be able to deliver a successful project and product. What a project manager decides upon in general planning and reviewing situations are the following: the progression of the project, the budget and cost allocation, the manning during different project stages, and the acceptance or modification of suggestions of actions to meet changes in a project.

In order to facilitate the clarification of such planning situations, a model of a mindset regarding the planning situation was developed (see Figure 24).

![Figure 24. The planning situation’s input and output.](image)

The model illustrated the elements important to consider when planning the next steps after a project change has occurred. It illustrates the input to the situation, as well as the output. This illustration shows the characteristics of a planning situation in the occurrence of a project change.

The third, and final, question used to guide the design of the illustration of a mindset was: What are the essential objects to be considered during project management decision-making?

The essential elements to be considered have been found to be related to both project and product performance, which could be considered the delivery for a project manager. The essential objects to be considered related to project performance are: the project life cycle including its interactions with stakeholders, the project progression and tractability, the tasks in relation to...
A suggestion of actions to meet a project change needs to be developed and formulated to provide a basis for future decisions in the project. This suggestion of action needs to be validated within the group and the stakeholders, depending on the impact of the change on the project organisation.

The decisions made during planning and reviewing aimed at adapting to a change involves the aspiration to still be able to deliver a successful project and product. What a project manager decides upon in general planning and reviewing situations are the following: the progression of the project, the budget and cost allocation, the manning during different project stages, and the acceptance or modification of suggestions of actions to meet changes in a project.

In order to facilitate the clarification of such planning situations, a model of a mindset regarding the planning situation was developed (see Figure 24).

Figure 24. The planning situation's input and output.

The model illustrated the elements important to consider when planning the next steps after a project change has occurred. It illustrates the input to the situation, as well as the output. This illustration shows the characteristics of a planning situation in the occurrence of a project change.

The third, and final, question used to guide the design of the illustration of a mindset was:

What are the essential objects to be considered during project management decision-making?

The essential elements to be considered have been found to be related to both project and product performance, which could be considered the delivery for a project manager. The essential objects to be considered related to project performance are: the project life cycle including its interactions with stakeholders, the project progression and tractability, the tasks in relation to project performance, the budget (included in business), the team, and the delivery. The essential objects of consideration related to product performance are: specifications, the product life cycle, and product cost (included in business). By illustrating the essential elements to be considered during planning and reviewing situations specific in order to make project decisions with regard to both aspects of performance, Figure 25 was developed. The figure shows the important elements to be considered in a decision situation regarding a project change.

Figure 25. The project manager’s decision map.

The results of the identification of important elements to consider in planning activities shows the essential input and output of planning situations in a product development project clarifies the characteristics of such a situation. This model links empirical findings with the recommendations within prescriptive project management and design methodology literature. The second model, called the decision map, is an illustration of the essential elements of consideration when deciding on the next steps to resolve a project change. The two models are idealised compared to industrial practice and are thought to be used as a point of discussion when a change has occurred.

The analysis of data from DC2 in Company A gave further detailed knowledge regarding the important elements of consideration when making decisions on project changes; in this case a deviation episode.

When a deviation occurs, the overall task of collectively reaching an agreement on objectives in the organisation and using those objectives in order to reach a satisfying decision is vital for project performance. In the analysis, there were three overall factors of great importance identified, both in the literature and the case study: (1) the ability to frame a decision situa-
tion, (2) the procedure used for reaching the decision, and (3) the methods used during the procedure in order to support the decision-making process.

The ability to frame a decision situation (make sense of it) depends on the availability of expertise and information that enables the common understanding of the current situation and knowledge, what can be done, and what the preferred outcome of the situation might be.

The procedure used for reaching the decision is often described on an activity or task level of the process. However, if a detailed decision process is investigated, more specific factors determine the results of the task. The actors’ understanding of their behaviour (steps taken, praxis), clarifying and reaching common preferences, as well as their point of view depending of their role in the decision situation, will greatly influence the results.

Finally, the decision methods used during the decision-making process are of great importance. These methods include organizational rules, techniques, and infrastructure. Rules often seem to be a part of the decision-making culture and are not written down; rather, they are fostered through cultural behaviour of managers (practices). Techniques are different ways of investigating trade-offs or aspects of the decision situation (QFD, FMEA, or FTA, for example). The infrastructure of a decision-making process in a product development organisation is often the organisational map, IT-systems, and formal decision bodies.

These results show the characteristics of the process of making decisions on deviations in practice, and provide insight into the complexity of managing such a process in practice. The competency required to manage project deviations in practice is a combination of the ability to clarify a decision situation, the practises and praxis used, and the availability and use of support methods.

The results also point to important questions to further explore. Findings regarding important elements of consideration show the amount of aspects needed to be managed holistically by a project manager. They also present a challenge, since bounded rationality may pose a natural limitation to such a task. The question is how the project managers act in order to cope with these multi-criteria activities in practice? Further, the finding that objectives and decision criteria tend to emerge during the process in a deviating situation points to the importance of adapting to small or large continuous project changes in decision-making processes. The question is how is it done in practice?
In Chapter 6, Case study B will be presented. I will start by describing the data collected during DC2 within Company A with a focus on identified praxis. A description of data collected during DC3 within Company A follows. Then the analysis of the data collected in DC2 and DC3 within Company A is described. The description of findings from the analysis will then follow. In order to conduct an initial validation of the findings from data collected in Company A, data was collected in six additional companies (Company B-G), which is described. Finally, the analysis and results from DC4 are presented. The overall process of data collection, the analysis of the case study, and, indeed, the overall disposition of the chapter is illustrated in Figure 26.

Figure 26. The overall process of collecting data and the analysis in the case study.

6.1 Deviation “one”, a change of scope. DC2 reanalysed
In this section, I will describe in detail the decision-making process identified during the deviation episode investigated in DC2 with a focus on praxis.
By conducting semi-structured interviews with actors involved in the management of a deviation episode, I was able to construct the timeline (Figure 23) which represents the main decision activities stated in interviews. Further, the interviews also included statements regarding informal activities and actors' processes which revealed their praxes and practices.

The project team in Company A was working in the concept study phase when, on the 25th of May 2007, a strategic decision was made by the management council to manufacture and assemble an in-house designed machine component (“X”) in the factory at the company’s main site in Sweden. The new component was to be offered to customers as an option between component “X” and another, simpler component “Y” in machine M1 and as standard in machine M2. This meant that customers buying a machine of type 1 would be able to choose between two system features, the “X” and “Y” component. This introduced uncertainty regarding calculated sales volumes of component “X” and “Y”. Customer options for components “X” and “Y” was a strong requirement from the four market representatives in the company, Sweden, North America, Europe, and Asia. During the following period, the marketing department in Sweden conducted market surveys with market representatives and retailers regarding how much they could increase the price for machines containing component “X”. Component “X” was more expensive than “Y” but offered higher quality and less service. The answer from the different market representatives and retailers regarding a possible increase of customer price differed from 0 to 300 €. The marketing department gave the information to the management council. Together with product planning, they discovered that the business case for offering “X” as standard on M2 did not show positive numbers any more. Company A would, according to certain expected sales volumes, lose money in offering customers only component “Y” as a feature on machines of type 2.

The management council and the marketing department informed another management team of the new business case situation. The other management team insisted on measures in order for the business case to show positive numbers again. The marketing department also had indications that competitors were going to offer a less costly variant of component “X” as standard in their comparable machines. As a result, the marketing department felt that they could not omit offering this feature to the customer, at least as an option to component “Y”. At the same time, market representatives indicated that there could not be any increases in price on machines even if component “X” were chosen by customers. This presented a problem for the management council and team.

The management council and team went over the business case with the marketing department and product planning, and decided to change the previous strategic decision to include the options of having component “X” and
“Y” as options on both M1 and M2, in order to meet customer demands and to make a profit.

When the news of the new decision reached the manufacturing representative in the development team, it went contrary to all the expectations of the feasibility of the configuration and manufacturing costs, which impacted investments in production technology, component costs, and uncertainty in projected sales volumes. The manufacturing representative turned to an expert on production costs (a financial controller) and put forward manufacturing’s view of the situation. With the support of the project manager and other people in the organisation, the manufacturing representative managed to get management to withdraw the newly made strategic decision. By indicating high manufacturing investments, component costs, and uncertain sales volumes, the manufacturing representative made the management council feel uncertain about the strategic decision made. The management had some figures regarding these aspects presented to them before the decision was made, but these figures were different and contradictory to the old. The production representative in the project brought in two controllers to analyse and calculate different costs dependent on the volume scenarios related to capacity in production and the resulting need to invest in production technology. During this time, the team also found that a cost estimate of production costs related to component “Y” was off by ∼30% (too low), which gave component “X” an unfavourable cost ratio compared with component “Y”. “Std. cost (based on [component Y]) has increased 30% compared to the 1st estimation” (Document from a steering committee meeting).

This news came as a surprise to management, which reacted strongly to the big increase in expected costs for component “Y”. The management council then asked the industrialisation group (including the manufacturing representatives in the project) to do an in-depth analysis of component costs given two alternatives with three different sales volume scenarios for component “X” (100% of customers chose X in both M1 and M2, 20% in M1 and 100% in M2, 21% in M1 and 59% in M2). These three scenarios had also been important input for the management council and team when they made the latest strategic decision. The controllers, the experts on production costs, also had two alternatives upon which they had made rough calculations earlier on in another unrelated situation. These two alternatives had been investigated during the radical production re-organisation two years earlier. The project team now had four different alternatives to resolve the issue: (1) buying external components, (2) buying in-house designed components and outsourcing manufacturing, (3) manufacturing components at the home site, or (4) partly manufacturing parts of the components at the home site and outsourcing the rest.

The project team made an in-depth analysis, with the new decision as a prerequisite, of the four developed and identified alternatives, and reported
the resulting figures to the management council. The management council found two alternatives to be too costly, and asked the project to continue evaluating the remaining two other alternatives (manufacturing components at the home site, or partly manufacturing parts of the component at the home site and outsourcing the rest). The analysis continued in the project team, and the conclusions drawn were that options of “X” and “Y” made calculating production capacity and investments highly uncertain and posed a great risk of high costs. Large variations in unexpected volume ratios would lead to under or over capacity depending on the level of investments in new manufacturing equipment. The team found that if the decision were options of “X” on both machines M1 and M2, costs in production would increase significantly and impact component costs, where component “X” would increase by ~8%. The team’s common recommendation to the management council was to not offer options on component feature “X” due to cost increases and the cost risk from uncertainties in production capabilities, including outsourcing alternatives. Management still decided to once again offer options of “X” on both machines M1 and M2 and adopt the last alternative, partly manufacturing parts of the component at the home site and outsourcing the rest. The component will still be assembled at the home site. The project manager of the project wrote in the formal decision document: “Marketing has not found it possible to increase the price on the machines so [component “X”] can be included as standard. The project has presented the consequences with [component “X”] as option. Management has decided to offer [component “X”] as an option on [M1] and [M2] anyway”.

6.2 Deviation “two to thirty-eight” (DC3)

The second data collection in Company A was made in a project aimed at developing a new technology platform system to be included in several future products and product models.

The company’s approach to concept selection choices in this project was what is called Set-based Concurrent Engineering (SBCE), a principle included in the “Lean Product Development” (LPD) framework (Ward et al., 1995). SBCE promotes making choices between a set of alternative solutions by eliminating the least promising alternative during the process until only one is left to implement. This is an approach in contrast with the often used “point-based” (PB) approach. The PB approach means that, early on in the process, multiple alternatives are considered and compared and one is chosen for detail design and industrialisation. The benefit of the SBCE approach is that alternatives are compared over a longer period of time compared to the PB approach, which enables the resolution of more uncertainties before a final alternative is decided upon. The SBCE approach was used in the pro-
The resulting figures to the management council. The management council found two alternatives to be too costly, and asked the project to continue evaluating the remaining two other alternatives (manufacturing components at the home site, or partly manufacturing parts of the component at the home site and outsourcing the rest). The analysis continued in the project team, and the conclusions drawn were that options of "X" and "Y" made calculating production capacity and investments highly uncertain and posed a great risk of high costs. Large variations in unexpected volume ratios would lead to under or over capacity depending on the level of investments in new manufacturing equipment. The team found that if the decision were options of "X" on both machines M1 and M2, costs in production would increase significantly and impact component costs, where component "X" would increase by ~8%. The team's common recommendation to the management council was to not offer options on component feature "X" due to cost increases and the cost risk from uncertainties in production capabilities, including outsourcing alternatives. Management still decided to once again offer options of "X" on both machines M1 and M2 and adopt the last alternative, partly manufacturing parts of the component at the home site and outsourcing the rest. The component will still be assembled at the home site. The project manager of the project wrote in the formal decision document: "Marketing has not found it possible to increase the price on the machines so [component "X"] can be included as standard. The project has presented the consequences with [component "X"] as option. Management has decided to offer [component "X"] as an option on [M1] and [M2] anyway."

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The observed project was tightly interrelated with another project conducted by an Industrial Group internal sub-supplier of technology to the platform being developed. Further, three other, related technology development projects were on-going and needed to be synched, as well as four product development projects where the developed platform was going to be included. The product development projects developed the products which were to be sold in different configurations to customers in the company’s four markets (described in Section 6.1). See Figure 27 for an illustration of the project’s interrelated projects and their respective steering committees (SC). The technology development project driven by the Industrial Group internal sub-supplier (external Company A) had its own organisation and steering committee. Another Company, also a Industrial Group internal sub-supplier, was rolling out a new technology platform which Company A had to develop further to fit their own products. This implementation project also had its own steering committee within Company A. The projects were overseen and governed by a range of decision bodies, as described in Section 5.2, in the company, and most formal interactions between the project managers and the decision bodies took place in the steering committee meetings. The thick arrows between the observed project and other related projects in Figure 27 illustrate the interdependencies, where most interactions and communication took place during the time I observed the project. Interaction and communication did occur with the other projects as well, but not as much so.
A large amount of planned project activities in the observed project went by without encountering any problems, issues or deviations. Many planned activities and deliveries were simply carried out and “ticked off” in the process management system. The following descriptions, however, focused on providing examples of overall interrelated issues and circumstances in the evolving activities of the observed project. These overall issues were often the sources of deviation in the observed project. The descriptions provide the opportunity to understand the unplanned side and circumstances of the project which impacted the way managers, the HPM, and the team made decisions regarding managing deviating situations.

The observations started on 12 August 2009, and were first focused on understanding the project organisation, governance, and purpose described earlier in this section. The project team observed had great experience developing the kind of technology platform system being developed, and the collaboration with the group internal sub-supplier was also something the team had experienced in earlier, recent projects. The sub-supplier had a major development project on-going developing technologies, some of which would be included in the technology platform project in Company A. The Industrial Group, which both Company A and the sub-supplier were a part of, had invested a great amount of resources in the sub-supplier’s project. It had also made a decision that parts of the technologies resulting from that
project were strategically important to reuse in as many projects as possible within the industrial group’s companies. However, since the project was ongoing, it presented risks for the project for Company A if the sub-supplier’s project was delayed or failed to develop expected technologies in whatever way. The sub-deliverer people involved in the technology development project in Company A were keen on reusing the “strategic” technologies their related project believed would be the result of that project. However, Company A was sceptical about simply accepting those upcoming technologies, for two reasons: risks for delays and failure existed, and a recent, similar project with a speedy concept decision had resulted in a large amount of rework and wasted resources. That specific project had also been a collaboration between Company A and the sub-supplier, and it had suffered from collaboration difficulties due to the problem following the concept decision. Therefore, a joint initiative from both companies was started to overcome the difficulties in the current common projects.

