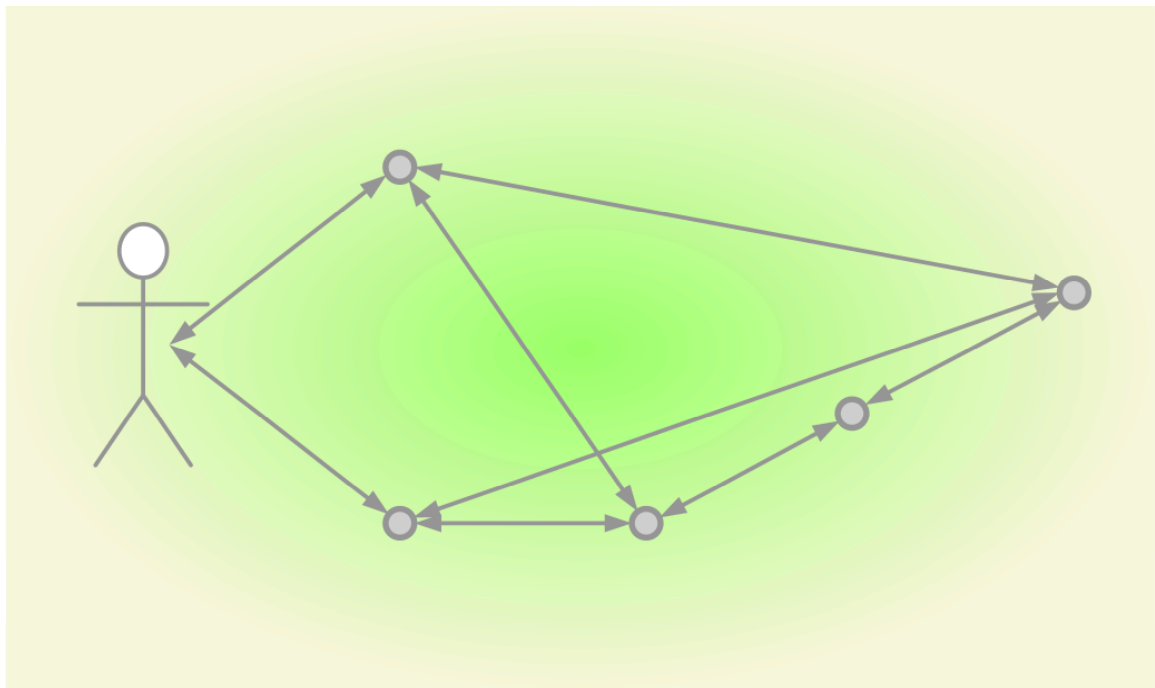# Deciding to Adopt Traceability in Practice

Influencing this decision

Floris Blaauboer

Deciding to Adopt Traceability in Practice

Factors influencing this decision

Master Thesis

Author	F.A. Blaauboer
University	University of Twente
Master	Business Information Technology
Track	Architecture
Internal Supervisors	Dr. N. Sikkel
	Dr. M.N. Aydin
External Supervisors	Dr. E. Wojcik
	Drs. N. De Swart
	Drs. J. Burkx

Utrecht, July 26th

University of Twente
Enschede - The Netherlands

ORDINA

Preface

Before you lies the result of six months of research, which is to be the "pièce de résistance" of my attempt of obtaining the title of Master of Science. I know that I may have disappointed some people by not finishing this report and presenting its findings on August 4th, as I promised so many people I would be doing from February on. I would hereby like to offer my sincere apologies to these people that in the end I required one week more to be able to present my findings in both this report and my colloquium at the University of Twente on August 11th.

To trace or not to trace, that's the question. This document is a report on the research performed during the last half year at Ordina N.V. into the "why" and "how" of the adoption of requirements traceability in development projects. This research required the assistance, guidance and contribution of a good many people, which I would all like to thank.

In particular, I would like to thank the people which offered me moral support during the period of this research, consisting of people I could bother on MSN, but also those nearer to me. My parents, for the diners we had every few weeks where I gave another update on how things were coming along but especially to my girlfriend, Marije, who sometimes must have been bored to death with the seemingly never ending stream of things I had to say about my project (does probably does not only apply to her) Luckily I'm finally starting to learn to let go of things and to stop thinking of work all the time.

Klaas Sikkel, my first supervisor, was always available to me. Both the discussions we had about the research and the research process, but even more the confidence he gave me through his support meant a lot to me and were of great help. Mehmet Aydin was very strong in the meetings we had discussing the progress and the work done, I was specifically helped by his critical view on the research process.

Except for the supervision from the university, I also had a lot of help from the people at Ordina. Emiel and Nicole did not only make sure that I did not take any unwanted shortcuts by critically reviewing my deliverables, but Emiel was also of great support when the project got into a dip. He was incredibly supportive with assessing the situation, looking for alternatives and determining how to pursue which of these alternatives. If anything had to be arranged, a contact was required or I simply had to discuss what was going on, nothing seemed to be impossible for Jos Burkx. Thank you Jos, Emiel and Nicole.

With regard to having a sounding board, nobody was as helpful as the person that invented the "flexplekken" at Ordina, where I was constantly surrounded by funny, interesting and very smart professionals who truly helped me a lot by listening to my ideas and coming with very sound suggestions (although not always of course). Harro, Jaap, Quinten, Art, Bert and Linda, special thanks to you for your many contributions. I really enjoyed my time at Ordina, both at work, during lunches and all of the events organized (keep that up!).

In the end, this was a very valuable period of my life, which is concluded with this report and of course my colloquium. I learnt (again) what it is like to have a steady rhythm, which took less adaptation then required. Over and over again, I was confronted with the fact that practice is quite different then theory and that one has to question everything. I learnt to pace myself, and to let go of things. I hope you will enjoy reading this report as much as I enjoyed writing it, for me it is time for something else, with this my studies have come to an end. For now.

Utrecht, July 2006

Floris Blaauboer

Management Summary

This research has been performed as the concluding part of the curriculum of the study Business Information Technology at the University of Twente in Enschede. The research itself took place at Ordina N.V. Ordina is an IT service provider that focuses on consulting, IT development and integration and outsourcing. ICT Management & Consultancy - Requirements is a business unit at Ordina, focusing on information analysis and functional design of IT systems, with a clear vision on the professionalization of processes. This business unit was the sponsor of the research.

In literature, (requirements) traceability is regarded as a very useful concept. In this research, traceability is seen as "*the ability to describe and follow the life of a requirement, in both a forward and backward direction*" (Gotel and Finkelstein, 1994). Many experienced practitioners also see the use of traceability. Yet in practice it is not adopted as much as one would expect. This gave rise to the following research:

What are the factors that influence the adoption of requirements traceability in a development project, and how should one go about these factors to influence the adoption of traceability?

Answering this question shows the issues with regard to the adoption of traceability, but also provides ideas about how Ordina should deal with this. To achieve this goal and to answer the central research question, an explorative research study was performed. The research technique chosen here was the use of case studies. First, a theoretical base has been developed, in order to gain an insight into the issues at hand. Subsequently, this theory was confronted with the findings of the empirical research, leading to an adaptation of the theoretical base.

The research showed that *awareness* was the most important factor influencing the adoption of traceability. The person making the decision on the adoption of traceability in development projects, the project manager, was often not even aware of the existence of traceability. None of the people that could inform him of this did this either, so there simply was no aware decision in many cases; traceability was not even considered. Awareness of the customer, and more specifically a demand by a customer, also proved to be quite an important influence on the decision. This research showed that a demand for traceability by the customer would always lead to adoption of traceability. Return on investment of traceability, both during the development project and the entire lifespan of the product is also a factor which weighs in heavily on the decision to adopt traceability. However, typically only return on investment *during* the project is considered, benefits outside the scope are neglected. Finally, the consequences for the flow of the process and the personal preferences of the decision maker are also influencing factors.