In Company A, both the management and the project team now wanted to investigate a range of system alternatives in a systematic manner. Therefore, Company A insisted on using Set-based Concurrent Engineering (SBCE) as a common method for investigating and eliminating concepts until the “most promising” concept was determined. Managers at Company A employed a consultant in order to educate the teams at both companies. In the middle of December 2009, the development manager and the HPM spoke in the HPM’s office about the “lean method” of SBCE. The development manager said, “I got a go ahead from [the sub-deliverer] late last week to use our Lean thinking method in the project.”

The technology platform system being developed in the project can be illustrated as in Figure 28, where the responsibility of Company A and the sub-supplier also can be seen (Dark grey is Company A responsibility, light grey is sub-deliverer responsibility). The technology system can be considered to be highly integrated, since the functionality of the overall system was highly sensitive to each sub-systems’ interrelated functionality. If the engineers “tweaked” the output function of A1 just a little, it could have a huge impact on the functionality of sub-system S3, for example. This made the overall system extremely difficult to balance. However, some sub-systems could be considered modular and could be replaced by continuously improved sub-systems (S4, for instance).
The sub-supplier was responsible for providing parts of the technology platform system (S1-4). Meanwhile, Company A was responsible for designing the system so it could be included into the different types of products at Company A, as well as other functional parts of the technology platform system (A1-3).

August 2009 – Main time plan issues
In the beginning of August 2009, in the middle of the Feasibility Study phase, the project manager at Company A was informed about a substantial difference between the main time plan at Company A and the sub-supplier. It was due to the fact that the sub-supplier team wanted to synchronise the project with the other project, from which technology could possibly be reused. “Time schedules not synchronised between [sub-supplier] and [Company A]” (SC meeting document). The HPM began to focus on managing this discrepancy, which threatened the possibility to adhere to the main time plan of the project at Company A. The HPM involved managers and other stakeholders in order to resolve the situation.

September and October ran according to plan (according to the HPM), and the project team focused on collecting requirements from the product development organisation and establishing formal contracts and routines with the sub-supplier.

November 2009 – Still main time plan issues, and a budget scenario
On 10 November, the project team went through a gate audit activity where the status of the project was assessed and recommendations regarding upcoming gate decisions were made to the steering committee before the gate meeting of the pre-study phase. The project had just gone through the feasi-
bility study phase where the feasibility of the project was assessed by collecting stakeholder needs and translating these into overall requirements. These requirements had been analysed and risks assessed in order to plan upcoming phases and activities. The work with managing system requirements, however, was behind schedule, and the team experienced a lack of resources (although this was not considered a major issue just yet). The main time plan discrepancy was listed as the biggest issue which needed to be resolved. Uncertainty in the synchronisation between other technology projects was also listed as critical for the HPM to monitor. The issues were presented by the HPM in the steering committee meeting a week later. At the meeting, the issue of the main time plan was considered a sign that the sub-deliverer wanted to promote the use of technology from their related ongoing project. The project at Company A was allowed to progress into the pre-study phase of the development process.

A week later, a small group of managers at both companies met to discuss the reuse of technology systems and project costs. A scenario was discussed where the common project budget (including both companies’ efforts in the project) would be half of the planned and decided budget. As such, an unexpected, possible project goal was introduced to the HPM and both of the project teams: what can be developed if the budget is cut in half? The HPM reluctantly accepted the challenge of taking on this huge extra effort in the project. Stakeholders were notified and charged with clarifying the implications of the scenario question.

A week later, the HPM presented the status of the project in a Cross-Functional Management Meeting (CFMM). The issue of the main time plan was discussed, and a manager volunteered to try and help to resolve the issue. Three meetings had already been held between the two companies and solutions had been discussed. However, the parties had not been able to reach a common understanding of a direction forward. Further, a project scope was shown in the CFMM which included five types of products including twenty different models. “This is the current [scope] plan for us now.” (HPM). Another issue came up regarding whether the platform system development project would include the requirement from a specific type of market. Further, an immediate need was to get the product projects up and running as soon as possible (in order to be able to synchronise them in a proper manner).

December 2009 – Main time plan synchronisation

During December, the project team received a decision on further financing for the pre-study phase of the project. Three meetings were held with two product development projects and the sub-supplier, respectively, to work
with the synchronisation of the main time plan. Thereafter, it was time for the Christmas holidays.

January 2010 – Scope changes and reuse of technology

In the beginning of January 2010, another CFMM was held, and the HPM presented the status of the project. The main time plan discrepancy had been resolved, resulting in a tightened project plan (a 30 week reduction) for the team at Company A. Still, the project goals were considered achievable if the team was continuously supported by the line organisations in the company. A possible change in the scope had been requested by the product planning function in the organisation to be investigated in the project. This meant more unplanned activities for the project team. Meetings with stakeholders and requests for information followed.

In the middle of January, the HPM and the EPM were seriously concerned with the sub-supplier’s pushing for the reuse of technology from the sub-supplier’s related project. The HPM and EPM wanted to make sure that several different platform system alternatives were considered. The HPM talked to the development manager, who in turn contacted managers at the sub-supplier, in order to get confirmation that they were open to other alternatives outside the “strategic” decision in order to make concept selection according to the agreed upon SBCE methodology. At the end of January, the HPM and the EPM received a concept evaluation matrix containing ten concept systems from the sub-supplier. The systems included alternatives suggested by Company A’s project team. The team gathered for a meeting in order to discuss and understand the proposed ten concepts, and the project team put together a list of questions for the sub-supplier to answer. At that meeting, the EPM also announced that the preparations for the activities related to the development of sub-system A1, while running late, were still manageable, since a new team member has been brought in to oversee those activities.

February 2010 – Another scope change, reuse of technology, and lack of resources

In the beginning of February, a meeting was held at the sub-supplier site where different technologies and consequences on costs, processes, and production were discussed. Further, in the discussions, it was quite clear that the sub-supplier team was implying that six or seven system concepts should be eliminated before the initiation of the concept study phase. Several arguments were presented by the sub-supplier team, including prototype order and build lead time, resource limitations, references to the common main time plan, and the “strategic” technology system reuse decision. The con-
cluding words of a manager at the sub-supplier were: “We now need to carry on towards the concept gate where we will eliminate some concepts. We can’t carry on with ten concepts!” During the week, the HPM, managers, and the EPM discussed how they were going to be able to convince the sub-supplier to accept going forward with several alternative system concepts. They agreed to show the many uncertainties surrounding the ten concepts and to focus on the fact that the risks of introducing untested technologies were legitimate and important arguments. After another week of e-mailing, phone calls and meetings, the sub-supplier eliminated two alternatives the Company A team also regarded as suitable for elimination due to performance and cost issues. The “strategic” technology concept was still in the running. If more than two or three concepts were to be investigated during the Concept study phase, the HPM needed to request additional funds and resources in order to manage the activities.

In the end of February, another gate audit is conducted, and the status in the project was assessed. The HPM stated: “It is a big job aligning different managers and steering committees regarding the concept choices.” Three more concepts were suggested for elimination, and the SBCE consultant was currently producing trade-off curves in order to better understand the feasibility of these concepts. Meanwhile, a project manager expressed his concerns regarding the concept elimination choices: “the criteria for choice can be sensitive in this case… cost, politics…” Regarding the synchronisation of product projects, two out of the four product projects had been initiated. The other two were hard to get going. The HPM also expressed his concerns regarding the amount of work and current available resources (manning) in the project. Manning had suffered due to “fire fighting” in another development project which was entering its last phases, thus demanding vast amounts of people to cope with industrialisation and ramp-up.

March 2010 – No new scope and the budget scenario

In the beginning of March, the managers and the team worked hard to conclude risk assessments, system quality assurance plans, and cost estimates. The results showed that the highest and most important risks were related to the choices of sub-systems A2, A3, S2, and S3. The team therefore started planning proactive activities, which the line organisations had agreed to support with resources. A steering committee meeting was held in order to decide whether the project would pass the concept study gate and continue into the concept study phase of the project process. The HPM presented the status of the concept system elimination matrix. The HPM stated that the team had two “favourite” concepts at that time (neither was the “strategic” technology system). The HPM also asked the product planning representative in the steering committee if the project scope was decided. The representative said
that it would be decided on in two weeks. “The scope change is postponed until two weeks then” (HPM). Some steering committee members were concerned that not all of the product projects were up and running. The HPM agreed that this could present a problem if left unattended and that the HPM needed help from the managers to get these projects going (not the responsibility of the HPM). A manager accepted that responsibility and agreed to try to influence the two specific product development organisations (located both in Sweden and abroad).

In the middle of March, a formal meeting with the sub-supplier was held to investigate the consequences of the scenario of cutting the budget in half. The conclusion from the meeting was that the obvious alternatives were to cut the project scope or technology platform features. Further, the meeting resulted in many new detailed questions which needed to be investigated, and the responsibility to answer these questions was divided between the two teams. In order to answer the questions, the product project teams also needed to be involved in order to assess consequences. This was difficult as two of these projects had not been started at that time. The scenario was also hard to investigate since it required the gathering of an extensive amount of information and would still involve major uncertainties. “How do we stitch this together so it becomes manageable. It could be combined into an infinite number of alternatives.” (HPM). The parties agreed to limit the investigations to cost assessments of the ten existing alternative system concepts. During a subsequent team meeting, the HPM and the team decided who would investigate the various parts of the Company A scenario.

April 2010 – Late product development projects and stranded in Peking

During April, the team worked hard to get the product projects involved in the development efforts and conducted simulations of integration of the technology platform system concepts in each product type and models. During a trip to one of the product development organisations abroad, the HPM and the EPM became stranded in Peking on their way home due to the ashes from an erupting volcano on Iceland circling the European skies. The managers back in Sweden tried in every possible way to assist the two managers to cope with the situation and get them home as soon as possible. After five days’ delay, the HPM and the EPM arrived in Sweden. The rest of the project team had managed all project activities without any resulting delay.
May 2010 – Scope changes, lack of resources, late product development projects, budget scenario, and reuse of technology

In the beginning of May, another CFMM was held. There the HPM alerted the managers that one of the product organisations had made an unexpected request of a prototype, “This prototype is not currently in the project budget” (Document shown by the HPM in the CFMM). The HPM suggested two possible solutions: “[The project] project to investigate possibilities for using a [similar technology] for performance evaluation” or “Support for additional founding – steering committee.” (Ibid). The recommendation from the HPM was to accept suggestion one, due to budget restrictions “Recommendation: Acc. to action no.1 due to budget restriction.” (Ibid). The next issue raised by the HPM was that the project suffered from an unstable project scope at that time. He presented nine changes of product models and sales volumes which had occurred in the project regarding the scope. “Unstable pre-requisites for [the project]” (Ibid). This unstable aspect of the project made it hard for the team to evaluate the technology platform concepts in a proper manner. As a result, the team had made its own assessments of what the scope should be for the project, which the HPM now presented for the managers, “Proposed basis for concept evaluation.” (Ibid). All extra work in the project at that time had now meant the team could manage no additional work, and the HPM requested additional manning in order to support the work of the EPM.

The next day, the sub-supplier team expected that the related “strategic” technology project would pass their concept gate in order to proceed with their concept study phase. The project did not pass (it was not even close), and the gate was postponed a month. This meant that the resulting technology from the project would start production several months later than planned. The team at Company A was concerned, and initiated evaluation to understand the consequences for their joint project with the sub-supplier.

Another steering committee meeting was held, the HPM presented the status of the project, and the same issues were raised as in the CFMM three days earlier. Also, the issue of the inclusion of requirements from a specific market discussed earlier was deemed to be outside the scope of the project. Further, the request to investigate the scenario of cutting the budget in half was questioned by several managers and discussed, as well as the different late scope changes introduced in the project. “[The HPM] is not supposed to have to deal with these kinds of issues four weeks before concept selection.” (a manager) A senior manager agreed, and said “This way of acting is not ok from a management perspective.” They agreed that the HPM and several managers would meet to clarify the situation, formalise scope changes, and plan ahead regarding scope and related activities. The steering committee approved additional support for the EPM. Finally, the suggested scope provided by the HPM and the team was approved by the SC. This meant that the
During the following two weeks, the project scope, uncertainties in simulation work on sub-system S2, support of the EPM, and other issues were worked on. The scope changes were formalised, and an experienced engineer supported the EPM in his work with the technical requirements. However, the team at Company A felt increasingly uncertain about the feasibility of sub-system S1, as well as the overall concepts. The team did not feel comfortable with the start of production delay in the “strategic” technology project. They called for a formal meeting with the sub-supplier. The two teams met and discussed the consequences of the delay, as well as the state of the different sub-systems and concepts. The sub-supplier promoted a specific type of sub-system S2 and pushed hard to eliminate another. The team at Company A resisted elimination at that time. The argument of the sub-supplier for elimination was that prototypes needed to be ordered right away if these were to be produced and assembled on time. Another discussion related to technology risks resulted in a cost assessment. Once again, the scenario of budget cost cuts was introduced, but with a less aggressive goal. The team could just upgrade the selection criteria of project cost in the priority list. The team agreed on this, and felt this was a productive act since the project cost had an extensive impact on product cost in the end. The discussion also resulted in the common view that the type of technology promoted by the sub-supplier for S2 was a high risk regarding cost. A manager from the sub-supplier said, “I’ll run it by my boss, who is leaning towards [another technology concept], and see if he goes crazy.” The choice of S2 technology was still considered uncertain by both teams.

The same day, product planning sent a formal request to the HPM to include investigations of the inclusion of the requirements of a specific market again. The HPM felt (after some informal meetings) that he had most of the SC members’ support to reject the request. However, it needed to be formally supported in the steering committee. The HPM informed his team of the request, and no actions were initiated.

The sub-supplier had at that time started planning a commonality project related to the “strategic” technology project. This was done in order to investigate the possibilities of reusing technologies within the industrial group’s companies. This related project proved to be the source of the most serious deviation in the technology platform project four months later.

During the next two weeks, uncertainties surrounding sub-systems S1, S2, and A1 were investigated in both teams in order to be able to eliminate some system concepts at the concept gate. The sub-supplier team passed their concept gate and entered the second half of the concept study phase of their project. The team at Company A was working towards their concept gate when they were told that product planning opposed the project's passing the
gate. The argument was that the impact of leaving out the requirement of the specific market in the project scope needed to be investigated. The approach from the project was to let the product planning, SC, and project organisation managers sort the issue out. “I’m going to be as quiet as possible in this matter.” (HPM in a team meeting). The sub-supplier manufacturing representatives also wanted to prevent the project at Company A from entering the concept study phase. They were going ahead with several alternative concepts of sub-system S4, which they meant was impossible from a production capability and cost viewpoint. Only one type of S4 technology was going to be manufactured by the sub-supplier, which also pointed to high manufacturing costs as a consequence if not adhered to.

June 2010 – Scope change, reuse of technology, lack of resources, and planning pro-active activities

In the beginning of June, a steering committee meeting was held where a decision was to be made regarding if the project was to be allowed to proceed or not into the second half of the concept study phase of the process. During the last two weeks, the two teams had agreed on eliminating all but two technology platform concepts. The two remaining concepts were the “strategic” concept and a “favourite” concept of the team at Company A. The concepts were accepted by the SC. The HPM informed the SC of the lack of manning in the project at that time. It also requested support in order to cope with the intensified work with executing proactive activities. Regarding the issue of the sub-supplier not supporting the project to pass the gate, a sub-supplier manager declared that no such strategic decision existed and that two different alternative technologies for S4 could be further investigated. This allowed the project team to consider both alternatives in the last stage of the concept study phase and presented no reason for blocking the gate. The responsibility for the project scope issue once again was pointed out by the SC to belong to product planning. The SC also noted that the HPM and two managers from product planning needed to sit down and divide the responsibility for investigating the consequences of including the specific market requirements. The project passed the concept gate.

A meeting took place the following week regarding the project scope, and the issue was sorted out. The work continued in the project and focused on generating data, information, and knowledge reading sub-systems S1 and S2. The team at Company A felt uncertain about the validity of some simulations made by the sub-supplier, and inquired about assumptions and models used in the simulations. The project team also wanted to make some of the planned simulations. However, they met resistance when they tried to be included in the simulation plans.
Meanwhile, sub-system S2 leaned towards the “favourite” of Company A. This presented a political problem since it was not from the “strategic” technology system project. In order for the sub-supplier team to be able to promote technology other than a developed sub-system from the “strategic” project, the two teams needed to find valid reasons for eliminating the “strategic” technology. As it turned out, an unexpected event enabled the team to find just that. The “strategic” development project had fallen behind regarding the S2 sub-system development and validation, which meant that the lead time became a possible “show stopper”. The two teams could now together legitimise promoting the “favourite” technology for the S2 sub-system, which everyone felt was the right way to proceed at that time.

At the same time, as discussed in the last SC meeting, a big focus on executing proactive activities was promoted by managers and line organisations. However, the HPM experienced a lack of resources (manning) in the project team, which was coping with a large amount of diverse activities already. Still, a group of managers and consultants responsible for supporting the project in product quality methodology had initiated an extensive quality and risk management program which was expected to be executed jointly by the two projects. The planning activities carried out before the initiation of the quality and risk program had been extensive, and resulted in over two hundred planned activities which the joint project now was expected to execute. The HPM and the development manager discussed what the program meant in terms of work, but they needed to gather all involved to create a common understanding of what was expected and what the team could cope with.

The sub-supplier also pushed for concept elimination in order to order prototypes. The work with the now up and running product projects had provided insight into the difficulties of finding feasible alternative technologies for sub-system S3. A plan between the two teams for selecting technologies for sub-systems A2, A3, S1, and S3 was created in order to focus their efforts before people went on summer vacation.

Finally, at the end of June, the HPM and the EPM had a meeting with another company within the Industrial Group which had also planned to start a similar project with the same sub-supplier. At the meeting, a discrepancy in information provided by the sub-supplier regarding an eliminated technology platform system concept was discovered, and could not be understood. The sub-supplier was contacted several times during the week, and the matter resulted in a common view between the teams. The choice of technology for sub-systems S1, S2, A2, and A3 was starting to converge between the two teams which now started focusing on investigating S3 technologies. Two types of S3 technologies were investigated. One was a more developed concept than the other, but both had different uncertainties which needed to be understood before a choice could be made. Suddenly, it became clear for the team that the delay in the “strategic” technology project at the sub-supplier...
had resulted in a change of manufacturing capacity for producing and assembling prototypes at the time when the team had planned to use this manufacturing capacity. Both teams quickly booked a common meeting at the manufacturing site and assembled. At the meeting, the teams (including manufacturing representatives) explored and discussed options and prerequisites of building prototypes. The meeting resulted in a common view regarding when, how, and under which conditions the prototypes could be built. The plan was tight but achievable.

July 2010 – Planning pro-active activities

In the beginning of July, a steering committee meeting was held where the HPM described the current status in the project. The elimination of the “Strategic” S2 technology, A2 as well as A3 technologies was suggested by the HPM. This proposal was approved by the SC, which meant that A2, A3, S1, and S2 were finally formally decided. However, the issue of the extensive work with proactive activities was still not fully understood. The HPM requested both additional resources (manning) and assistance gathering the right people to clarify the situation.

At the end of that week, most team members went on summer vacation.

August 2010 – Budget planning, loss of team members, requirement lists, scope change, and reuse of technology

The project activities recommenced with full force in the middle of August, and the requirement specifications were sent out to stakeholders for signing. Also, a new budget definition process had been implemented in the company which the HPM now needed to learn and adhere to. To the HPM’s surprise, the new budget was due in a week, which engaged the HPM that week. Many technical questions remained regarding the S3 sub-system and its interactions with the other sub-systems. Meanwhile, the sub-supplier was becoming more anxious about the facts that prototypes had not yet been ordered and the building plan agreed upon earlier at the manufacturing site was tightening. The engineers responsible for the S3 technology intensified their interactions with the sub-supplier, and now had common daily meetings over the internet.

At this time in the project, the HPM and the rest of the team found it hard to pinpoint the project status: “It is chaos on all fronts right now” (EPM). Both the HPM and the EPM made inquiries regarding the status of different activities in the project. Several members of the team had revealed that they were leaving the project. The team at Company A held a team meeting as well, and went through each activity and responsibility at that time. In that meeting, the HPM announced that he was going to change position in Janu-
ary 2011 within the organisation, and would not be in the project from that date forward. A replacement was already in place and would follow the HPM until that point. Further, two other functional representatives were expecting a child together and announced that they were also leaving the project in early November. Replacements were already in place and would ease into the positions during the next two months. The meeting continued, and the HPM spoke about product planning. The HPM’s proposed project scope seemed to be accepted by all parties in the organisation, but it needed to be formally decided. The project manager responsible for the requirement specifications had difficulty getting the lists signed by some stakeholders, and asked the HPM to give those stakeholders a “nudge” in order for the lists to be signed on time. “I’ll do that.” (HPM). A new team member, who also attended the meeting, now supported the team and the EPM with executing proactive activities. Nonetheless, more manning was still needed in order to cope with the extent of the planned program. The EPM now focused all his attention on the selection of a feasible technology for the S3 sub-system, which was highly uncertain at that time. A joint meeting is held between the two teams in order to clarify the situation surrounding the S3 technologies. The meeting resulted in a “favourite” technology and a second which is considered a fall-back solution. They hoped to investigate both simultaneously during the detailed development phase because they realised that a comfortable level of knowledge would not be possible to achieve until the development gate. It was difficult for both teams to produce validated data and information in time.

Another meeting was held regarding the newly started project, with the purpose of promoting the reuse of “strategic” technologies within the industrial group. The purpose of the meeting was to jointly investigate which sub-technologies could be used in the technology platform system development project in Company A (small updated and improved technologies used in order to increase overall product quality). The result of the meeting was that the cost of reusing suitable technologies was high due to the interrelated nature of the technology. If one component was selected, a second component was necessary in order for the first to work. For the second component to work, a third was necessary, and so on. The teams, experiencing significant pressure from management to keep costs down, estimated the cost of the project to be too high.

The following week, another team meeting at Company A was held. In it, the HPM announced that the project scope was decided: it was to be the scope proposed by the HPM earlier, with the exception of an additional type of product. The HPM said, “We can look at the inclusion of the [product] as a request so we don’t need to include these yet in requirement lists for example.” The HPM counted on the product not being included in the scope at the end of the current project phase since it would probably be too expensive
to do so. The team had worked hard to produce and gain support for a plan for coping with the proactive activities which included that the work of executing the activities were supposed to be finished in April 2011. This would give them more time to get more manning for executing the planned proactive activities. Still, there was a lot of work to be done even with an increase in manning.

The EPM requested additional manning for helping out with clarifying the choice of technology for sub-system S3. The requirement list was still not signed by a stakeholder the HPM had “nudged” several times. The stakeholder in question was the additional product organisation seen as a request to be included in the scope. The team decided to bypass the stakeholder and get the support of the SC, and the requirement specifications were approved without the stakeholder. A decision on the amount of reused technology from the “strategic” technology project was now needed in order for the prototypes to be ordered. However, the team had not heard anything about the related status lately. The HPM started making inquiries in the organisation.

The following week a meeting between the HPM, EPM, engineers and managers from both Company A and the sub-supplier took place to discuss the choice of technology for subsystem S3. The meeting resulted in a common recommendation to select one of the technologies to develop further and to use another as a fall-back solution if the first did not work out as planned.

Finally, at the end of the same week, a steering committee meeting was held where the HPM presented the status of the project. A new organisation of the project was introduced, and the HPM requested more manning in order to cope with the planned proactive activities which got approved. The HPM showed the new project scope, but the “requested” product was not included (since it proved to be too expensive to include in the project). The scope was now finally decided. The HPM raised the issue of the reuse of “strategic” technologies, and inquired about when a decision could be expected. Several SC members were to examine this question.

September 2010 – Project goals, reuse of technology, technology project uncertainty, and main time plan issues

During the previous few months, the HPM had laboured to define the different goals for the project regarding costs, product quality, and product features. As a result, he now felt he had the support of most steering committee members regarding the specific goals. A meeting was held to go through the numbers with the senior director of development (who concurred on the assessed goals). However, the issue of the reuse of “strategic” technologies, which affected the project cost and product cost, was not resolved, making
defining these goals uncertain. Further, as the prototypes needed to be or-
dered and required the definition of several “bill of material” (BOM) lists,
the decision on the amount of reuse was critical for the project. The issue
had turned into a question of which company should pay for the develop-
ment of some of the “strategic” technologies, and the decision process had
fallen out of sight of the HPM. Consequently, the HPM contacted the senior
director of development and asked him to keep the team continuously in-
formed. The senior director of development made inquiries and attended
meetings at the sub-supplier on a management level in order to be able to
influence the decision and get it made.

The next week the team learned that the “favourite” technology for the S3
sub-system was only in its early stages of development, posing a greater
uncertainty than previously understood. Activities were intensified in the
team to create a common understanding of the situation. At the same time,
the plan for building prototypes was revised in order to adapt to changes in
the “strategic” technology project. The teams once again went to the manu-
facturing site in order to revise the plan and develop a common understand-
ing of the restricting conditions (certain types of technologies could only be
produced during certain weeks). The reuse issue became even more critical
since they did not know if they would be allowed to use certain types of
technologies (and therefore could not define the BOM lists needed to place
the order for prototypes).

At that time in the project, the HPM and several project managers in the
team felt torn regarding the question of passing the development gate and
entering the detailed development phase of the project. On the one hand,
they felt that there were many uncertainties still left to resolve regarding the
S3 sub-system, as well as some other issues. On the other hand, they needed
to make the order of prototypes as soon as possible. Without passing the
gate, the project would not have the approved funds to make the order. If the
development gate was not passed and no new funds were approved, a project
catastrophe would be a plain fact. The start of production would be delayed
several months.

At the end of September, a team meeting was held in which the HPM in-
formed the team of the status of the delayed reuse issue. The senior director
of development continuously informed the HPM of the progress. Nonethe-
less, it was hard to get any clear information about the process since it was
located in the sub-supplier’s organisation. The manufacturing organisation
resisted some of the “favourite” technologies of Company A since it would
be too expensive to manufacture both old and new technologies at the same
time. They wanted to reuse as much as possible of the new “strategic” tech-
nologies, which the Company A team felt was going to be too expensive for
Company A. The team wanted to select some of the “strategic” technologies,
which would have meant high quality at a low cost, and leave out the most
expensive “strategic” technologies. This became a complex issue, and reaching a decision on the matter took a long time. The issue of defining BOM lists reached critical levels.

Finally, the sub-supplier team had a steering committee meeting. The SC did not approve of going ahead with two types of technologies for the S3 sub-system. Instead, they insisted on a choice being made before entering the detailed design phase. The sub-supplier team also changed the common main time plan for the project in order to include the results from another related technology project at Company A. Further, it suggested postponing the development gate for a few weeks in order to resolve some critical uncertainties of the S3 sub-system. The plan, however, was too optimistic regarding some of the prototype test phases, and the team at Company A quickly rejected it. The plan was investigated in detail by the HPM and the different project managers in the team, and a meeting was held with other managers in the organisation.

October 2010 – Reuse of technology, main time plan, and project goals

At the beginning of October, the issue of reuse of “strategic” technology was beginning to be clarified, and rumours started circulating about a decision of full reuse of “strategic” technologies (in other words, all technology from the “strategic” project should be reused if technically possible). That meant that the team at Company A had no way of rejecting to the most expensive technologies. This was not yet officially decided, and the team prepared for two different scenarios: selective reuse and full reuse. Based on these two scenarios, they began putting together two types of BOM lists, one set of lists for each of the scenarios.

In the middle of October, a steering committee meeting was held at which the HPM presented the status of the project. After careful consideration of the new main time plan after the change by the sub-supplier, the HPM recommended to postpone the development gate a few weeks in order to be synchronised with the sub-supplier’s activities. This recommendation was approved, and the development gate was postponed until the middle of November. An unexpected change of assessed development costs received from the sub-supplier upset some of the SC members, and was discussed further by managers after the meeting. The HPM presented the defined goals of the project to be used during the rest of the project. However, a steering committee member unexpectedly opposed the level of one of the goals. A discussion was held, but the goals were not approved by the SC. The HPM was frustrated, saying to the development manager afterwards, “I did not get the goal approved even though I have been communicating these for a year's time…” The HPM was annoyed. A meeting was planned to review the goals and
reach a common understanding. Meanwhile, proactive activities at the sub-supplier had not been attended to in a proper manner (according to some of the project managers in the team), and the HPM now requested help in order to get that work up and running again. Some SC members were going to help with this issue by contacting managers at the sub-supplier. The reuse issue was still leaning towards the full reuse scenario. At that time, the HPM said that the resulting decision did not matter anymore. It was just important that the decision be made so they could order prototypes from the manufacturer. The senior director of development criticised the way the decision process had been managed between the sub-supplier and the Industrial Group Companies, and a meeting was held afterwards involving different managers at Company A to discuss how a decision could be promoted.

During the following two weeks, the managers at Company A made great efforts to get the decision on the reuse of technology in place. Still, the decision was not made. The team at Company A carried on with activities regarding sub-system S3 and other planned activities. Finally, both teams realised that they regarded the feasibility of a technology to be the same related to a concept which they considered to include the least overall uncertain technology for sub-system S3. A formal decision was made at both companies to choose the technology for further development.

At the end of October, another delay in the related “strategic” technology project at the sub-supplier was announced, once again threatening the time slots planned for the manufacturing of prototypes. The team decided to use the two sets of BOM lists to make two separate orders of prototypes and to cancel one set when a decision on reuse was in place. The team learned from various sources in the two companies that the reuse issue decision was lagging due to the facts that the “strategic” project, too, was lagging and the resulting technologies were uncertain at that time. The team requested to go to the manufacturer of sub-system S3, but was denied by the sub-supplier. The sub-supplier wanted to be the only contact for the manufacturer at that time.