There are several ways Ordina can deal with the adoption of traceability in development projects. It can continue to go on as it currently does, not influencing the adoption in any way. On the other hand, traceability does offer an opportunity for Ordina to improve its services for the customer, to be a true strategic partner as its vision statement claims. Improving the adoption of traceability can be done with regard to people being rented out, or for Ordina projects. The latter offers more room for influencing the people, and is recommended. I would change the sequence. The recommendation to Ordina is that the decision regarding the adoption of traceability be embedded into the standard development methods and sales processes. This eliminates awareness as an issue. If traceability is not to be adopted in a particular project, this can only be achieved by a conscious and motivated decision which is an improvement over the general current situation.

To achieve this, the requirements business unit should create a task force which develops a clear business case showing the advantages and disadvantages of traceability, preferably expressed in numbers. With this business case, the owners of the development methods have to be convinced to embed traceability into their respective methods, including an aspect where its applicability for individual projects is determined.

Brief Content

Extended Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Research Setting

The research project at hand takes place at Ordina N.V., at the headquarters in Nieuwegein. Ordina is an IT service provider with a yearly turnover of € 444 million and 4200 employees in 2005, with its base of operations in The Netherlands. A small part of their operations take place in Belgium, as seen in Figure 1 (Ordina N.V., 2005).

Ordina is an ambitious organization which aims to be part of the top three contenders in each of the areas in which it is active. It aims to grow faster then the market itself, achieving an economy of scale and becoming the national champion in IT service provision in the selected areas. To do so, Ordina has segmented the market into five sections, being *finance*, *public*, *social security*, *trade, transport & industry (TTI)*, and *energy, telecom & media (ET&M).*

Figure 1 – Structure Ordina (Ordina N.V., 2006a)

Ordina has identified forty preferred clients to do business with on the long run, so called strategic clients. For each of its clients, Ordina wants to be a true partner in the broadest meaning of the word, adding value to its processes instead of being just another IT supplier.

The services Ordina provides can be split into two categories. More then half of its turnover comes from the placement of Ordina employees at other organizations, in line functions. In this case, Ordina functions as a provider of temporary labor. Besides this, there are also complete projects which are performed, where the entire project is the responsibility of Ordina. These projects range from system development and system implementation to management consultancy and a range of other activities.

Ordina N.V. contains Ordina Holding B.V., which is again subdivided. The three lines of business, as well as the different staff departments, are shown in Figure 1. The project at hand takes place within the IT Solutions line of business. This part of the holding deals with the development of custom solutions for its clients, whereas Business & Enterprise Solutions deals more with COTS-products as the solution for a customer. A more complex organization chart, showing the true nature of the matrix organization of Ordina, can be found in appendix I.

IT Solutions, after a recent reorganization, has been split up into four parts, which are found in Figure 1 as well. Systems Integration & Development, where this research takes place, is again subdivided into several parts, being:

- ICT Management & Consultancy
- Development Centers:
- Microsoft
- Java
- Oracle
- Mainframe & Midrange

ICT Management & Consultancy performs all tasks in software development which are not the actual development of systems, divided into the business units of *alignment*, *requirements*, *testing*, *implementation*, *project management* and *technical consultancy*. These business units have been clustered towards the competences of the employees, centers of knowledge on the respective areas. This is the part of the organization where the research project takes place, specifically in the requirements business unit. The competence of this business unit is the analysis of the wishes of the customers and creation of software requirements specification as well as functional design. The department consists of around sixty employees with and average age of 34 years and has two responsible business unit managers.

1.2 Problem Exploration

Within the requirements business unit of Ordina, one of the current topics is the professionalization of the service provided and especially the professionalization of the requirements process. One of the issues which has arisen, and not just in the requirements unit, is the notion that changes within a system can be performed a lot faster, and therefore less expensive, when the entire process is performed in a repeatable, but more specifically, traceable, way.

When discussing "the entire process", this entails both the traditional development process and the management of the IT-application afterwards. Quite often, the management of IT is ignored when looking at applications, whereas this part of an applications life cycle is by far the largest and most modifications are performed here.

Requirements, which are *a measurable statement of intent about something that a product must do; or a property that a product must have: or a constraint on a system* (Robertson and Robertson, 2004), are the formal basis for software development. Design, code, testing and implementation deliverables all depend on the outcome of the requirements process. The interdependence of development deliverables leads to the aspect of traceability. Requirements traceability is defined by Gotel and Finkelstein as *the ability to describe and follow the life of a requirement, in both a forward and backward direction, ideally through the whole systems life cycle* (Gotel and Finkelstein, 1994).

Requirements traceability, a much discussed topic in scientific literature, is not something which is standard in every development project. At Ordina, many projects consist with limited or no traceability available. This was also found in an informal survey which can be found in appendix II. Literature, however, claims a high added value. The main added value of requirements traceability, in literature, is twofold. First of all, there is the aspect of *change management*. Through requirements traceability changes in the context of an application (changing requirements) can easily be analyzed for their impact on the code and test cases and vice versa, which heavily shortens the time required for software maintenance. On the other hand, increased *accountability* simplifies the verification of a system to its requirements and allows better monitoring of the process.

This added value of traceability is widely recognized throughout literature, and many quality standards require it during development. Still, it is not a concept which is applied in every project. This is also stated in literature, as discussed recently by Arkley and Riddle (Arkley and Riddle, 2005). As observed at Ordina, many people in practice claim they see the use of traceability, yet few projects actually appear to adopt traceability explicitly into their

development process. The exact reason for this is unclear, which is the cause of this research. The organization wishes to know why traceability is not used in so many projects, as well as how to increase the use of it where required.

1.3 Research Goal

The goal of this research is *to create an insight into the factors influencing the adoption of requirements traceability in development projects and to draw up recommendations on going about the factors influencing this adoption.*

Requirements traceability, for the purpose of this research, is defined as *the ability to describe and follow the life of a requirement, in both a forward and backward direction, ideally through the whole systems life cycle* (Jarke, 1998). When looking at the adoption of requirements traceability, in this research this is defined as *the process leading to the decision to use requirements traceability in a software development project.*

In contrast to other research into the adoption of traceability, such as that of (Ramesh, 1998) which looked at the adoption by a development organization after this decision has been made, this research looks at the stage before this, where the decision to apply the concept of traceability explicitly is to be made. Whereas other literature focuses on the implementation aspects and the technical aspects of the concept, this research focuses on the factors which influence the decision of applying traceability in a project from a management point of view.

1.4 Structure of the Report

This report consists of seven different chapters. This chapter, of which this is the last section, is an introduction to the problem at hand and the organization which constitutes the setting of the research. The methodology of this research is presented in chapter 2, which includes a discussion of the research strategy, the research model and the research questions.

Chapter 3 of this thesis contains the theoretical basis for the research. The research method applied requires a solid basis of theory after which the research continues with a more empirical part of the research, and this basis is presented in this chapter. This chapter leads to the development of an overview of the factors which are to influence the adoption of traceability as found in literature. The next chapter presents the findings of the empirical research, which is confronted with the findings presented in chapter 3. With the data gathered in the research an overview is created that presents the factors influencing the adoption of traceability and which of these factors is most important. This chapter, chapter 5, also presents the different types of projects which can be found in practice and the factors which influence each type of project most.

With the newly developed theory, chapter 6 presents an overview of the recommendations made to Ordina. These recommendations are focused on how Ordina should deal with the issue of traceability and how it should influence the adoption of it. Finally, the last chapter reflects on the research process, the findings and the interrelations with other issues.

2. Research Design

The previous chapter introduced the motive and the goal of this research. This chapter provides the reader with an overview of the way in which the research was performed. First, the relevant strategy for this research project is discussed. Next, the used research model is presented in section 2.2. This model presents the different phases of which the research is composed and describes the way these phases are executed. Following the presentation of this model, a central research question has been drawn up, as well as several sub questions of which the answering leads to the achieving the research goal. Chapter 4 deals with the way the data gathering occurred in this research.

2.1 Research Approach

Verschuren and Doorewaard identify two types of research on the highest abstraction level (Verschuren and Doorewaard, 2002). First of all, there is theoretically focused research, whereas on the other hand we have empirically focused research. Empirical research attempts to create a direct contribution to an action which is meant to change an existing situation in practice. Theoretical research attempts to solve a problem in generic theory development. In the case of this research, a general problem is to be explored, categorizing this as theoretical research.