November 2010 – Project description, system specification, and reuse of technology

At the beginning of November, a gate audit was held to assess the status of the project. Four major issues were presented during the meeting: the project description was not finalised, system specifications were not finalised, the consequences of the reuse issue were unknown, and the BOM lists were not decided on. The next week the team worked hard to finalise the project description and the system specifications. The decision on reuse was still not made. Therefore, the final decision on BOM lists could not be made either.
A week later, the decision for technology reuse was finally made by the sub-supplier’s management: full reuse of “strategic” technology. The HPM cancelled the other set of prototypes, and the assessments of consequences on costs and quality could be made. Further, the teams came to common understandings regarding technologies for sub-system A1 and S4. All sub-system technologies were now decided on. However, they did not fully correspond to the last technology platform system concept presented before. Instead, they included types of technologies both the sub-supplier and Company A had found to be uncertain solutions. Nonetheless, both teams and companies were satisfied with the final concept since the system as a whole now made sense to them related to set goals of time, cost, and quality aspects. A concept decision had been made.

Finally, in the middle of November, at a steering committee meeting, a decision was to be made regarding whether the project was to be allowed to proceed into the detailed development phase of the process. The HPM presented the status of the project description, which was finished. Although the system specifications were not finalised, an action plan was presented, stating that these were to be finalised in two months. All sub-systems were decided on. The S3 sub-system included the most uncertainties at that time. The HPM suggested a project organisation for the next phase. The project was allowed to pass the development organisation gate and to proceed into the detailed development phase of the project.

The analysis of the collected data in DC 2 and DC3 will now be described in section 6.3 to 6.5.

6.3 Reanalysis of data collected in DC2

In a first step of reanalysis of data collected during DC2, identified praxes were related to the four different decision consequences stated by Brunsson (Brunsson, 2007). A pattern of praxes was identified. It shows how praxis is used to reach sub-decisions that have specific consequences. The identified praxes and the relationship to the four decision roles can be seen in Table 12. This was done in order to answer the first research question, (RQ1): what roles do decisions play in practice when managing deviations? By identifying the use of different praxes and their relationship to decision roles, I was able to identify the different roles micro-decisions play in practice when managing deviations.
Table 12. Praxes, decisions, and consequences (Filter 2).

<table>
<thead>
<tr>
<th>Praxis</th>
<th>Sequence</th>
<th>Choice</th>
<th>Mobilisation</th>
<th>Responsibility</th>
<th>Legitimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seek external confirmation of deviation</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Call for attention</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Indicate wrong assumption</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Indicate deviation</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Revoke decision</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Request objective information</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Involve external expertise</td>
<td>7</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detach project time</td>
<td>8</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop alternatives</td>
<td>9</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reuse old alternatives</td>
<td>10</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Produce objective information</td>
<td>11</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confirm interim results</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Limit alternatives</td>
<td>13</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Produce objective information</td>
<td>14</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present final information</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Decide against proposal</td>
<td>16</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transfer responsibility</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

This analysis was presented in Appended Paper III of this thesis. There I considered micro-decisions made at the same time to be a part of the same decision if the decision roles were the same as well. In paper III, I reported that eleven micro-decisions were identified when reanalysing data from DC2 (by finding connected praxes related to the same decision consequence). The micro-decisions were: (1), (2), (3-4), (5-6), (7-8), (9-11), (12), (13-14), (15), (16), and (17). I have changed this view of shared micro-decisions, and I now consider these micro-decisions to be separate micro-decisions. This means that I regard the decision episode identified in DC2 to include 17 micro-decisions.

The 17 identified micro-decisions are quite many micro-decisions for a single decision episode compared to the decision episodes observed when
collecting data in DC3, which will be described in the next section. The conclusion I have drawn is that if data had been collected through direct observation during DC2, the episode would have included several decision-making processes related to the overall deviation during that period of time, which actors interviewed consider as a single decision-making process in retrospect. The limitations of semi-structured interviews probably contributed to a more general explanation, and resulted in statements about many praxes used during several decision-making processes during that time.

What the analysis show is how different decision roles are used to handle different types of uncertainties. This is illustrated in Figure 29. The Figure shows how the overall classical decision-making process in practice involves a series of micro-decisions as a response to the different types of uncertainties. Viewing a decision-making process in this manner allows for a detailed understanding of how and why a decision-making process evolves the way it does.

Figure 29. The identified pattern of decision roles in data from DC2.

6.4 Analysis of data collected in DC3

In the analysis of data collected during DC3, I needed to analyse the dynamics of interactions of the project team to describe the nature of the project. Therefore, I asked the HPM and the EPM if they would trust me with their e-mail boxes. They did, and I am greatly thankful for their trust. I performed a Social Network Analysis of the HPM and EPM’s email correspondence during the first year of the project in order to understand the width and dynamics of their social network. The analysis can be seen in Figure 30. There, the
large circle represents the HPM, and the smaller circle represents the EPM. A software called NodeXL was used for the analysis of the emails, and a Harel-Koren Fast Multi-scale algorithm and layout was used to identify natural groupings.

![Diagram](image)

**Figure 30. Social Network Analysis of the HPM’s and EPM’s e-mail interactions during the first year of the project.**

The closer an actor is to one of the two project managers, the more (frequent) interaction occurs between them. The analysis shows the amount of different stakeholders involved during the first year and the connections made between the two managers and stakeholders in the organisation. The stakeholders ranged from project internal experts (engineers, for example) to the CEO of the company to management members of the external sub-supplier company and related project. The interactions crossed functional, project, and organisational boundaries. The formal hierarchical chain of command was used when making formal requests, but partly ignored when making informal requests. In total, 664 people were involved to a greater or lesser degree, from only being informed to taking an active part in the project. Figure 30 represents a large extent of the project managers’ social environment affecting the sensegiving-sensemaking processes and interactions during decision-making regarding the management of deviations in the project. It shows both the level of complexity the project managers needed to relate to when managing deviations in the project and the large social resources they had access to.
In a second step of analysis of data collected during DC3, I identified what the project team experienced as episodes of managing deviations. By identifying statements, such as “FYI!” (Often from the HPM about urgent new matters) or “Decision regarding [reuse of technology] content needed!” (Issue raising in the project team meetings, the cross-functional reference group meetings or in the steering committee meetings), I was able to find the point in time when an actor reacted (started to communicate) to an experienced deviation. Since I was only present about 50% of the time in the project, I have certainly not been able to identify all the deviations experienced by the project team. Some of the deviations were managed during a single workday or in some cases during a few hours. However, I claim that the main deviations in the project were identified since these took place during a longer period of time.

Thirty-seven decision episodes were identified in the data collected during DC3, and they can be seen in Table 13. The table also includes the decision episode studied in DC2 (ID = 1). As in the previous section, this was done to answer the first research question (RQ1).

Table 13. The thirty-eight identified decision episodes from DC1 and DC2.

<table>
<thead>
<tr>
<th>ID</th>
<th>Deviation</th>
<th>ID</th>
<th>Deviation</th>
<th>ID</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Component X or Y?</td>
<td>13</td>
<td>Late requirements #2</td>
<td>26</td>
<td>Late resources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>Requirement review</td>
<td>27</td>
<td>Project delay</td>
</tr>
<tr>
<td>2</td>
<td>Responsibility of test</td>
<td>15</td>
<td>Software off-line</td>
<td>28</td>
<td>Delivery date delay</td>
</tr>
<tr>
<td>3</td>
<td>Synch of project plans</td>
<td>16</td>
<td>Requirement signing</td>
<td>29</td>
<td>Installation re-planning #2</td>
</tr>
<tr>
<td>4</td>
<td>Lead time on alt. component</td>
<td>17</td>
<td>Manufacturing capacity</td>
<td>30</td>
<td>Quality information</td>
</tr>
<tr>
<td>5</td>
<td>PMs stranded in Peking</td>
<td>18</td>
<td>Requirement process</td>
<td>31</td>
<td>Sales requirements</td>
</tr>
<tr>
<td>6</td>
<td>Stretch target</td>
<td>19</td>
<td>Preliminary request</td>
<td>32</td>
<td>Platform input</td>
</tr>
<tr>
<td>7</td>
<td>Component information</td>
<td>20</td>
<td>Component supplier</td>
<td>33</td>
<td>Component size</td>
</tr>
<tr>
<td>8</td>
<td>Responsibility of simulations</td>
<td>21</td>
<td>Installation re-planning #1</td>
<td>34</td>
<td>System effect</td>
</tr>
<tr>
<td>9</td>
<td>Change of project scope</td>
<td>22</td>
<td>Re-organisation #1</td>
<td>35</td>
<td>Development cost calculation</td>
</tr>
<tr>
<td>10</td>
<td>Strategy of choice of system</td>
<td>23</td>
<td>Re-organisation #2</td>
<td>36</td>
<td>Data quality</td>
</tr>
<tr>
<td>11</td>
<td>Missing representative</td>
<td>24</td>
<td>Re-organisation #3</td>
<td>37</td>
<td>Information request</td>
</tr>
<tr>
<td>12</td>
<td>Late requirements #1</td>
<td>25</td>
<td>Risk management</td>
<td>38</td>
<td>Reuse of components</td>
</tr>
</tbody>
</table>

The third step of the analysis was made by analysing the actors’ resulting micro-decisions on managing the deviation. Brunson’s (Brunsson, 2007) decision roles were used to codify each praxis’ relationship to a decision.
role. As an example, the identified deviation “reuse of technology” can be seen in Table 14.

### Table 14. Analysis of the deviation “reuse of technology” by relating the actors’ praxis with decision roles.

<table>
<thead>
<tr>
<th>Decision episode</th>
<th>Decision roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation</td>
<td>Choice</td>
</tr>
<tr>
<td>Reminder</td>
<td>x</td>
</tr>
<tr>
<td>Information gathering</td>
<td></td>
</tr>
<tr>
<td>Mobilisation</td>
<td>x</td>
</tr>
<tr>
<td>Use experience</td>
<td>x</td>
</tr>
<tr>
<td>Reject responsibility</td>
<td></td>
</tr>
<tr>
<td>Create alternatives</td>
<td></td>
</tr>
</tbody>
</table>

As described in Section 6.2, the issue of “reuse of technology” re-emerged several times during the process, and it finally resulted in a deviation when the expected strategic decision was not made at the time expected. The deviation can be described as building up over a long period of time (i.e., a cumulative deviation). The project team responded by reminding several managers of their responsibility to make the decision [reminder]. At the same time, an analysis of possible consequences of the absent decision was made [information gathering] by the project team. Several project external managers and other experts in the organisation [mobilisation] were involved. The project team used their experience to plan for several possible scenarios of actions when a decision would be made [use experience]. When the strategic decision fell out of sight of the HPM, the team did not know when and by whom the decision should be made. This led the team to decide that they could no longer be responsible for the consequences in the project, and they made this clear to the steering committee and the sub-supplier organisation [reject responsibility]. The project team continued to talk about how they were unable to act in the current situation. However, they did order two different sets of prototypes (two BOM lists) in order to cancel one of these depending on the decision finally made by the sub-supplier's management team [create alternatives]. By doing so, the project team was able to proceed with several project activities (compiling the BOM lists, for example) which were dependent on the strategic decision, even though this meant performing extra work not planned for in the project.

In this manner, I analysed all 37 decision-making episodes from DC3, and the full matrix with all 37 decision-making episodes can be seen in Appendix A.
6.5 Analysis of data collected in DC2 and DC3

In the common analysis of data collected in DC2 and DC3, in order to answer research question two (RQ2) (*what types of decision strategies are used in practice when managing deviations*), the loosely coupled systems theory by Orton and Weick (1990) was used.

The loosely coupled systems theory by Orton and Weick (1990) was used as one view of the decision episodes in order to identify decoupling decision strategies resulting from the actors’ praxes (see Table 15). In the case of the “Reuse of technology” episode, the praxes used were choice (related to responsiveness, r), mobilisation (related to distinctiveness, d), and responsibility (related to responsiveness). These “mechanisms” of creating loosely coupled activities were then analysed to determine the decision-making strategy related to loosely coupled systems theory.

Table 15. Analysis of decision strategies in the “reuse of technology” episode.

<table>
<thead>
<tr>
<th>Decision episode</th>
<th>Decision consequences</th>
<th>Praxis</th>
<th>Choice</th>
<th>Mobilisation</th>
<th>Responsibility</th>
<th>Legitimisation</th>
<th>Mechanism</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuse of technology</td>
<td></td>
<td>Reminder</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>(r) -&gt; I</td>
<td>Mixed irrational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information gathering</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>(d) -&gt; R</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mobilisation</td>
<td>x</td>
<td></td>
<td></td>
<td>(r) -&gt; I</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use experience</td>
<td>x</td>
<td></td>
<td></td>
<td>(d) -&gt; R</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reject responsibility</td>
<td>x</td>
<td></td>
<td></td>
<td>(r) -&gt; I</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Create alternatives</td>
<td>x</td>
<td></td>
<td></td>
<td>(r) -&gt; I</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each of the identified decision episodes was analysed by comparing the design of related praxes’ decision roles (rational or irrational) (and thereby the praxes’ relationship to creating distinctiveness or responsiveness). By analysing the decision roles related to praxes used in the start, middle, and the ending of decision episodes, a pattern of decoupling decision strategies could be identified. In the case of the “reuse of technology” episode, the sequence was I, R, I, R, I, and I. This was interpreted according to I=Irrational approach, and R=Rational approach, which revealed a mix-strategy (mixed irrational) for creating loosely coupled activities.

Overall, six different patterns were found by analysing all 38 decision-making episodes from both DC2 and DC3. By building on Häggren’s illus-
tration of decoupling patterns, the identified six patterns could be illustrated accordingly (see Figure 31).

![Figure 31](image)

**Figure 31.** Decoupling decision strategies analysed by rational or irrational design of start, middle, and ending of processes.

A full summary of the decision episodes and the related decoupling decision strategies can be seen in Appendix A.

In a common analysis of data collected in DC2 and DC3, I created the timelines of the project process (see Figures 10 and 23). I also identified the overall process characteristics of each identified decision-making episode. These episodes were then compared with the normative and the garbage can model of decision-making in order to describe similarities and differences of the characteristic. Table 16 shows how I compared characteristics of the identified episode “reuse of technology” with the two decision-making models. This was done to answer research question three (RQ3) (*what characterises the decision processes when managing deviations?*). By comparing findings with theoretical decision models, I was able to describe the characteristics of decision processes when managing deviations.
The characteristics of each episode were all very similar with regards to emergent objectives, micro-decisions made by successive search for ways forward which were dependent on the situation, and a mix of an in-depth analysis of consequences regarding the issue itself. However, they limited the search for alternative ways of managing the decision-making process of the deviation. In the case of the “reuse of technology” episode, the issue was that the project team did not receive any strategic decision regarding how much of the new technology, developed in the sub-supplier's project, was mandatory for the project team to use in their project. This made several key project activities impossible to proceed with. The objective of the project team evolved even late in the process, since the information was scarce. However, they were still able to estimate two scenarios by searching for information through informal communication within both organisations. If

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Episode characteristics</th>
<th>Normative decision model</th>
<th>Garbage Can decision model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>Emerged during the end of the decision process.</td>
<td>Objectives are defined before alternatives are generated.</td>
<td>Objectives emerge during the process and are not defined before alternatives are generated.</td>
</tr>
<tr>
<td></td>
<td>Analysis of the consequences of two possible scenarios on cost, time, and scope goals (practice related).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Created loosely coupled activities by involving managers and ordering two sets of prototypes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limited search for alternative ways of managing the decision-making process (praxis related). The project team was limited by their amount of involvement and influence over the issue. Needed to use “back channels” and informal communication to a large extent to manage the deviation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comprehensive analysis, where all alternatives and consequences are considered.</td>
<td></td>
<td>Limited search for alternatives and analysis of consequences.</td>
</tr>
</tbody>
</table>
the managers in Company A were leaning towards one scenario, the project team adapted their arguments and took action with regards to this. If the opportunity to gain assistance in influencing the decision-makers at the sub-supplier through a manager or someone else presented itself, they took it. By moving forward, step-by-step, making situated micro-decisions, and running necessary activities at the same time as the planned activities, the process of managing the deviation emerged.

During observations, I found that most of the actors’ time was spent trying to understand the current situation regarding the development work – what was the current status of different technical systems? Who could possible know more about a technical system? What debates are on-going in the management team which could affect the project work? A constant learning process as far as the project team’s current situation was their main day-to-day process in the project, and even more so when a deviation occurred. I view decision-making processes within product development projects to be mostly embedded in the actions of actors. Decisions are hardly visible in product development projects, which has been stated before (see for example Bragd, 2002, Brunsson, 2006). In order to describe these processes and further answer research question three (RQ3), I applied the sensemaking theory by Weick (1995) in the form of the addition of Maitlis’ (2005). I used this theory as a viewpoint in order to identify and describe the interaction and result characteristics of the processes. Maitlis’ (2005) four different types of organisational sensemaking processes were used in order to categorise the decision episodes according to process characteristics as well as resulting common accounts (actors’ views of a common situation).

In the example of the “reuse of technology” episode, there were many actors involved in trying to manage the deviation [high animation]. However, there were few or none in the project team or even within Company A who could control the process [low control]. The result was that the actors involved in managing the deviation started viewing the situation differently, from their own point of view [multiple narrow views on the situation]. The result became actions that did not follow a single plan, and micro-decisions were made ad-hoc throughout the process regarding directions [inconsistent]. Table 17 shows the analysis of the “reuse of technology” episode related to the type of sensemaking process which emerged.

<table>
<thead>
<tr>
<th>Process characteristics</th>
<th>Results</th>
<th>Type of Sensemaking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation</td>
<td>Animation</td>
<td>Control</td>
</tr>
<tr>
<td>Reuse of technology</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
A full summary of the decision episodes and the related types of organisational sensemaking processes can be seen in Appendix A.

Over all, analysing the data collected during DC3 also showed some general, interesting findings regarding decision-making behaviour in the project, and they applied when making decisions on managing project deviations as well. The first general finding was that very few formal decisions were observable in meetings or other project activities. I could sit in a meeting observing the project team discussing what to do in order to understand the desired functionality of a sub-system and what technology would be able to deliver such functionality, and not see a single decision being made. Still, afterwards, the project team members ran off and took actions related to the discussion as if a decision had been made. After some time, I understood that the continuous discussions on different product aspects served as a way of creating common understanding of which final decision the involved and affected actors, as a whole “community” of the organisation, was “leaning towards” at that time, with the support of formal as well as informal information. The common understanding mostly took the form of silent agreements, which I had a hard time detecting in the beginning but slowly started to see in meeting after meeting. This type of on-going discussions, resulting in silent tentative decisions towards what would be the final decisions, would be continued until the very last concept decision was made. I did not even see the final decisions on sub-system choices being made, but first understood that a final decision had been made when the HPM presented these as final decisions to the steering committee. I was present during the meetings where silent agreements between different stakeholders were created. Nonetheless, it was still hard to determine if that agreement was a final choice or if the discussion would carry on for some time. The discussion “matured” over time. When the HPM felt that the discussion did not lead to any new insights (and that view was shared by the involved actors), the HPM presented the status of the discussion as a final choice in formal meetings. The same behaviour was observed when project managers were engaged in managing deviations. I found that this behaviour enabled the project managers and team to move forward in activities despite unresolved uncertainties and act on what they believed to be an expected decision. They “tuned in” the direction of the product development organisation.

During interviews in DC2, I received statements from interviewees pointing to the same phenomenon, but was unable to identify or describe the nature of the phenomenon of “invisible decisions”. By analysing data from DC3 (the discussions between the HPM, the project team, and different stakeholders), I was able to identify the general types of questions asked, the performance aspects considered, and the roles of micro-decisions (related to praxes). As an example, in the case of selecting technology for the S2 sub-
system, as described in Section 6.2, the sub-supplier organisation (and thus the sub-supplier team) pushed for a certain “strategic” technology to be used as sub-system S2. The project team at Company A resisted, since they experienced indications that the “strategic” technology was uncertain as a solution. The choice of technology for the S2 sub-system also became a political issue. During that time, the HPM and the rest of the team spent a substantial amount of effort and time understanding what strategic decisions had been made in both organisations and needed to be considered, what different opinions existed in both organisations regarding the choice of direction, what other related discussions were on-going and could affect the choice, and who were involved or should be involved in the discussions.

The HPM and the EPM (with help of the rest of the project team) worked to understand the different possible technology choices’ consequences on a range of performance aspects used in the project. Those aspects were product quality, delivery, cost (product and project), and product features (functionality). These goals were not absolute, and were determined by collective assessments by many actors in the organisation (in other words, the “community”). The process of reaching a common view of a goal, product quality for example, involved using earlier products’ resulting quality as a reference and projections (assessment) of possible quality improvements (or losses). The HPM had to work hard to unify the steering committee members and other actors in both organisations to get an approval of these project goals, as described in Section 6.2. In most cases, there were political issues involved. That was the case in the product quality goal, for example, since an overall goal was set (100, for example) and was to be achieved when the product reached the market. But the project team was only responsible for the development work until manufacturing took over the project. At that stage, product maintenance was responsible for product quality. Therefore, if the project team aimed to reach 70 in product quality, then product maintenance had to achieve the remaining 30. The result of 100 was ambitious, and the project team did not want to set a goal it could not achieve within the time plan. At the same time, product maintenance argued that the project team would set the goal as high as possible. The process of reaching an agreement was not easy, each group searching for what they considered arguments and facts for appropriate goals. Different groups or even actors had different values regarding what reasons should be prioritised, and they pointed to different corporate norms they deemed important for the decisions on project goals.

During these processes of reaching agreements on different goals, the project team at Company A used both formal and informal sources to create an understanding of the choice of technology for the S2 sub-system. After long discussions in many meetings with the team at the sub-supplier, the two teams reached a common view on the issue: it would probably not work technically with the “strategic” technology. This presented a political prob-
lem for both teams, who needed to legitimise the choice for the management of the sub-supplier. However, a deviation presented a possible solution. A delay in the “strategic” project at the sub-supplier meant that there could be a problem manufacturing this particular strategic sub-system. The two teams made no effort to overcome the delay, but instead used the opportunity as a reason for concept elimination (legitimisation).

Throughout this overall process of making a choice on sub-system S2, the HPM, EPM, and the rest of the project team at Company A constantly worked to update their current understanding of the situation, investigating what they did not know and how to learn about those issues (they called it knowledge gaps). The project team often discussed what the different stakeholders were leaning towards at this time regarding the choice, who could be involved to help in making the choice, who was responsible for different activities in reaching the choice, and who needed to be persuaded to sympathise with the project team’s view of the issue.

What can be seen is that the questions asked by the project managers during the decision-making processes were about what, why, and how questions. For example, what questions were identified as: what strategies exist and need to be considered? What opinions exist (formal and informal)? What other related discussions are on-going and could affect the situation? Who are or should be involved in the discussion? Why questions were identified as: what is the current collective view on QDCF? What norms should we follow? What values should we consider? Finally, how questions were identified as: what do we not know about the current situation (lack of knowledge or common view of S2) and what should and could we do? What is the collective leaning towards at this time? Who do we need to involve to assist in clarifying the issue (of S2)? Who is responsible for what? Who do we need to convince, and how should we present our view on the issue?

As shown, making a choice in terms of technology or managing a deviation is not only about the choice itself; it is a part of an overall social, and political, organisational decision-making process. It shows how, in order to navigate in this decision-making process, the actors (HPM, for example) needed to investigate different questions and use praxes related to managing uncertainties regarding alternatives, actors, responsibility, and organisational legitimisation.

6.6 Results from DC2 (reanalysed) and DC3

Firstly, the analysis showed how each of the four decision roles played their parts in reaching decisions on managing deviations. Choice played the role of reaching final choice related to the issue at hand in a given situation. Choices were mostly about the general question of “how can we act now so
that we progress in the project by ensuring projected product quality, project delivery, product/project costs, or/and product features”. The projected performance aspects were often based on an interim common estimate made by the team, influenced by influential stakeholders in the organisation.

*Mobilisation* played its role as a means for the project managers to get support in performing certain decision activities, gathering or generating information, evaluating information, and generating alternatives, for example. Mobilisation was done internally in the project by putting low-priority work on hold while a deviation was being managed. Mobilisation could also be done by temporarily including external actors, experts or managers, for example: “Can we get a CAD model of the [sub-system part] and a consultant resource to do the job!?” (PM Company A). By including certain influential stakeholders, the project managers could also increase their ability to create legitimacy related to other stakeholders. “Who [which manager] could we include to get their team on board in this issue?” (Manager Company A).

*Responsibility* played its part in the observed project by splitting responsibilities between the team and stakeholders in the organisation. Responsibility could be demanded by the project managers or team members when they wanted to check the process (wanted to do their own simulation work to check the reasonability of the claimed status of technology) or were being forced to accept it by influential stakeholders or managers (the project managers accepted to conduct an investigation and report on how a budget cut of 50% would influence the final results in the project). Responsibility could also be refused by the project managers, if possible. If responsibility was refused, it often demanded a formal basis, by referral to the project scope, for example: “That’s not in the scope!” (PM Company A).

*Legitimisation* played its role by enabling the project managers to create leverage in conflicting issues. By referring to, or demanding, rational basis for actions, by themselves or others, it was used to gain acceptance for the project managers’ views on performance aspects regarding what levels were acceptable. “We’re not going to be able to achieve [x hours] MTBF at SoP if we look at the numbers from the last project”. (PM Company A). This was done in order to gain acceptance from team members, influential stakeholders, or managers, and to reach agreements on achievable goals, for example. Legitimisation was also used to gain acceptance for planned actions in the team. They would benefit from having approval from managers or other stakeholders if they were later criticised.

The pattern of use of the four roles of decisions was shown in the analysis to be a response to different types of uncertainties and what types of stakeholders that were involved in the process. The different roles were analysed by comparing the resulting decision roles with each type of sensemaking.

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7 Mean Time Before Failure.
8 Start of Production
Secondly, by illustrating the decoupling decision process designs according to Hällgren’s decoupling patterns (see Figure 32), the six types were visualised. Irrational design (A-D) simply means that the decision roles were almost exclusively irrational according to Brunsson’s classification, as described in the example of the first decision episode above. In a similar manner, Rational design (1-4) means that the decision roles were almost exclusively rational. Mixed irrational (A, B, X, 3, and 4) means that the decisions in the start were based on irrational patterns of decision-making, the middle of rational designs, and the end of irrational designs. Mixed rational (1, 2, X, C, and D) means that the decisions in the start were of rational designs, the middle of irrational designs, and the end of rational designs. Irrational-to-Rational (A, B, X, C, and D) means that the start was of irrational designs, the middle of rational and irrational designs, and the end of rational designs. Finally, Rational-to-Irrational (1, 2, X, 3, and 4) means that the start was of rational designs, the middle of irrational and rational designs, and the end of irrational designs.

Figure 32. The six identified decoupling decision strategies.

The Rational and irrational patterns were often used in situations where formal decision procedures or other forms of rules existed and could be used as a remedy. The management of these deviations often involved less praxis than the other four patterns. When no formal procedures or other supporting
rules existed or worked, more elaborate praxes were necessary in order to manage political, power-related, and other social issues, in order to manoeuvre within the organisation. The strategies were often a step-by-step process where team members and/or managers interacted and discussed which way to act as a response to different uncertainties.

Furthermore, process governance literature regarding managing uncertainty in early phases of projects treats the nature of uncertainty as mostly technical, financial, market, and schedule. These aspects are stated as needing to be reduced. However, the governance literature disregards the organisational, political, and social uncertainties project managers need to skilfully manoeuvre every day in projects in order to ensure progress. If managing uncertainty through the use of a decision process is analysed solely from a traditional point of view, the process will appear confusing. But if a decision process is looked upon as resolving several different uncertainties, besides alternatives, it can explain not only how actors act, but also why they act as they do. A seemingly confusing and ineffective process may instead seem skilfully executed and effective. This is especially true when observing the management of deviations, since the actors is often not acting according to management rules.

Thirdly, the different decision roles were analysed within each type of sensemaking process. The distribution of decision consequences related to the sensemaking types was found to be interesting. Most deviations were managed by restricted sensemaking processes, controlling the processes by creating responsibility and making choices. At the same time, many deviations were managed by fragmented sensemaking processes, where control was low and discussions were open for most stakeholders (see Figure 33). In order to explain the results in detail, a detailed description and discussion will follow.
rules existed or worked, more elaborate praxes were necessary in order to manage political, power-related, and other social issues, in order to manoeuvre within the organisation. The strategies were often a step-by-step process where team members and/or managers interacted and discussed which way to act as a response to different uncertainties.

Furthermore, process governance literature regarding managing uncertainty in early phases of projects treats the nature of uncertainty as mostly technical, financial, market, and schedule. These aspects are stated as needing to be reduced. However, the governance literature disregards the organisational, political, and social uncertainties project managers need to skilfully manoeuvre every day in projects in order to ensure progress. If managing uncertainty through the use of a decision process is analysed solely from a traditional point of view, the process will appear confusing. But if a decision process is looked upon as resolving several different uncertainties, besides alternatives, it can explain not only how actors act, but also why they act as they do. A seemingly confusing and ineffective process may instead seem skilfully executed and effective. This is especially true when observing the management of deviations, since the actors is often not acting according to management rules.

Thirdly, the different decision roles were analysed within each type of sensemaking process. The distribution of decision consequences related to the sensemaking types was found to be interesting. Most deviations were managed by restricted sensemaking processes, controlling the processes by creating responsibility and making choices. At the same time, many deviations were managed by fragmented sensemaking processes, where control was low and discussions were open for most stakeholders (see Figure 33). In order to explain the results in detail, a detailed description and discussion will follow.

Figure 33. The distribution of decision consequences related to the four sensemaking types.