If we reduce the abstraction level, Verschuren and Doorewaard discuss theory developing research and theory testing research. For this research, little or no existing theory on the subject was available, which lead to the effort of attempting to develop new generic theory on the subject. The fact that no theory is available yet makes this research explorative, searching for the corresponding theory to explain the existing situation.

Yin states that case study research is quite well suited for exploratory research, just as histories, experiments, surveys and archival analysis. Case studies, however, are best suited in situations where there is no control required over behavioral events, the focus lies on contemporary events and one is mainly interested in the *how* and *why* of a situation. These questions are more explanatory and look at more then just frequencies and incidence (Yin, 1994). The essence of a case study, the central tendency among all types of case studies, according to Schramm, is that *it tries to illuminate a decision or set of decisions: why they were taken, how they were implemented, and with what result* (Schramm, 1971). Reviewing the goal of this research, this is exactly what is attempted to be achieved here. The case studies investigate a phenomenon within its context, where the influence of the context is not yet clear. This fact makes the case study a perfect information gathering method for this research. It copes with many different variables of interest and is open to new influences.

Yin identifies four different types of case study. First of all, the difference between single-case and multi-case studies is distinguished (Yin, 1994). As its name reveals, single-case studies focus merely on one case, whereas multi-case studies can take along many different influences which are context-dependent and different contexts should be looked into. Second, there is the difference between holistic and embedded studies. Holistic studies consist of one single unit of analysis, yet some studies might focus on more than one unit of analysis. In this case, attention is also given to subunits such as individual projects within a program. That is not the case here however, so we are dealing with a holistic multi-case study in the classification of Yin (Yin, 1994).

The different sources available to and used in the research are further discussed in section 4.1 and 4.2 of this report. These sources are used for the confrontation of theory and practice, where theory offers the basis and expected issues and practice shows the way things actually occur.

2.2 Research Model

This section of the document shows the model which will be used for reaching the research goal. It has been visualized with the method of Verschuren and Doorewaard, and is shown in Figure 2 (Verschuren and Doorewaard, 2002). It should be read from left to right, which is the way the research project shall be executed.
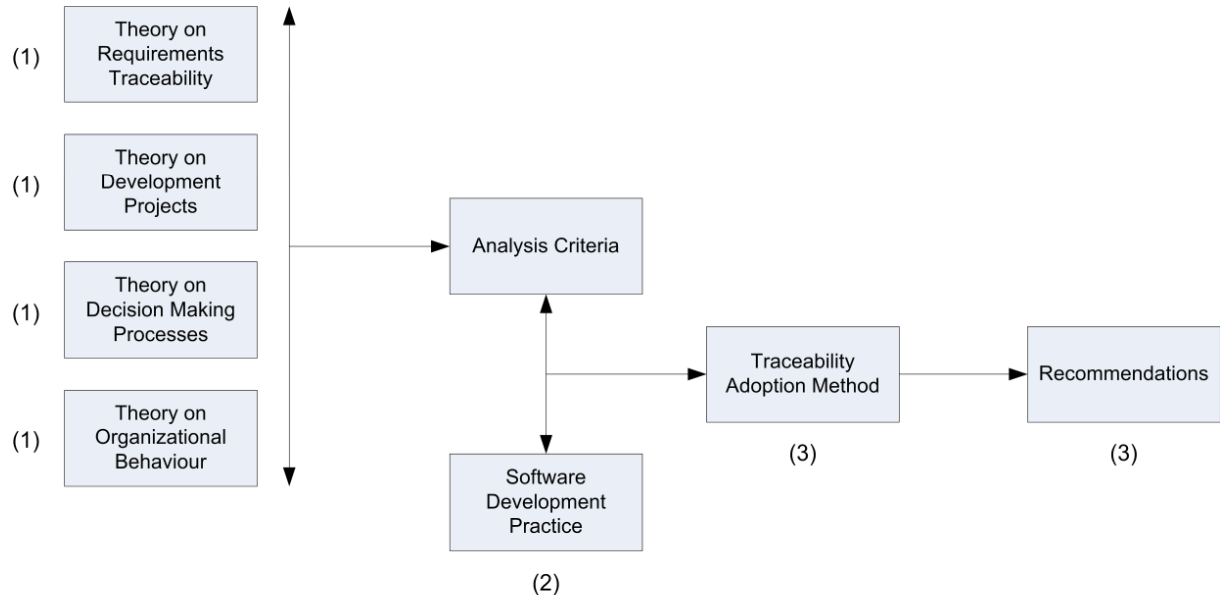
Figure 2 – Research Model

The goal of this research, as presented in section 1.3, is to present a set of recommendations on how to deal with the adoption of requirements traceability in a software development project. To reach this goal, the issues from scientific literature are compared with several cases in which this transfer actually took place. Literature (1) provides the researcher with the factors which are of importance to address in a theoretical framework according to the current scientific literature. With these analysis criteria, the research object (2) is researched. By studying the software development practice, the factors found in literature are validated on their actual influence. On top of that, any issues initially not found in literature can be identified. With these results, a piece of generic theory is developed on how the process of adopting requirements traceability in projects takes place (3). This theory, in its turn, leads to a set of validated recommendations (3), which is the last product of the research.

A note on this research model is that it does not sufficiently illustrate the iterative nature of the research. During the study of the research object, the analysis criteria are altered due to the outcome of the different case studies, which occurs in different iterations.

The literature study, which precedes the empirical part of the research, looks into four different subjects which all contribute to the theoretical framework. This framework is the end result of the theoretical part of the research. The topic of the research, being requirements traceability, is explored through studying existing literature on the subject. The subject of the research goal is defined and the basic concept is described. The context in which the adoption is to take place, the initial phase of a development project, is looked into as well during the literature study. The different actors in this process are identified. Third, theory on decision making processes is studied to further look into the process surrounding the adoption, creating an empty framework of influencing factors. The generic framework from decision making theory is filled out to fit the specific situation in this case, being the adoption of traceability in development projects.

After the literature study, the first part of the research, has been concluded, the empirical part is started. With the analysis criteria that are the result of the theoretical research, a number of structured interviews are done with relevant actors to validate the

factors identified in the theoretical framework and discover any other influences. The number of interviews, as well as which people should be interviewed, depends on the relevant actors identified. These interviews are subsequently analyzed.

The results of this empirical analysis are compared to the knowledge and insights taken from literature. The issues identified here are then looked into to identify facilitating measures to overcome these issues, which is transformed to a generic theory on adopting requirements traceability in development projects. This leads to the end result: the recommendations.

2.3 Research Questions

The previous section provided a research model, which showed the different parts of the research. To be able to reach the goal of the research, several questions have to be answered. This section gives an overview of the research questions which have been defined and have to be answered. The central research question is the following:

What are the factors that influence the adoption of requirements traceability in a development project, and how should one go about influencing the adoption?

This question requires information on a number of components of the question, which is gathered by answering the following questions:

1. *What are the factors of importance that are distinguished in scientific literature influencing the adoption of requirements traceability in development projects?*
   a. *What is requirements traceability in general?*
   b. *Where in the development process should requirements traceability be adopted?*
   c. *Which factors influence the decision making process regarding the adoption of requirements traceability?*
   d. *Which factors influencing the adoption of traceability can be identified in literature on decision making, requirements traceability, development projects and organizational behavior?*

2. *How do the factors influencing the adoption of requirements traceability in development projects discerned from literature compare to practice?*
   a. *Which factors from literature can also be found in practice?*
   b. *Which factors from literature were not identified in practice and might not be applicable?*
   c. *Were any influencing factors discerned in practice which were not previously identified in the theoretical framework?*

3. *What are the factors influencing adoption of requirements traceability?*

4. *Is it possible to influence these factors as to improve the adoption of requirements traceability and how?*

3. Theoretical Framework

Chapter 3 of this thesis covers the theoretical framework used in this research. As the research design presented in the previous chapter has shown, this is the basis for the further research to achieve the research goal. This chapter introduces and explores the concepts which touch the goal of the research, as well as introduces a collection of factors influencing the adoption of traceability, the analysis criteria as presented in the research model.

First of all, the concept of requirements traceability is further explored and discussed. With this knowledge in mind, software development processes are examined to discover their relevant processes and phases with regard to the adoption of traceability. Adopting traceability is regarded as a decision to be made during this development process, leading to the further research of decision making theory. The framework introduced in section 3.3 is used for the discovery and structuring of the factors influencing the adoption of traceability, which results in the identified factors in section 3.4.

3.1 Requirements Traceability

This section provides the reader with an overview of he basic concept of requirements traceability (from now on simply referred to as traceability). The definition and concept of traceability is further explored, and the different underlying techniques are discussed. Finally, a concise overview of the benefits and drawbacks of the use traceability is discussed.

Section 3.1.4 provides a deeper insight into the factors which influence the adoption of traceability, where several of these factors come directly from traceability literature. These factors are lightly touched in this section, but for a further specification one is directed to section 3.4.

3.1.1 Definition

The Oxford dictionary translates the word "trace" as *to follow the course of* or *to find or describe the origin or development of* (Oxford University Press, 2006). Traceability exists in many different industries. Think for example of the pharmaceutical industry and the manufacturing industry. Another industry where tracking & tracing is an important topic is the food industry, where for example the origin of meat is tracked. The route of a steak is followed from cattle-fodder to the agrarian and onwards to the supermarket where it is sold. The concept of tracing, both in a backwards direction (back to the source) and in a forwards direction is nothing new, and it's not new in the software industry either. In 1978, Pierce designed a tool with the purpose of tracing requirements for a large navy undersea acoustic sensor system (Pierce, 1978).

The complete form of the definition of traceability provided in section 1.2 is the following: "*traceability refers to the ability to describe and follow the life of a requirement, in both a forwards and backwards direction (i.e., from its origins, through its development and specification, to its subsequent deployment and use, and through all periods of on-going refinement and iteration in any of these phases)"* (Gotel and Finkelstein, 1994). This often used definition shows the different aspects involved with traceability.

The definition provided by Gotel and Finkelstein shows that traceability exists both in a forward and a backward direction. In that same article, they also distinguish pre- and post-requirements-specification traceability. This is why the concept is called *requirements* traceability, requirements are seen as the central point in the process.

3.1.2 Traceability Concept

Jarke has further explored this notion of requirements being the central point of traceability (Jarke, 1998). He states that there are four kinds of traceability links which are of relevance, being the following:

Forward from requirements. Responsibility for requirements achievement must be assigned to system components, such that accountability is established and the impact of requirements change can be evaluated.

Backward to requirements. Compliance of the system with requirements must be verified, and gold-plating (designs for which no requirements exist) must be avoided.

Forward to requirements. Changes in stakeholder needs, as well as in technical assumptions, may require a radical reassessment of requirements relevance.

Backward from requirements. The contribution structures underlying requirements are crucial in validating requirements, especially in highly political settings (Jarke, 1998).

Figure 3 is a meta model of requirements traceability, as it is regarded in the context of this research. The structure provided in this model is only a guideline, due to the fact that specific projects ask for specific traceability, where only some of these items are traced, or new elements are added. This model provides a good overview of the basic traceability items however. The model consists of several different items and the relations between them. A solid line between two items means that there is a traceability relation there, showing that one wants to trace the relation one item has on the other.
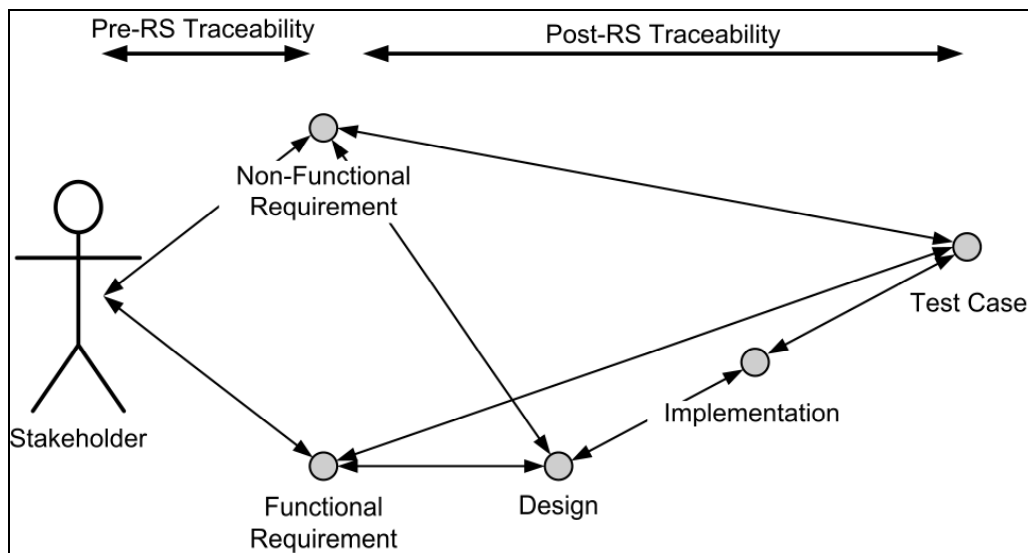
Figure 3 – Requirements Traceability Meta Model

The basis of the traceability figure are the requirements, which have been split up into functional and non-functional requirements. Grady has divided requirements using a "*functionality*, *usability*, *reliability*, *performance*, *supportability* and *others*" classification better known as *FURPS+*. The last four of these classes have been combined and form non-functional requirements (Grady, 1992), which are all statements which a product should adhere to that are not specifically related to a function of the system. Functional requirements, on the other hand, are statements on what a product should do. Both trace back to the demands of stakeholders, which expresses them.

Both functional and non-functional requirements are linked to design elements. These elements, again, are linked to relevant parts of the source code (implementation), and onwards to test cases. The requirements are also directly linked to test cases, for verifications purposes in the functional acceptance tests.

The model presented in Figure 3 shows relations which exist during any development project. Requirements are always based on input from the different stakeholders, a design is always based on requirements, and so on. What the concept of traceability prescribes, however, is that one should make these relations explicit on a lower level, instead of the implicit relations which always exist. Linking individual requirements to individual design elements creates situations such as shown in Figure 4. This figure is part of what a full

traceability diagram of a system could look like, yet on a very small scale and with only some of the development artifacts and relations taken along.
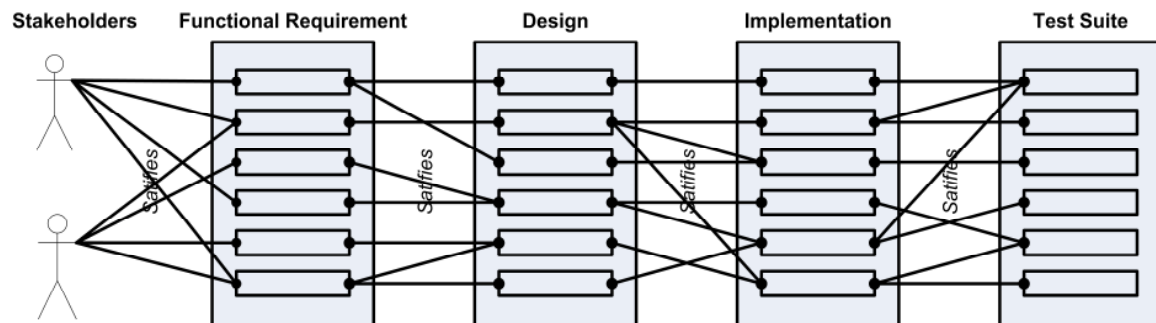
Figure 4 – Lower Level Traceability

In small projects, people may argue that traceability is not required. They can remember everything in their own head, since they created the links. This is a clear example of *implicit* traceability, where the links do exist but are not documented. The danger of this approach is that the knowledge will slowly disappear, or possibly all at once with the original developer leaving. Due to the fact that more people are involved in larger projects, *explicit* traceability where these relations are documented is required. Whereas implicit traceability always exists, this research looks only at explicit traceability and that is what is referred to when talking of traceability.