Guided organisational sensemaking (16% of the episodes) would often be controlled by formal meetings where project managers and team members met different stakeholders to resolve a deviation. One example was meetings held between project managers and experts of different development project teams. Between formal meetings, the involved actors communicated by email and local small face-to-face meetings in order to prepare information and reach local common understanding. The project manager and project leader would promote a distinct perspective from the specific project’s perspective. However, at the same time, they would invite a large number of stakeholders to share their accounts of the situation. This shaped common beliefs and knowledge, including the important aspects of the issue and different views (strategic targets for commonality within the product portfolio and detailed choices of technology design, for instance). The praxes and decision roles used in this kind of sensemaking processes were mostly fo-
focused on choices. Often in these processes, the project managers had a specific complex issue they needed external experts or management support to resolve, and controlled the process themselves. Responsibility was also a common decision role. This underlines the importance for the project managers of clarifying and defining whom to contact, gather information from, and remind of the already established responsibility in some cases. The processes were about issues that transcended the development team, and the different stakeholders tried to shape opinions. That was why the project managers in some cases needed to legitimise their ideas and actions to be able to move forward with the support of the stakeholders. In some cases, the processes led to unexpected situations that demanded more manning, and the project managers needed to mobilise the team with experts, managers, or other actors in order to manage the deviation. This kind of sensemaking process was the result from the use of 24% of all the praxes observed.

*Restricted organisational sensemaking processes* (51% of the episodes) could be observed in deviating situations which the project manager and leaders found important to control, and could be managed internally by the team (except in a few cases where a few trusted managers or external experts needed to be involved). Different types of meetings were used to mobilise the actors, develop and gain acceptance of solutions, create legitimisation, and distribute responsibility (team meetings, small planned meetings, or face-to-face meetings). The sensemaking processes could be on-going during a single face-to-face meeting, over several weeks, or even months where e-mail was a common communication form. Interestingly, these sensemaking processes was focused on the decision roles of responsibility and choice. Responsibility was an important role, since the project managers tried to “position” the thought alternatives and choices related to external issues and stakeholder opinions. This demanded that the project managers explored and defined their responsibility in relation to external consequences. It was shown that 15 out of 21 praxes concerned the team’s responsibility, and six out of 21 praxes concerned identifying and sometimes reminding external actors of their responsibility. Since alternatives and, ultimately, choices were sought to resolve the deviating situations, the consequences of choice were a major focus. Mobilisation also ended up being a fairly common decision role. It is explained by the project manager’s need to contact remote actors in the company to investigate certain aspects of the issue and in that way gather information. The processes were about issues that in some cases needed management support, and the project managers needed to inform and legitimise their ideas and actions. This was also common in order to prepare management regarding planned actions before steering committee meetings and cross-reference meetings, gatherings designed to ensure support before taking action in the project. This kind of sensemaking process was the result from 31% of all the praxes observed.
Restricted organisational sensemaking characteristics (22% of the episodes) can be compared to a decision-making model called the garbage can model (Cohen et al., 1972), with regards to outcome being multiple, individualist accounts. This form of sensemaking could be observed over time when an issue became widespread in the organisation (often by e-mail and other day-to-day contacts). External stakeholders contacted the project managers regarding the issue and gave their view of the situation. The misalignment of priorities (use of time and other resources), tactics (planned possible ways of acting), and understandings of current prerequisites in the project were often too extensive to be processed into a single common view. This made the resulting common view fragmented, which acted as a source of reoccurring discussion and discontent regarding the results of the deviation management processes. The team did what they could afford (time and resource-wise), and sacrificed stakeholder commitment and satisfaction in order to manage the deviations. These discontents sometimes led to stakeholders taking action, informing management of their discontent or wanting them to intervene. Sometimes stakeholders took actions that did not support the actions of the team, which were intended to remedy the deviating situation. A highly relevant finding regarding this kind of sensemaking process was the common use of responsibility as a decision role. Twenty-eight of 72 praxes involved responsibility. Further, it was shown that 13 of 28 praxes were about internal responsibility, and 15 of 28 involved external responsibilities. This even ratio indicates the highly animated and uncontrolled nature of these sensemaking processes. Many external actors demanded to give their accounts of the deviating situation. This was of great importance for them, but not always equally important to the team. This often led to discussions surrounding the responsibility of the issue and its consequences, both internally within the team and externally. In these highly dynamic and uncontrolled processes, politics often emerged as an influential factor, and the project managers needed to skilfully legitimise the team’s points of view, ideas, and actions. Many choices were made, but those choices unfortunately were often not based on a consistent single common view of suitable actions. This kind of sensemaking process was the result of 40% of all the praxes observed. This accounted for a substantial amount of effort, which led the project managers to, in some cases, mobilise experts or management actors in order to cope with the management of the deviations.

Minimal organisational sensemaking (11% of the episodes) could be observed when a deviation was considered easily remedied, and the project managers felt confident in their common account of a deviating situation. Also, since the deviation was considered easily remedied, no commitment or support was needed from management members to progress. These sensemaking processes were often short-lived and informally managed. Responsibility was the most common decision role, and was often enough to resolve
the issue. An issue was remedied by either accepting responsibility or reminding some external actor of their responsibility of the issue. Few choices were made, and mobilisation was not needed (except in a few cases where new information needed to be generated by external actors). This kind of sensemaking process was the result from 5% of all the praxes observed.

Finally, the observations leading to the view of decisions as being tentative and “invisible”, included investigating three overall questions: what questions were asked in order to “tune in” the collective mind of the involved actors, why questions were posed in order to understand driving forces of the process, and how questions were asked in order to clarify the current need for action and guide emergent situated behaviour. In Figure 34, I have illustrated the phenomenon, the continuous process of reaching tentative “invisible decisions”.

![Figure 34. The process of reaching “invisible decisions”](image)

The actor, the HPM for example, continuously monitored the surrounding environment and received feedback from actions taken. The feedback included information regarding different actors’ current view regarding performance aspects, values, and norms. The HPM put together the information and assessed the collective’s view on a current situation. From that knowledge, the HPM determined the need for further action and made mi-
micro-decisions as to how to proceed (praxis). The micro-decisions played different roles depending on what type of uncertainty the HPM aimed to resolve. By acting (praxis), the HPM influenced other actors’ views of the situation and the current situation itself (enactment). The HPM then received new feedback on the action taken and compared the new situation with the old, drawing conclusions on which way the situation was “leaning”. The HPM again determined the need for further action.

This way of continuously moving forward in the product development process (making context sensitive micro-decisions) stood in contrast to what the actors in the organisation officially regarded as appropriate decision-making behaviour. The actors often spoke about the need for more formal and clear decisions. Further, if asked, the managers often regarded deviations as something that was to be eliminated through more planning. Meanwhile, the project members mostly regarded deviations as a, even though frustrating, natural occurrence in projects which needed to be managed on a regular basis.

6.7 Data collection and analysis of the initial validation

In order to validate the results described in the last section, a fourth data collection (DC4) was conducted through semi-structured interviews with six experienced and valued (by their respective organisation) project managers in six different large international manufacturing companies (B to G), as described in the method chapter of this thesis.

The descriptions the project managers provided about how deviations are managed in practice involved statements related to different decision roles. When presented with the results regarding the four roles of decisions, all the respondents stated that the four decision roles were familiar to them in practice. They could all mention examples of the use of each decision role, but had a hard time describing any pattern of use of the four different roles. They argued that it was dependent on the situation and circumstances which differed largely.

Regarding the decoupling decision strategies, the statements varied. Five of the respondents stated that they mostly followed the four middle strategies and the irrational strategy. Two others said mostly the rational strategy, but that it also varied during the process (mostly rational in the beginning of projects and more the middle strategies and the irrational strategy in the later phases of projects). All respondents stated that three different types of strategies were familiar to them in practice: rational, irrational, and the middle strategies (the four strategies in the middle bundled together into one strategy).
Regarding the sensemaking processes, the statements and discussions were more fruitful and the project managers had in most cases a good feeling of the amount of different sensemaking processes in their projects and the reasons behind the numbers. In Table 18, a summary of the ratio between each of the four types of sensemaking processes in each company is presented. Those project managers that did not have a clear assessment of the ratio between sensemaking types in their project (two) required further descriptions of examples of the different process types, and were after some discussion able to assess the ratio.

Table 18. The ratio of sensemaking processes in Companies A to G.

<table>
<thead>
<tr>
<th>Sensemaking types</th>
<th>Company (A)</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guided</td>
<td>24%</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
<td>35%</td>
<td>15%</td>
<td>30%</td>
</tr>
<tr>
<td>Fragmented</td>
<td>40%</td>
<td>70%</td>
<td>65%</td>
<td>60%</td>
<td>10%</td>
<td>35%</td>
<td>40%</td>
</tr>
<tr>
<td>Restricted</td>
<td>31%</td>
<td>15%</td>
<td>15%</td>
<td>15%</td>
<td>50%</td>
<td>45%</td>
<td>20%</td>
</tr>
<tr>
<td>Minimal</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Characterised by:

- Declining trust between stakeholders and project
- Many stakeholders must be involved during a short time
- Highly defined interfaces
- Management priorities differ
- Highly defined interfaces
- High trust and authority
- Stakeholder priorities differ

A common view among the interviewed project managers in the study was the aim of working with guided and restricted sensemaking processes. These two types of sensemaking were seen by the six interviewees as ideal for managing deviations. Guided sensemaking was seen as an ideal process for managing the integration of stakeholders, and restricted was considered ideal for managing internal issues which needed little input from stakeholders. Fragmented sensemaking was seen as a demanding process which took an excessive amount of time to manage and entailed a great risk of ending up with the shortest straw (the downside of a trade-off).

Statements by five out of the interviewees also highlighted the difference between internally and externally initiated sensemaking processes. Internal processes, initiated by project managers, were seen as easier to manage than external processes. That was because of the increased ability to plan and control the integration of project stakeholders. Externally initiated sensemaking processes, on the other hand, were often seen as problematic due to an inability to plan and control the integration of project stakeholders. These fragmented processes often emerged when influential stakeholders needed to involve the project managers in external issues which affected the project.
They were then experienced by the project managers as deviations in the project which needed managing.

### 6.8 Results from the initial validation

This initial validation of results obtained by analysing data collected in Company A during DC2 and DC3 has partly confirmed results of how decisions on managing deviations are managed in practice. The behaviour connected to each decision role, in combination with the four types of sensemaking processes, show the complexity of reaching decisions on managing deviations in practice. The ratio of decision roles within each sensemaking type was observed in Company “A”, estimated by the six case companies to be a good description of their praxes, and partly confirmed the observations. A specific decision which needs to be made by engaging in a decision-making process cannot always be controlled by project managers. “The external issues come into the project and are very difficult to manage because they can come from every possible direction, and you can’t guide or control that process. The work becomes highly reactive for the project manager throughout the whole process.” (PM Company B).

This initial validation of the result is based on statements made by the respondents, and can be considered an estimate of their practices. Even though the project managers are highly experienced, the results must be further validated by more interviews or other methods (participant observations, for example).

Finally, the combined results described in this chapter correspond to the overall research objective posed in the beginning of this thesis. The first result in Case study B shows how different roles of decisions play critical roles in order for actors in interrelated projects to identify, learn about, and act in deviating situations. The second part of the results shows how decision strategies are used to decouple a deviating situation from normal operations in projects and create the ability of the actors to learn about and act on deviating situations. The third and final part of the results show how the praxes used and the related decision roles play distinct roles in the resulting different types of sensemaking processes.
CHAPTER 7 - Discussion and Conclusions

In this chapter, the results and conclusions of the conducted research will be discussed in relation to the research purpose, objective, and stated research questions. The contributions are also discussed in relation to previous research. The research is then discussed regarding quality. Finally, future research is presented, which conclude this thesis.

7.1 Discussion

Firstly, the focus of this research has been on the articulation of the characteristics of decision-making processes and the results, rather than on defining and testing propositions. The descriptions are intended to create knowledge regarding how decisions on project deviations are made in practice within medium-size and large manufacturing companies. The focus on practice is a response to the synoptic accounts (Hällgren, 2009a) dominating product development literature addressing decision-making. By observing and analysing praxis, this research aims to provide knowledge about how project managers manages deviations on an operational level in projects where deviations demand both distinctiveness and responsiveness in tightly coupled organisational systems (Hällgren, 2009b, Orton and Weick, 1990, Weick, 1976).

The objective of this research, to analyse and describe the practical work of project managers has led to comparisons and the use of several theories and theoretical models. In order to describe the impact of complexity on decision-making behaviour, this research draws upon theories of complexity and uncertainty. The description of the characteristics of these emergent processes in practice draws upon theories of organisational decision roles, decision models, and sensemaking.

7.1.1 The impact of complexity on decision-making

Non-linear interactions of factors and actors result in complex systems in which unexpected system behaviour will always be present (McDaniel and Driebe, 2005). That behaviour will include natural deviations from expectations (Hällgren, 2009b). In the observed project at Company A, the deviation...
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7.1.1 The impact of complexity on decision-making

Non-linear interactions of factors and actors result in complex systems in which unexpected system behaviour will always be present (McDaniel and Driebe, 2005). That behaviour will include natural deviations from expectations (Hällgren, 2009b). In the observed project at Company A, the devia-
tions were in almost all cases a result of acts by other groups or actors based on good reasons but which had unforeseen consequences. Since the actors which could be seen as responsible for the deviations were not able to foresee the consequences or the magnitude of the consequences on other actors, it can be argued that the complexity of the organisational system was too high for the original actors to be able to fully grasp when making decisions and acting. The original actors were not able to fully know what the consequences would be or mean to other actors or groups due to the limitations of time for interactions and gathering and processing information within the organisation. This is in line with March and Simon’s (March, 1994, Simon, 1959) concept of bounded rationality. Therefore, one actor’s carefully assessed actions may still be the next actor’s deviation.

Since the product development organisations at the companies studied in this research were large and globally dispersed with centralised technology development projects, they can be compared to the structure of pooled interdependence (Weick, 2005). This means that the organisations are mostly suited to deal with activities that are “skill-based actions and automatic cognition” (Weick, 2005, p. 54). However, the decision-making behaviour found at the eight companies also points to the fact that decision-making behaviour in individual projects is characterised by sequential interdependence, where actors consider what formal process need to be followed and rules adhered to when deviations are managed (scope goal changes and requirement management, to name two examples). Further, in some cases, when it was possible, the project managers used organising structures comparable to reciprocal interdependence when deviations occurred. In some cases, the project managers were able to guide the process of gathering actors, reaching a common view of the situation, inside the project team as well as with external stakeholders. In these cases, the structure can be argued to have been “knowledge-based and (inducing) controlled cognition” (Weick, 2005). This shows that the complexity of the organisational system involves all three types of structures. This, in turn, means that when managing deviations, the ability to cope with the situation changes depending on the structure of the organisation involved in a specific deviation. If a situation involves groups of actors the project managers consider remote and unfamiliar, the ability to cope with a deviation by employing an appropriate approach (reciprocal) diminishes. One example of this was the “reuse of technology” issue. There, a management team at the sub-supplier used the observed project to gather information on the impact of different levels of reuse of technology as a part of a greater decision which was to be made. The situation can be compared to a pooled interdependence structure, where the project team felt that their needs and opinions were being ignored. On the other hand, if a situation involves mostly local actors within the project organisation, it increases the ability of the project managers to control the
sensemaking processes by creating reciprocal interdependence organising structures. This is in line with Weick (2005, p. 57): “The problem with network structures is that reciprocal interdependence is most readily achieved on a local basis among small sets of players. As more subsets are hooked together, the interdependence drifts from reciprocal to sequential to pooled”. However, it is not the project managers that dictate the structure of the deviation, but the organisational system and related responsibilities. The project managers need to keep continuous track of the actions of other related actors, forming and continuously evolving the understanding of the situation in order to be able to make decisions which suit that understanding. This also explains the structure and results of the four types of sensemaking (Maitlis, 2005). When a deviation was dispersed in the global organisation and many remote stakeholders were involved, the structure was pooled. This resulted in extensive discussions which tended to re-emerge along the way and often did not lead to a single narrow common view of the situation. In these situations, the project managers tended to use praxes focused on solving uncertainties regarding internal and external responsibilities, organisational legitimisation in order to reach a choice (temporary direction) on the deviating issue. The resulting actions were a series of inconsistent actions (fragmented sensemaking). When a deviation involved many stakeholders but was not dispersed in the organisation (consequences were not far reaching), the project managers managed to control the process and guide the sensemaking process (Maitlis, 2005). The structure of these situations often constituted sequential or reciprocal interdependence (Weick, 2005), and project managers could focus praxes on uncertainties regarding choice (temporary direction) of the deviating issue and overall responsibilities. The resulting actions were an emergent series of consistent actions (Maitlis, 2005).