Traceability is a concept advocated to be applied in systems development, as discussed above. In the end, the goal of systems development is to satisfy stakeholder needs by delivering an error-free system on time, within budget and of high quality which satisfies the demands of this stakeholder. Something many authors stress, is the importance of performing requirements traceability throughout the entire lifecycle of a system. Operation, also known as maintenance, is quite an important phase where a lot of the benefits can be reaped so where there should be definite attention to traceability (Ramesh et al., 1995; Palmer, 1997; Candida Pinto et al., 2005). A prerequisite for this, however, is that traceability is consequently performed during the phases preceding this one, since once traceability is lost it requires quite an effort to get it back. The costs of restoring traceability information in a project rises substantially, yet the return on investment of this effort might still be worthwhile (Becker, 2003).

3.1.3 Techniques

Many different techniques exist for tracing requirements, of which Huffman Hayes provided a nice overview (Huffman Hayes et al., 2003). Traceability matrices are quite a common tool for traceability, which works by linking the two dimensions with different artefact instantiations in a matrix and assigning the relations between them to this matrix. The disadvantages of this technique are the high amount of different matrices because they are only two dimensional, and the size that can become a problem as well, spanning more then a page or a screen. For a big system, this will create a high amount of enormous spreadsheets, causing one to lose track of matters quite fast. Linking documents through hypertext is another well-known technique here, but has the disadvantage of not directly showing the contents which is available at the other end of a link (Hull et al., 2005). Another solution which is widely used is the implementation of a traceability database. This database allows development artefacts to be linked to other artefacts and can create overviews similar to traceability matrices but combines them in one structured database. A disadvantage of each of these techniques is that they currently still have to be filled manually which takes a lot of time (Palmer, 1997).

The rise of new techniques in information technology brought along new and more sophisticated techniques for requirements traceability. One of these techniques is information

retrieval (IR), which links documents on the basis of similarity. With information retrieval, one can automate a large part of the link generation process, but one will still have to determine whether or not the traces identified are valid (Antoniol et al., 2002; J. Huffman Hayes et al., 2003). Changes in technology are improving the success rate of this technology rapidly, which seems hopeful for the future. One of the main advantages of IR is the fact that one can pick up traceability with a reasonable success rate during later stages in a project and still get a good rate of return.

There are many tools which support requirements traceability in one way or another. An ongoing survey of the international council on software engineering (INCOSE) shows that more then 25 specialized requirements management tools are available, that is without taking along generic tools (word processors, spreadsheets) and built-in tools (INCOSE, 2006). Each of these tools has its own way of dealing with traceability, yet the number of tools shows the interest which exists in the market.

3.1.4 Benefits and Drawbacks

This section provides a short overview of the main benefits and drawbacks associated with traceability in development projects as found in literature. In literature, most authors approach traceability from a technical perspective, especially when dealing with drawbacks.

Three main advantages of traceability can be discerned. The first of these has to do with the verification of requirements, as discussed by Blaauboer (Blaauboer, 2006). During the verification of requirements, the requirements specification is compared to the system to see whether or not these demands were fulfilled. With traceability this can be made visible, showing that requirements are both covered by test cases as well as by the actual implementation (Palmer, 1997; Antoniol et al., 2002).

Secondly, a system which has complete traceability in place allows for a lot easier analysis of the impact of changes. The consequences of a change can be traced from requirement to design, code and test cases, drastically shortening and improving this process (Antoniol et al., 2002; Arkley and Riddle, 2005). Changes occur during development, especially when using an iterative or incremental development methodology, but most of the changes to system occur during operation/maintenance. This is why, as stated before, it is important that traceability is used during this phase as well. Niessink and Van Vliet show that the effort connected to a change not only depends on the size of a change, but that the size and complexity of its environment is probably even more important (Niessink and Vliet, 1998). Using traceability to lower this complexity can drop costs due to impact analysis by over 25%, and impact analysis often accounts for over 70% of the entire change effort (Ordina!T Excellence, 2004).

A third benefit of traceability, if that is what one should call it, is compliance to standards and regulations. Both CMM and ISO 9000, two of the most well-known standards for process quality, demand traceability in development processes (ISO 9000-1, 1994; Carnegie Mellon SEI, 1999). The US military has set their own standard for software delivery, which also specifically demands traceability (MIL-STD-498, 1994). A hot topic of the recent days is compliance to acts such as the Sarbanes-Oxley act, which is a requirement for all companies on the NYSE. (US Congress, 2002). Other sets of rules, such as that of Basel II for financial service providers, also demand traceability.

Despite these advantages, traceability is as mentioned still just an advocated desirable property of a software development process (Lindvall and Sandahl, 1996). Several problems were identified in literature with regard to the implementation of traceability. A central problem is the fact that many developers see traceability as an optional activity, for which there are too few resources available and of which they see too little direct benefits (Stout, 2001; Arkley and Riddle, 2005). The reason of this limited amount of resources lies not with the developers, but should be sought one level higher, with project management. They have to

release the resources required in the form of time, tooling and training (Dorfman and Chardon, 2001).

Another problem found in practice with regard to traceability is that it is not clear what should be traced (Lindvall and Sandahl, 1996; Stout, 2001; Arkley and Riddle, 2005). Every traceability link costs money to create and maintain, and it has also been determined that not all requirements are equally critical and not all should be traced (Ramesh and Jarke, 2001). Determining the criticality of an issue depends on both the chance of it changing and the impact this change would have, therefore defining the risk involved with an item. The dynamics of a system and its surroundings heavily influence the chance of occurrence.

3.2 Software Development Projects

The subject of this research is the adoption of traceability in software development projects. This section deals with software development (from now on simply spoken of as development) and projects in general, but also the place of traceability and any related decisions in these projects. In the end, this section provides an overview of development projects and their structure, but more important it shows in what part of the process decisions with regard to the adoption of traceability are taken. With this information, the different factors influencing the adoption and the form of the empirical research can (partly) be determined.

3.2.1 Software Development Methodologies

Software development processes take place whenever a (new) piece of software is developed. In order to define a standard process, which leads to the enablement of repeating a process and increasing its quality, software development process models have been created. These models prescribe in which phases a process should be grouped, in which order such phases should be executed and when iterations and coordination between the work of the different phases should occur (Boehm, 1988; Cernuzzi; et al., 2004). Several different process models have been developed, such as the waterfall model, the incremental model and iterative development (Boehm, 1988; Beck et al., 2001; Cernuzzi; et al., 2004).

3.2.1.1   Rational Unified Process

The standard process model used at Ordina for development projects is the Rational Unified Process (RUP). The Unified Process is a software development approach that is iterative, architecture-centric and use-case driven (Jacobson et al., 1999). RUP is a well-defined and well-structured software engineering process. It clearly identifies who is responsible for what, how things are done, and when to do them, as long as you tailor your process to your projects needs (Kroll and Kruchten, 2003). To achieve this, it has created an overview of disciplines and phases of which a development process consists. Phases can consist of several iterations, working to mitigate the largest risks first.

What Figure 5 shows, is that development activities start during the inception phase already, where the project plan is developed and a lot of the requirements elicitation is performed.
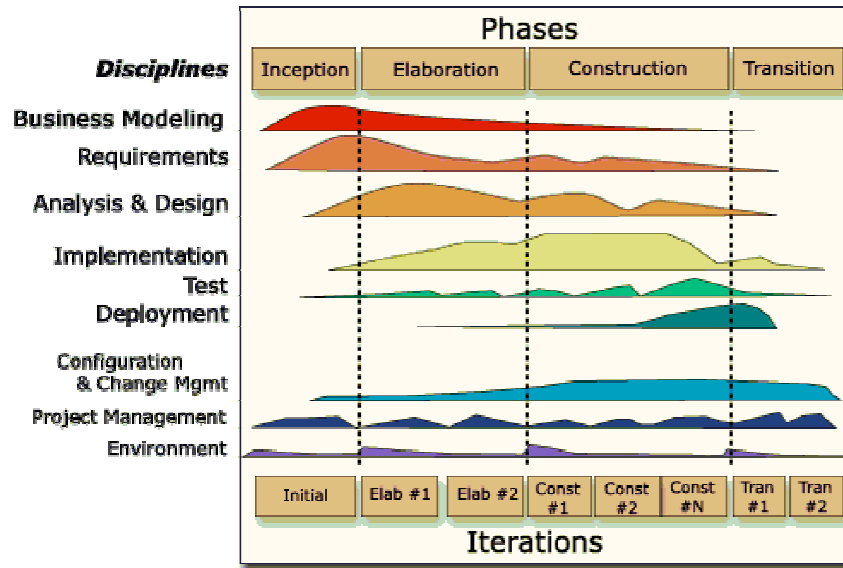
Figure 5 – RUP Disciplines, Phases and Iterations (Rational, 2006)

3.2.2 Projects

3.2.2.1 Definition

System development is an process which is not a regular everyday activity for an organization which attributes to their core business. It is a finite process which has the aim of improving the organizations processes, which is therefore different from the regular tasks of an organization. For this reason, the organization form of this process differs from regular processes. This kind of activity is performed in a project, which is *a temporary organization that is needed to produce a unique and predefined outcome or result at a pre-specified time using predetermined resources*(OGC, 2005).

3.2.2.2 Project Management

A "regular" process is managed by a functional manager with a hierarchic position. Projects, however, have been identified as temporary organizations outside the regular organization. These organizations have to be managed as well, however, which is why the separate competence cluster of project management has been identified.

Project management is responsible for the initiation, planning, execution and closing down of a project, in a sense that they are responsible for providing both control and resources to the project (Hoffer; et al., 2002). For this, a project has one or more project managers which perform the actions required. Several methods have been developed for the management of projects, which prescribe a uniform high-level approach to project management. In the Netherlands and the United Kingdom, Prince 2 is the de facto standard for this methodology.

3.2.3 Project Management – PRINCE2

3.2.3.1 History

In 1989 the current Office for Government Commerce (OGC) in the United Kingdom developed the PRINCE project management method. PRINCE was developed from PROMPTII, which was created in 1975. PRINCE (Projects IN Controlled Environments) is a structured method for effective project management, which focuses on IT projects. The current OGC kept developing the method, and in 1996 launched PRINCE2 (OGC, 2005).

PRINCE2 is based on a collection of best practices which were contributed by project managers and project teams. Where PRINCE was mainly focused on IT projects, PRINCE2 is

a method which is applicable in different environments. The method is supported by trainings, tools and a lot of written material.

3.2.3.2   Projects in PRINCE2

PRINCE2 covers the entire life-cycle of a project, as well as some pre-project preparation, which should be noted is not the same as the products life span. The project life cycle spans from the trigger of a product development to the implementation of it, yet everything before and after this falls out of the scope (such as operation and maintenance).

The method of project management consists of processes and components. The eight distinctive processes cover everything from setting the project off correctly to the completion of a project. Figure 6 provides an overview of the different processes identified in PRINCE2, which are all addressed in any run of a project but which have to be tailored to any individual project.

The first process in PRINCE2 is *Starting up a Project (SU)*. This process is in the pre-project phase, preparing the initiation phase of the project. It is a relatively short process which takes a project mandate and then makes sure the required resources for the initiation process are available, amongst which the project board and the project management board.

The main objectives of the next phase, *Initiating a Project (IP)*, are to define how the required product quality will be achieved, to plan and cost the budget, to prepare a justified business case and to provide the baseline for the decision making processes required during the project's life. At the end of this stage of a project, the startup phase is finished and the implementation work of the project is started.
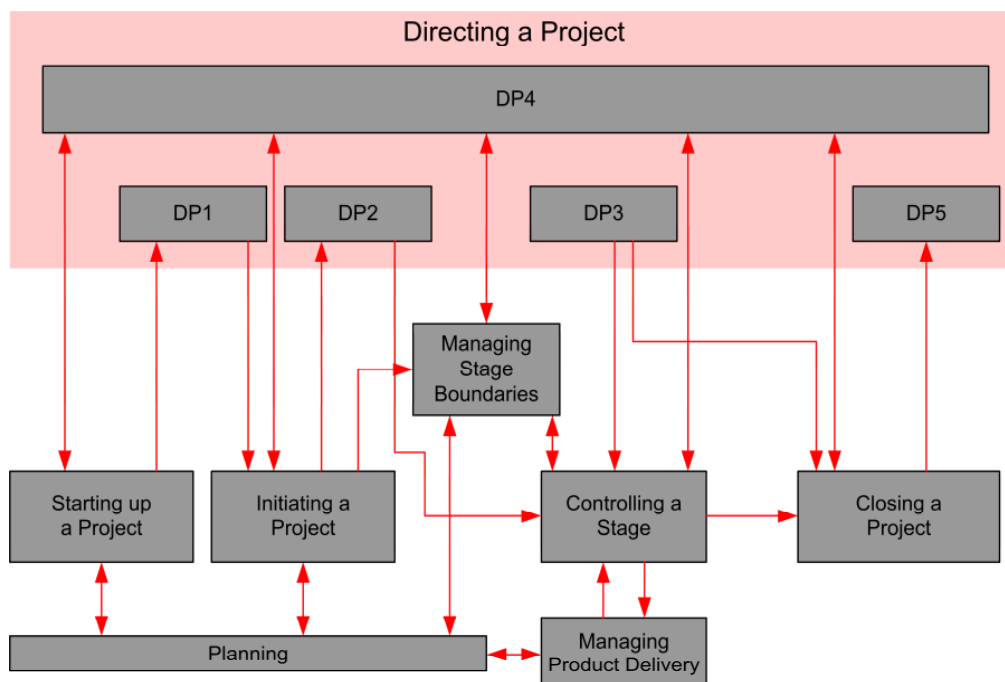
Figure 6 – The PRINCE2 Process Model (OGC, 2005)

The top of the model in Figure 6 shows the *Directing a Project (DP)* process, which has been split up into several parts in the process model. This process is aimed at the project board, which is the group of business, users and suppliers that makes the high level decisions on a project such as authorizing initiation, committing resources and project closure.

Planning is the process which allocates resources to the phases and tasks involved with the project. PRINCE2 prescribes an intricate seven stage process for creating a plan, which is iterated when required.

Managing Stage Boundaries (SB) is the process which informs the project board allowing them to decide on whether or not to continue with the project at the end of a stage. It reports on the work performed in a stage, and prepares the next Stage Plan when obtaining authority for this. This phase can often be performed quite informally.

When a project has been authorized and the work is underway, project management is responsible for controlling the production to make sure the result is up to standard. *Controlling a Stage (CS)* is the process identified here in PRINCE2 which assesses progress, captures and examines issues and takes corrective actions or escalates issues where required. To get work done, the project manager works with team managers in the *Managing Product Delivery (MP)* process. Work packages are conferred, work is done and in the end the work is handed back to the project manager. This process is closely related to controlling a stage, as Figure 6 shows with the double arrow.

The final process identified by PRINCE2 is *Closing a Project (CP)*. The finite character of a project leads to the fact that a project has to end sometime, where the work is either completely successfully or the project is aborted. Several activities, such as defining follow-up actions and correctly archiving an end report, have to be performed in this process (OGC, 2005).

3.2.3.3   PRINCE2 Components

Besides processes, PRINCE2 also defines several components, which are particular subjects that affect project management. PRINCE2 addresses when and how these issues should be addressed. A summarized overview of these components can be found in Table 1.

Business Case	The business case shows the viability of a project and warrants its existence. It is updated frequently during the project.
Organisation	PRINCE2 provides a structure for the project management team and the project board, and defines their responsibilities.
Plans	PRINCE2 offers a series of plans that can be tailored to the needs of a specific project.
Controls	The main controls for senior management consist of "management by exception", putting the control on the execution of a defined plan.
Management of Risk	Several key moments are defined where risks are reviewed.
Quality in a Project Environment	The importance of quality is clearly recognized in PRINCE2, focusing on quality standards and quality inspection methods.
Configuration Management	PRINCE2 defines the essential facilities and information requirements for a configuration management method and its position within the PRINCE2 method.
Change Control	The need for change control is emphasized and enforced by several techniques.