These different organising structures can also be linked to the juxtaposed views of deviations as natural unavoidable events, or something that is to be controlled, prevented, or eliminated. In Company A, for example, the actors mostly involved in overall project governance often expressed the view during planning and reviewing activities (such as in the steering committee) that deviations were too common and “needed to be sorted out” (a steering committee member). On the other hand, team members (including the project managers) often expressed the position that “chaos is a natural state in projects” (a team member). This reflects how the identity of the actors (profession) impacted their view of deviations and their view of how they should be treated (proactive planning or situated management). This is argued to be a fruitful mix of diverse views concerning deviations since previous research has shown that the ability of an organisation to hold opposite frames simultaneously aids in giving both serious attention and resources to solving the unexpected event and treating the situation as an opportunity (Gilbert, 2006). In Company A, the steering committee members aided the HPM in mobilis-
ing actors and resources when deviations occurred, and the HPM often used the uncertainty of the deviating situation as an opportunity to deal with related issues, such as a lack of manning or management attention. The complexity of the organisational environment presented not only difficulties in decision-making, but also opportunities for the project managers. They used these opportunities to cope, not only in making decisions on managing deviations, but also in dealing with other project issues.

7.1.2 The characteristics of decision-making when managing deviations

The identified characteristics of decision-making when managing deviations in practice can be compared to the different decision models described in the introduction and the results from the research clarification stage in order to highlight similarities and differences.

The results show that when managing deviations, the task of understanding the impact on the project team’s work and involving affected stakeholders to try to reach a common understanding of the current situation was a continuous process. This is in contrast to the Satisficing model (Simon, 1959), which is described as a step-by-step process of recognising and defining the problem, analysing the current situation, defining criteria for a satisfactory outcome, and planning, initiating and evaluating the actions. The Satisficing model does highlight the fact that solutions to deviations are considered appropriate if they satisfy the involved actors according to a set of boundaries. When managing deviations in product development projects, these boundaries include different actors’ understandings regarding technical feasibilities, costs, time, and project scope, for example. This simultaneous generation and consideration of objectives and alternatives is line with the decision-model muddling through (Lindblom, 1959). However, the muddling through model states that decisions are made when stakeholders agree on alternatives regardless of objectives. This does not apply to managing deviations in product development projects since objectives are partly governed by different management groups, such as steering committees. The boundaries are set by the involved actors, and other people. Cohen et al.’s (1972) decision model, the garbage can model, seems to correspond well with findings in this research. First, the findings in line with Weick (1995) show that actors tend to act and then reflect on the feedback received from other actors, and fit well. Further, high levels of ambiguity, uncertainties regarding cause and effect relationships, and adaptive organising of temporary actors correspond not only to loosely coupled systems (Orton and Weick, 1990), but also to the Garbage Can model. The model helps to describe the rationale behind decision-making processes that otherwise seems irrational to affected actors. It explains the situated actions and their purpos-
es as objectives emerge spontaneously throughout the process. The mixed scanning model (Etzioni, 1967) does not apply to managing deviations in product development projects since the findings do not point to any use of broad organisational policies as objectives when managing deviations. The actors were mostly focused on narrow, not broad, ends, as the model describes.

The different roles of decisions (as described by Brunsson, 2007) play an important part in meeting the situated demands of a deviation in the product development project since the project manager needs to be able to navigate in an environment prone to ambiguity and political pressures. Different praxes are used with different intents to meet these demands. This is in order to acquire resources, support, acceptance, and commitment from stakeholders. It is also to create legitimacy for the actions and choices of the team. In other words, project managers have to work to understand deviations which arise, reach a common understanding of the situation with others, and act in order to achieve progress in the project. The observations and interviews in this research also show how project managers regard the social and psychological aspects of managing deviations a skill that is based on experience and is difficult to document or describe. The different roles of decisions enable a more nuanced description of decision-making, not confined simply to the making of choices. The findings on the use of different decision roles reveal the types of uncertainties project managers need to manage when deviations occur and in what types of sensemaking processes these uncertainties are more or less common.

The resulting four sensemaking types, related to the four different decision roles, show the characteristics of the processes and the uses of the roles of specific decisions. Furthermore, analysing sensemaking processes is revealing regarding the driving factors and characteristics of emergent decision-making processes. Through participant observations, it was possible to observe actors continuously trying to make sense of the current situation including multiple issues (creating distinctiveness) and to get things done despite opposing preferences and forces in the project organisation (creating responsiveness). The social network analysis conducted showed the amount of actors and communication involved in the HPM and EPM’s sensemaking processes during the first year of the observed project in Company A. On an individual level, both of these two actors continuously focused their daily efforts on organising their understanding of the current situation in the project, as well as organising the current situation itself. The HPM focused on organising a range of concurrent activities and monitoring the progress related to the main project plan.

The individual understandings of the HPM and the EPM were not separate from the collective sensemaking processes. Rather, they corresponded in various degrees to a continuously evolving common overlapping understand-
ing of the current situation in the project organisation. The more discussions that had taken place about an issue, the more in detailed the understanding of the situation became. This did not, however, necessarily create a common understanding between actors involved. Much of the detailed knowledge of the technology and the process of developing the technology was unknown to actors in the project team at the beginning of the project. That is not to say that these actors did not know what they were to develop or which processes and methods to use. They had developed similar technologies for many years and possessed both knowledge and experience about the technology and process, which made them quite able to repeat the development this time. However, to turn that initial knowledge and experience into another producible technology by simply planning the project and adhering to it was not enough. The actors needed to depart from the plan at times as well as adapt the plan to the emergent process resulting from praxes.

The results of this research can be used by project managers or other decision makers within product development to reflect upon how to manage unexpected deviations, proactively as well as reactively, within their specific contexts. By analysing the structure and present uncertainties, project managers could use the results of this research to discuss how deviations have been managed, the reasons behind the behaviour, and responses to on-going management practices.

7.2 Conclusions
In this section, the conclusions will be described and I will look back on the research questions stated at the beginning of this thesis and reflect on the level of fulfilment achieved.

7.2.1 The roles a decision plays in practice – RQ1
In the previous two chapter of this thesis, the analysis of empirical data showed the use of different praxes in order to make decisions on managing deviations in complex product development projects. These results correspond to the first research question: “What roles do decisions play in practice when managing deviations?” The result shows that it is possible to view praxes as related to a role of a decision. This reveals for what purposes different praxes are used in order to resolve a deviating situation. The results show how patterns of micro-decisions in a process can be analysed in detail by relating each identified praxis to a role of a decision. The initial validation also shows that practitioners recognise the descriptive value of the four decision roles in describing the purposes project managers have throughout the process of managing deviations. Each decision episode can be compared
to a box of possible praxes to use with specific purposes to resolve situations and context dependent uncertainties (decision roles), thereby managing a situation.

Research on decision-making in product development has predominantly focused on decisions playing the role of choice. On the other hand, Brunsson suggested four roles: choice, mobilisation, responsibility allocation, and organisational legitimisation. He wrote that “all in all, decision processes tend to become much more complex than they would have been, had the only effect and purpose been choice.” (Brunsson, 2007, p. 6) Previous research on these roles has mostly been focused on why these roles are used in organisations and little on how on a micro-level in practice. This conducted research has shown how these roles are practiced through the use of different praxes. This also explains the different types of uncertainties that are managed in order to cope with deviations. By analysing the relationship between praxis and decision roles, the results show which praxes are used by actors to make decisions which play each of these roles. By further relating the use of praxes in the decision episodes to four types of sensemaking, the pattern of using certain praxes was related to both process characteristics and the results of the processes.

The conclusions that can be drawn regarding the results from answering the first research question are that the use of the four decision roles enabled the identification and description of purposes of praxes used to manage deviations in practice. Praxes related to choice and legitimisation enable distinctiveness, while praxes related to mobilisation and responsibility allocation enable responsiveness. The results show how the resulting sensemaking processes emerge from different levels of use of these decision roles as a response to different uncertainties. The roles reveal the different types of uncertainties project managers in product development projects need to manage when making decisions on managing deviations. In order to understand the identity of a situation (distinctiveness), the project managers need to manage uncertainties related to alternative solutions and organisational legitimacy. In order to be able to have the time and resources to respond to a deviation (responsiveness), the project managers need to resolve uncertainties related to mobilisation and responsibility. The main contribution from this part of the research is the descriptions of the connection between praxis, decision roles, and emergent behaviour of project managers managing deviations in complex product development projects.

7.2.2 The emergent decision strategies – RQ2

After describing the relationships between praxes and decision roles, the data was used to further analyse what decoupling decision strategies were used by actors in practice when managing deviations in complex product develop-
ment projects. The results corresponded to the second research question: “What types of decision strategies are used in practice when managing deviations?” Even though six decoupling decision strategies were identified, the validation with six project managers showed that three strategies were regarded as useful to discuss: rational, irrational, and mix strategies (patterns). In addition to Hällgren’s (2009a) results, which argue for a dominant pattern (one strategy is mostly used in an episode), the results in this conducted research showed that three evenly distributed patterns of decision strategies were used by actors in order to decouple deviating situations from planned operations in the project. Eleven decision episodes were of rational patterns, twelve of irrational patterns, and eleven of mixed patterns. These results partly confirm Hällgren’s results. They also contribute to showing that a mix-pattern can exist which is not dominated by a single pattern, but can be an even combination of the two (see Figure 35).

![Figure 35. Decoupling decision strategies (adapted from Hällgren (2009a)).](image)

The rational decoupling decision strategy was used when following predetermined processes (process standards or practices). It often included little praxis since the actors knew what they were expected to do in order to resolve the situation. In some cases, the use of legitimisation was included since the predetermined processes could be used as a means of gaining leverage over other groups of actors by pointing to the “way things should be done.” Irrational decoupling decision strategies were used in different situations which were suitable for a trial-and-error approach (in other words, different steps were taken and feedback continuously evaluated until the deviating situation was resolved. Orton and Weick (1990) make a point of viewing organisational systems as both tightly and loosely coupled systems at the same time. The results in this conducted research adopt that view, investigating how the couplings in the organisational system change over time and...
concurrently are tight and loose. While a plan for manufacturing and assembling prototypes may be tightly connected to a decision in an external organisation, the loosening of the situation by creating several scenarios and ordering two related different prototypes is concurrently existent. The description of the strategies used by teams to manage deviations in practice is based on the notion that the coexistence of both tight and loose system couplings is what holds projects together. The ability of teams to loosen the couplings to the project plans means that they in fact create the possibility for the teams to work according to the plans as well.

The conclusion that can be drawn regarding the results from answering the second research question is that it is possible to use praxes that enable both distinctiveness and responsiveness in an equal amount when managing deviations (a mix-pattern). This can also be considered the main contribution of this part of the research. Adding to Hällgren’s results of two decoupling mechanisms used by actors, I have extended that theory to three predominant decoupling decision strategies: rational, irrational, and mixed. These results also extend the use of these decision-making patterns to a product development project context.

7.2.3 The resulting knowledge and actions – RQ3

During the research clarification stage of this research, the important elements to be considered were identified and described. The proposed mindset of a project manager gave a simplified and idealised version of decision-making on deviating situations in projects which were used as an input to further in-detail studies of the phenomenon. If the decision roles are used as a basis and in combination with the theory of sensemaking (Maitlis, 2005, Weick, 1995), they enable the identification and description of overall process and process result characteristics. The results correspond to the third research question posed earlier in this thesis: “What characterises the decision processes when managing deviations?”

First of all, by using the theory of sensemaking, the decision processes are not viewed as a step-by-step process of first defining a problem, identifying alternatives, defining selection criteria, evaluating the alternatives, and making a choice. Instead, the decision-making process is viewed as a continuous process of identifying changes in the environment in which one acts (enacts) related to one's own mental model of how things work in that environment. This interaction between “ecological change” and “enactment” (Weick, 2009) involves the following sensemaking activities: sensing changes, enacting order in a state of change, and being influenced by external factors. The sensemaking activities start to transform the understanding of changing circumstances into order. The different multiple possible meanings of a changing situation are narrowed down by a selection process. Further, the meaning
of the situation that seems most plausible related to the mental model and the one that is experienced over time as being the most useful in order to make sense of different situations is “retained” (Weick, 2009). This view of how actions are connected to an explorative search for meaning and experience was used in this research in order to highlight the behaviour observed in practice when actors try to make sense of an ever changing project environment. The results show how the behaviour of actors, trying to make sense of deviating situations, is linked to a social and context-dependent process where actions are based on more or less common understandings of the situation.

The results of this research cannot be applied to distinguishing between successful and unsuccessful strategies or processes. They can, however, be applied to show the details of how actors “keep going” in practice when things deviate in complex product development projects. By analysing the relationship between praxis, decision roles, and the emergent process and result characteristics, the use of each decision role can be described in relation to sensemaking. This results in a detailed description of how common the use of different decision roles is in different types of sensemaking processes. The results can be seen as a way of understanding what uncertainties demand certain praxes and will lead to different types of sensemaking processes and results.

The conclusions regarding the results from answering the third research question can be stated as follows. Firstly, a discrepancy between what project managers consider to be ideal (the guided and restricted sensemaking processes) and the existing uncertainties which can lead to, according to the project managers, undesirable processes and results was clarified. The processes of managing deviations can just as often result in fragmented processes, meaning that the resulting common understanding of the situation is small. This is due to different circumstances hindering project managers from controlling the process, which in turn involves many diverse opinions concerning how to manage the deviating situation.