Table 1 – PRINCE2 Components (OGC, 2005)

3.2.4 The Rational Unified Process and PRINCE2

PRINCE2 and the rational unified process are mainly complementary methodologies. Whereas PRINCE2 is a generic project management method, RUP is a specialist method focusing on specific activities in a software development project. There is overlap between

them however, both on the field of organization and matters such as risk management, problem management and quality management.

Aligning RUP with PRINCE2 for the purpose of this research focuses on the processes identified in PRINCE2 and the phases we find in the Rational Unified Process. As shown by (Norlund, 2003), the *inception* phase in RUP aligns with the *initiating a project*-process in PRINCE2. The process preceding this one, *starting up a project*, lies outside of the scope of development methods and is only found in project management. The same applies for that last process in the series identified in PRINCE2, *closing a project*. The other phases identified in RUP occur simultaneous with the remaining processes found in PRINCE2, as identified in Figure 7.
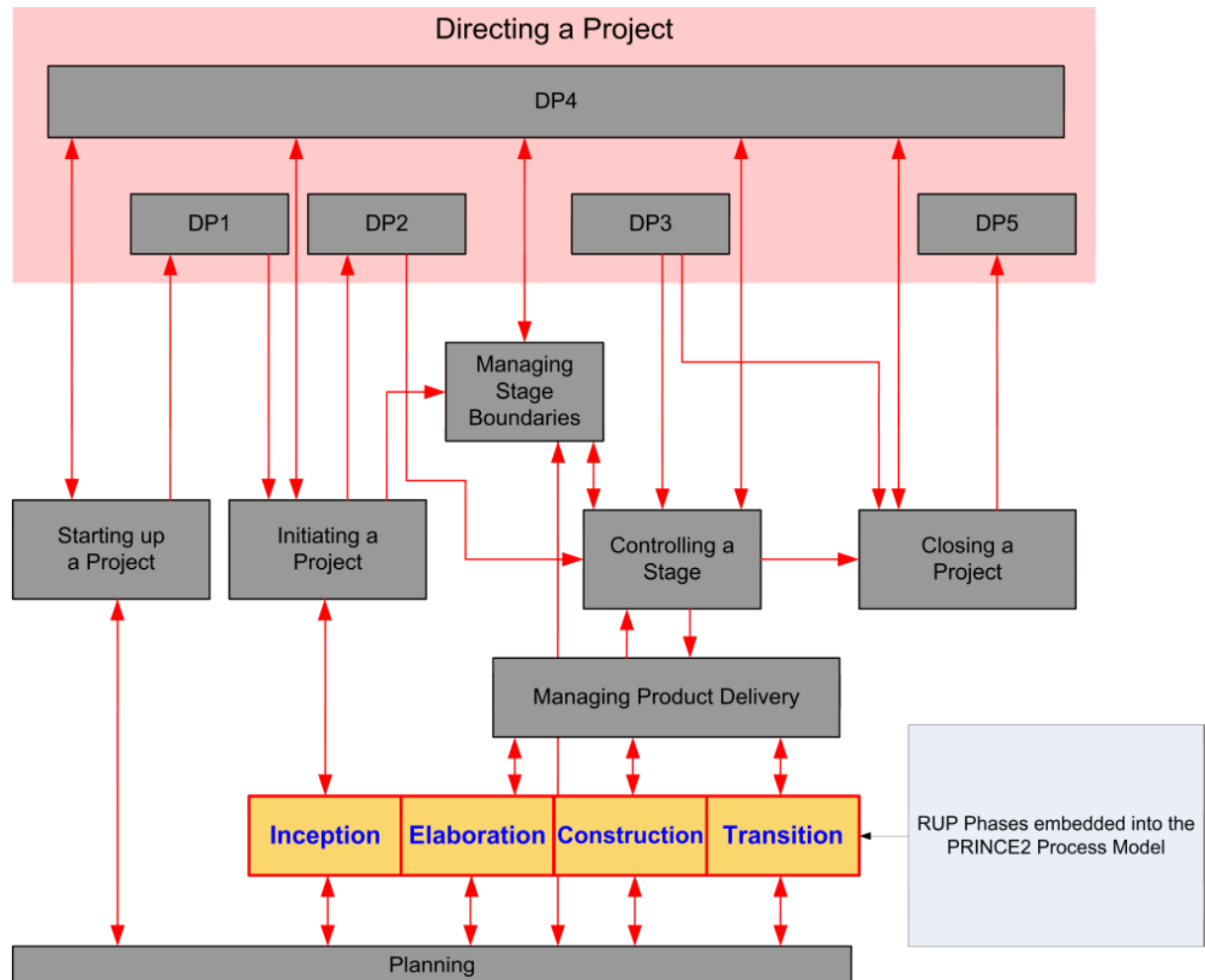
Figure 7 – Embedding RUP phases in the PRINCE2 process model (Norlund, 2003)

3.2.5 Traceability in Development Projects

Combining RUP and PRINCE2 to a generic layout of a development project as in Figure 7, we are now able to identify *where* in a project we can find traceability, and which processes and components in a project are related to them, after which the actors involved can be pinpointed.

Section 3.1 shows that traceability is involved with every effort in development from requirement elicitation to testing. Theory also prescribes that it is quite expensive and hard to start traceability when a project is already underway, so when performing traceability this should always start at the start of a project. Starting halfway through a project will increase the costs of the traceability effort tremendously. The Rational Unified Process shows that

after creating a project plan, development starts straight away, from which we can derive that adopting traceability should be initiated during the creation of a project plan.

Linking this to project management, and specifically PRINCE2, we see that three processes are of importance with deciding whether or not traceability should be adopted. During both the *startup* and the *initiation* of a project, the project team determines the way in which the work should be performed. More specific, these processes look amongst others at the quality requirements which are valid for the specific project. The third process involved is the directive process. It is this process in which decisions on accepting or rejecting a project plan are made by the project board. This project board consists of representatives from the business, users and suppliers. It is the two processes discussed previously which provide them with the input in the form of information on which they base their decisions on how the project should be performed. This information consists of *plans*, which amongst others contain a clear *business case* and the *project initiation document*. On top of these *plans* and *processes*, PRINCE2 also discusses several *components*. The *Quality in a Project Environment* component of PRINCE2 deals with achieving the quality expected by a customer, amongst which traceability could be an item. *Configuration Management* shows that the interdependencies between sub products should remain aligned and that this should be supported. Finally *Change Control* is offered by PRINCE2, stating that changes will arise during projects and that these influence all the sub- and byproducts of a project which have to remain intact.

Concluding, we can see that the process of adopting traceability in a project should be started before the actual development is started. The people involved with the start of adoption are the project board, the project manager and the project team involved with the preparation. With this knowledge, the next section of this chapter looks into the decision making process involved with the adoption.

3.3 Decision Making

Adopting traceability is a choice. In a development project, one can either make a choice to trace or choose not to trace during development. A decision is *a choice made from available alternatives*, which is exactly what is happening when adopting traceability or not (Daft, 2000). This definition is somewhat lacking depth, however. Matheson and Howard defined a decision as *an irrevocable allocation of resources that is revocable only at a cost in some resource, such as time or money..* Some decisions are inherently irrevocable, such as the amputation of a pianists hand, whereas others such as the decision of a major company to enter a new market is essentially irrevocable (Howard, 1983a; Matheson and Howard, 1983).

This section introduces decision models and explores one specific model for decision making, which is later applied to discovering and structuring the factors influencing the adoption of traceability. Section 3.4 deals with the way this model is used and introduces these factors.

3.3.1 Decision Models

Decision making is *the process of identifying problems and opportunities, and then resolving them* (Howard, 1988). People make decisions all the time, although they might not always formally identify them as decisions. They call them choices, something which just happens, but they ignore the effort involved both before and after this choice (Daft, 2000).

The area of decision making has become a separate field of science. Probabilities already date back as far as Bernoulli, Poisson and Bayes, yet these mathematical models do not structure the world of top management decision making (Howard, 1966). Often, people feel that decisions are based purely on intuition, which is completely the opposite of these statistical models. The real promise of decision theory lies in the ability to provide a broad logical basis for decision making in the face of uncertainty. A process in which this logical basis and everything influencing it is elicited and applied is what is researched in this field.