Secondly, the identification of micro-decisions related to the four decision roles of Brunsson (2007) categorised according to Maitlis’ (2005) four types of sensemaking resulted in the description of distinct process characteristics. The results showed how four types of sensemaking processes related to certain decision roles emerge through the use of praxes. The main contribution of this part of the research is the description of how project managers respond to different uncertainties by certain praxes and how this results in different types of process characteristics and process results.
7.3 Contributions

The discussions and conclusions in this chapter have contributed to the fulfilment of the purpose and objective of this research. The purpose of the research on a high level was to contribute to knowledge about how project managers manage change in complex product development projects. In this thesis, I have described how the management of project changes include archiving flexibility, through different praxes, which is not a static condition but changes depending on the situation; a dynamic process of adapting to evolving circumstances and knowledge which cannot be foreseen. I have described three types of flexibility: the flexibility between planned and unplanned activities; formal and temporary organising; and rational and non-rational actions. The flexibility between planned and unplanned activities changes from being able to follow plans accordingly to managing both planned and unplanned activities at the same time when a deviation occurs. The organising shifts from using allocated resources to reprioritising them, as well as creating new resources in order to manage the deviation.

Besides restructuring and creating resources, a deviation means that the flexibility of formal and temporary organising shifts from a written down project organisation to both a formal and a situation-dependent informal network-based organisation created by the team and affected stakeholders. The new, temporary organisation influences interactions, communication, and resulting decision-making processes.

Finally, the flexibility between rational and irrational actions is shown to be a response to emerging needs for managing different types of uncertainties, and not only alternatives related to a choice. The organising shifts from the pursuit of rational behaviour to adhere to management rules to a focus on investigating the identity of the deviation (becoming distinct) and progressing (becoming responsive), which often includes a mix of both types of actions. It can be argued that a more constructive view on decisions on managing deviations is not about rational behaviour, but instead meaningful behaviour which depends on what types of uncertainties are present in a situation.

The objective of the thesis was to analyse and describe how decisions are made regarding managing deviations in complex product development projects in practice. The in-depth knowledge of the current practices of managing deviations in practice was created in order to provide a theoretical basis for future studies on reactive decision-making in projects. That basis can, in turn, be used in order to manage deviations in complex product development project organisations. The new knowledge resulting from this research can be summarised as a micro-perspective on decision-making roles, the relationship between decision roles and praxes, and the relationship between decision roles and types of sensemaking.

As described in the method chapter of this thesis, the two case studies in this research was carried out by collecting data in four steps, DC1-4. The
data collections were executed in order to answer the related research questions, and results were published in peer-reviewed scientific reports (see Figure 36).

The results from the analysis of data from Company X (DC1) and Company A (DC2), collected during Case study A, provided knowledge regarding what is considered to be important elements to be considered when making decisions on project changes. The results were used as a basis for further indepth studies of identified relevant research questions (RQ1-3).

The results from the reanalysis of DC2 in Case study B showed the usability of viewing decisions as not only playing the role of choice, but also mobilisation, responsibility allocation, and legitimisation. These results therefore led to the use of decision roles as a basis for all the analysis of data collected in later stages, and decision roles are part of reported results in appended papers III to VI in this thesis. The combined results from DC2-3 were validated through the collection and analysis of data in the six additional companies in DC4 (B-G).

Research question one (RQ1), “What roles do decisions play in practice when managing deviations?”, was answered through the identification of praxes and their associations with roles of decisions. This question was initially partly answered through the reanalysis of data collected in DC2 and reported in Appended Paper III. Research Question one (RQ1) was further answered through the analysis of data collected in DC3 and reported in Appended Papers IV, V, and VI. The answers contributed to theories of organisational decision-making by applying Brunsson’s decision roles from a macro-perspective related to praxis. These results could be used as a basis in order to discuss practices and strategies for making decisions relevant for managing project deviations. Yet little or none of this knowledge is existent in project governance literature or educational contexts. Therefore, the project managers used these strategies as a part of the validation carried out in the fourth data collection (DC4) and reported in Appended Paper VI. The answers contribute to the theory of sensemaking; they extend Maitlis’ four types of sensemaking by relating them to praxes used in practice. In order to resolve such a social issue, the project managers used realising the objective of creating in-depth knowledge of the current context.

They also contribute to the extension of the model by applying it in a product development context. Examples of these decisions underlying future governance methodologies, methods, and models would be relevant in order to understand how and why certain processes emerged in practice when managing deviations in practice also contributes to providing a basis for discussing organisational strategies for managing unexpected events in complex product development projects, including reliable assumptions and decision-making processes. The validation of these descriptions were carried out resulting processes. The validation of these descriptions were carried out through the collection and analysis of data in the six additional companies in DC4 (B-G).
sational decision-making by applying Brunsson’s decision roles from a micro-perspective related to praxis.

Research question two (RQ2), “What types of decision strategies are used in practice when managing deviations?”, was answered through the analysis of data collected during DC3 and reported in Paper IV. Identified praxes and associated roles of decisions in combination with the theory of loosely coupled systems led to the identification of decoupling decision strategies. These strategies were also a part of the validation carried out in the fourth data collection (DC4) and reported in Appended Paper VI. The answers contribute not only to confirming parts of HäIlgren, but also to extending the results by identifying the possibility of a mix-strategy for decoupling processes from planned operations.

Research question three (RQ3), “What characterises the decision processes when managing deviations?”, was answered through the analysis of data collected during DC1, 2, and 3, and was reported in Papers I, II, V and VI. Identified praxes and associated roles of decisions in combination with the theory of sensemaking led to the ability to describe the characteristics of decision processes and the role that micro-decisions played, leading to the resulting processes. The validation of these descriptions were carried out through the fourth data collection (DC4) and reported in Appended Paper VI. The answers contribute to the theory of sensemaking; they extend Maitlis' four types of sensemaking by relating them to praxes used in practice. They also contribute to the extension of the model by applying it in a product development context.

Realising the objective of creating in-depth knowledge of the current practices of managing deviations in practice also contributes to providing a basis for discussing organisational strategies for managing unexpected events in complex product development projects, including reliable assumptions underlying future governance methodologies, methods, and models developed in industry. In addition, a focus on micro-decisions was shown to be relevant in order to understand how and why certain processes emerged from certain praxes. Intuitively, experienced project managers seem to know that managing project deviations is primarily a social issue involving diverse praxis. In order to resolve such a social issue, the project managers used context-sensitive approaches which consider not only technical and financial, but also organisational, social, and political aspects. This means that experienced project managers already pose questions based on both tacit and explicit knowledge relevant for managing project deviations. Yet little or none of this knowledge is existent in project governance literature or education. The question I raise here but do not answer is: would project managers benefit from discussing practices and strategies for making decisions regarding managing deviations? These results could be used as a basis in order to begin to answer that question. All project managers interviewed dur-
The interrelatedness of decision issues related to specific deviating situations (context sensitiveness) was shown in this research to be quite high. Still, many process models and decision support in product development do not consider these circumstances. For example, Hansen and Andreasen (2004, p. 7) presented a design decision model “The decision node” which considers several product and project performance aspects and interrelated decisions. It is a good illustration of the overall design decision process, but it leaves out the consideration of organisational, social, and political aspects necessary to consider if a project deviation is to be managed, even if the deviation relates to a design decision. In practice, practitioners need to consider current interrelated issues at the time of the occurring deviation which are relevant to the management of the deviation. The relevant aspect can be anything, ranging from an overall corporate strategic change to an influential manager who is difficult to convince regarding the necessity to be involved in managing the specific deviation. In order to consider either of these aspects, different praxes can be used with various intents to resolve the situation, resulting in different sensemaking processes between the project and involved stakeholders. The understanding of the interrelated context-sensitive nature of making decisions on managing deviations is crucial for project managers. Engwall (2003, p. 1) has described the context as follows: “How the structures and procedures employed in a project have to be understood in relation to previous and simultaneous courses of activity, to future plans, and to standard operating procedures, traditions, and the norms of its surroundings.”

In several cases, actors, involved in projects and not aware of these contextual circumstances, were observed (as well as commented on during interviews) as being “too square” for the work in projects. That meant that the actors were not aware of contextual factors in specific situations, and were considered by team members and involved managers to be either too general or too rigid in their approach to the situation, or, in other words, “out of tune” with the current situation, prescribing actions that did not consider important contextual aspects. These findings point to the need of sensemaking processes resulting in a detailed common understanding of a situation and the acceptance of decisions playing different roles in order to manage deviating situations in projects. However, this will not always be a possibility, due to different preferences and politics in organisations, and presents a challenge for project managers when managing deviations. The question I
pose here but do not answer is: how can inexperienced project managers learn about and improve on making decisions concerning managing deviations. Answering the question posed belongs to future research, as discussed in Section 7.5.

7.4 Discussing the quality of the conducted research

The overall purpose of writing this thesis was to document and describe in detail the content and procedures of the research carried out in order for others to be able to understand and review it. I regard the most important aspect of the quality of this research to be measured by the amount of transparency achieved (see for example Yin, 2010, p. 17). By providing detailed descriptions of steps taken, methods used, data collected, and analyses made, I seek to provide as accurate a description as possible in order for the reader to be able to understand how and why my conclusions were drawn. For that purpose, the research process has also been methodically carried out by planning a set of research procedures and rigorous field routines. Data has been collected systematically from multiple sources (triangulation). It has provided a good base for analysis and to adhere to evidence on which conclusions were drawn (see for example Yin, 2010, p. 20). This adherence to case study guidelines and rules, as well as systematically collecting and storing data, adds to the reliability, or credibility, of this research. Also, my written reports have undergone peer reviewing processes at conferences and in a research journal (conditionally accepted). Having the results and conclusions accepted by the research community adds to the credibility of this research.

Another aspect of research quality which I regard as an important measure of research quality is validity. Yin divides validity into construct, internal, and external validity (Yin, 1994).

Construct validity measures how relevant sources and collected data are to the questions posed, as well as the purpose of the research. In order to ensure construct validity in this research, Yin’s (1994) proposed steps have been taken. This meant to first choose the specific type of change to be studied (deviations) and relate these to the purpose of the research. The second and final step was to show that the chosen measures of these changes (experienced outspoken deviations and praxes observed) actually reflect the specific type of changes chosen in step one. Triangulation has been used in all data collection. The description of the chain of evidence in this thesis was reported in order to increase the construct validity as well.

Internal validity treats the degree of truth of conclusions. In this research, the knowledge view underlining the practice approach means that it is hard to claim objectivity and truths. Between observations and interviews, the world and individuals change and efforts to try to reach the same conclu-
sions are meaningless. However, in this research, I have focused on describing the actors' praxes on a micro level, which can be compared to the building blocks of processes. Investigating these building blocks within specific organisations could be claimed to be the same in each organisation and used in similar ways if observed over a longer period of time, adding to the research’s internal validity. At the same time, the results are based on theoretical abstractions which could also be claimed to add to the “expire date” of the results, and in turn the internal validity. In Company A, the data collections were made during a prolonged engagement in the field in order to gain multiple encounters with the phenomenon of managing project deviations in practice. Further, the observations of deviations made in Company A were compared with statements during interviews made of three participating actors (HPM, EPM, and Development director) regarding the identified deviations (in order to ensure that I had perceived the episodes in an accurate way).

The external validity treats the generalisability of the research results from conducted case studies. In this research, the results of the two data collections in Company A (DC2 and DC3) have been compared with statements of practices in Company B to G (DC4) in order to investigate the generalisability of the research results obtained. Further, the theoretical abstractions made were also made with the intent to expand the generalisability of the research by comparing it to previous theories. The continuous literature review conducted in this research was the basis for this activity.

Even with the systematic work of this research, there are unquestionably matters that in hindsight could have been carried out differently and possibly resulted in research with even better quality. At the beginning of this research, several small case studies were carried out with the broad objective of creating knowledge about decision-making within product development organisations. These studies presented a good opportunity for me to learn about applying research methods, the complex task of analysis, and writing scientific reports, but they did not necessarily result in new scientific knowledge with high quality.

The continuous literature review has sometimes been structured and other times chaotic. There exists an overwhelming amount of literature on product development, decision-making, and project management. Thus, it has at times been difficult to have a clear understanding of the different topics and relationships between them. I approached this task by making an extensive “mind map” with categories (topics). Doing so has helped in creating an overview of the most central topics as well as a range of related topics. The literature review could perhaps have been planned and structured in a different manner to be more efficient, by narrowing down the scope of the research early on, for example. However, the broad scope of the research in
the beginning gave me the opportunity to “follow the evidence” and end up in the narrow field of research that I did.

In 2009-2010, I conducted a case study with two other PhD students from Chalmers University (Ulf Högman and Amer Catic) regarding technology transfer between technology development and complex product development projects. We planned the study for several months, gathered data through eighteen structured interviews which were fully transcribed, and started analysing the data in NVivo8. None of us three was able to finish and use the results in our theses. Ulf and Amer ran out of time when writing their theses, and I realised that my plan of analysing the data regarding the occurrence of deviations and decision-making did not work out as planned. Even though the data and initial analysis showed interesting findings regarding technology transfer activities, the data was too unspecific for drawing conclusions about decision-making practices. The work with the case study, besides the pleasure of working with two inspiring colleagues, gave me the opportunity to “rehearse” collecting and analysing large amounts of data in NVivo8. In the end, it was a great deal of work not used directly in this research work. Nonetheless, the experience gave me an advantage in the end regarding planning, collecting, and analysing large amounts of data, which was done later in this research.

It has been a gradual learning curve for me regarding what planning, carrying out, and reporting on scientific work entails. This means that I regard most of my early works as results from a trial-and-error process which in the end have provided me with enough knowledge and skill to be able to conduct scientific research.

As a scholar of human decision-making, I would argue that if one listens to other opinions and dares to make decisions based on the knowledge that nothing is certain, it is possible to take one step at a time and learn as one goes along. At each moment during my research, I have considered what I know, what I would like to know, and how I could learn about that issue. I have done so by attending conferences, interacting with interesting people within (as well as outside) my research area, and visiting research groups at the Danish Technical University, Stanford University, Cambridge University, Copenhagen Business School, Umeå Business School, and Luleå University of Technology, among others. I discussed my research on each occasion, soliciting comments on my results and how to proceed. I have continuously searched for and read scientific articles and books regarding a range of related topics. This has resulted in a broad and deep view of research concerning product development, decision-making, and project management. I have read and studied approximately 1,600 articles and 70 books, which was possible because of continuous reading. It did present some difficulties during the first two and a half years since I continuously stumbled upon new and interesting related topics, which sometimes led me astray and took time. What
has always led me back on the right path are the numerous meetings in industrial settings where the evidence has tended to speak for itself. It has been the most effective way to discard or validate my own views on managing product development activities in practice.

7.5 Future research

Based on my observations and insights, there are several future research areas that come to mind. First, as stated earlier, it would be possible to further validate the results from the conducted research by observing more teams in complex product development projects from start to finish. The two questions posed earlier regarding the benefits of the results from this research for both experienced and inexperienced project managers would be an interesting topic to explore further. It could also be carried out in other industries besides large manufacturing companies in order to explore the generalisability of the results.

Secondly, it would be interesting to explore the phenomenon of managing deviations on a portfolio management level in an industrial setting. This could create knowledge about project portfolio management and product portfolio management in practice related to decisions regarding managing deviations. This could be done through the use of longitudinal participant observations, or even action research, to get close to the phenomenon.
References


Appendix A
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<tr>
<th>ID</th>
<th>Deviation</th>
<th>Choice</th>
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<th>Responsibility</th>
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Summary of episodes identified during DC2 in Company A.

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