Several different schools of decision making have arisen in the recent years. Classical decision making theory (CDM), focuses on four different aspects. These are those of choice, the aspect of modeling the input/output of the different alternatives, that of conceptualizing decision making as a deliberate and analytic process that requires a relatively thorough information search and finally developing abstract, context-free models allowing quantitative testing of alternatives (Lipshitz et al., 2001). Researchers have criticized the rational decision model which was part of CDM, and newer streams were developed adapting this model. They did, however, retain the essential characteristics. Normative models for evaluating decision alternatives were still part of these newer models. Another stream, which is even more recent, is that or naturalistic decision making. This method is more informal and less focused on statistical normative methods (Lipshitz et al., 2001).

In decision making theory there are normative models, which prescribe how to make a decision, and the descriptive models, which are oriented towards understanding and predicting decision making. The classical decision making theory is a normative theory, which stipulates how decisions should be made on a normative basis and what the best outcome would have been (Meredith, 2004). Howard states:

> *Decision analysis is a normative practice of decision-making. The acceptance of its norms allows me to recognize my decision mistakes. Using decision analysis I can be sure that the decision I make follows the rules I would use to reason in very simple, and therefore transparent, situations, as well as the rules I would follow to reduce complex situations to transparent ones.* (Howard, 1988)

This research adapts CDM, and specifically the Stanford school of decision making of which Howard is one of the most published authors (Howard, 1983b). The theories developed here adhere to the standards of classical decision making, focusing on creating transparent situations which can be analysed to reach the correct decision through a structured process.

3.3.2 Stanford School of Decision Analysis

Decision analysis is the name given to analyzing decision processes by Howard. The discipline of this "decision engineering" is defined in the following way: *A systematic procedure for transforming opaque decision problems into transparent decision problems by a sequence of transparent steps.* In other words, decision analysis offers the possibility to a decision-maker of replacing confusion by clear insight into a desired course of action (Howard, 1988).

Howard approaches the decision making process by modeling it as a shift from a real decision problem to a real action, including all the actions required to create this shift. This is a process of elicitation and analysis, leading to clarification of the actual problem in a way that it can be acted on in a logical way.. These actions have been classified into three separate activities, which can be iterated for further refinement when required. This process has been modeled in Figure 8.
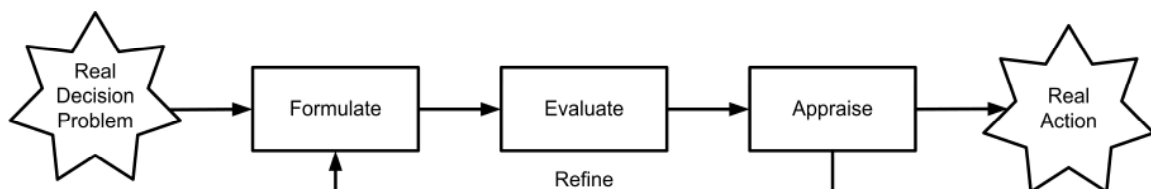
Figure 8 – The decision analysis process (Howard, 1988)

The three phases identified here deal with formulating, evaluating and appraising any actions which are appropriate for dealing with the decision problem. A problem, having been identified as a decision problem, goes through at least one iteration of the three phases shown in this model. When the decision maker is content with the outcome of the process, meaning that he sees no need for another iteration and no further information available, he will decide how to tackle a problem and take real action.

3.3.3 The Decision Basis

Central in the decision making process is the decision basis, which is constructed during the process shown in Figure 8. It is constructed during the "formulate" phase, where the required information is elicited and structured as needed. With this basis, the different solutions can be evaluated and appraised, after which, if required, another iteration of the cycle is performed. This entire cycle is based on the decision basis.

Howard defined this decision basis itself as consisting of three different parts, each influencing the final decision in their own way. As Figure 9 shows, one has to go through an elicitation phase in which this decision basis is formulated, after which the further steps as identified in Figure 8 are performed. In this research, the focus lies on this decision basis and the way in which it is reached. The activities required to reach this basis, as well as the different parts of the basis, are discussed in this section.

3.3.3.1   Problem Identification

The first step required in the decision analysis process, independent of any of the other steps, is answering the question of which decision is to be made (Howard, 1966). To be able to answer this question, however, one needs to know one has a question which has to be answered. without this awareness, no decision process can ever be started. This awareness has to exist even before the elicitation-arrow in Figure 9, because a problem is not a problem until it is recognized as such. On the other hand, a problem only leads to a decision problem if, consistent with the previously supplied definition, there are resources which are to be allocated.

3.3.3.2   Problem Synthesis and Information Elicitation

When the problem is recognized, the first phase of the process is initiated. As Figure 9 shows, the problem is synthesized into the transparent decision problem required for the normative process. For this, the decision basis is developed, yet as with any product it requires input. This input comes from the elicitation-activity which is in this same part of the model. The different stakeholders are required for their input into the decision basis. Stakeholders include the decision maker, yet also other people with an interest in the problem and/or its outcome and people which have information required to properly deduct the optimal decision.

3.3.3.3   Choice

The first of the three elements presented in the decision basis is that of choice. As Figure 9 shows, this aspect deals with the different alternative solutions for the problem at hand, which show the different courses of action open to the decision maker. Without alternatives, there is no choice to be made. Without this choice, there is not decision on how to allocate the resources available.

Defining the different alternatives open to a decision problem is the first step in the synthesis of a problem into a transparent decision problem. It is also the most creative part of the decision making process, attempting to think out of ones own frame of reference to find different alternatives. Alternatives can either be discrete, such as to buy something, or not to buy something, but in many cases can also be described by continuous variables such as when deciding how much of something should be bought. The process requires ingenuity and cannot really be helped in any way by logic or decision analysis. In the end, this part of the decision basis determines *what we can do.*
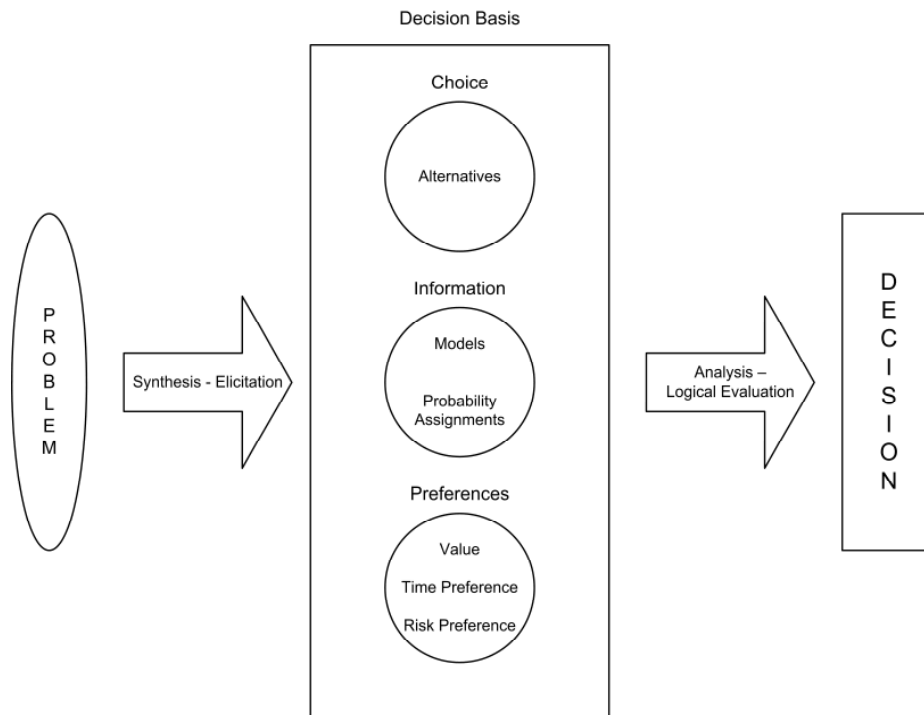
Figure 9 – Decision Basis (Howard, 1988)

3.3.3.4   Information

The second part of the decision basis is that of information. To be able to judge the alternatives which were formulated, one needs information. This information consists of two different things in Howard's classification, being *models* and *probability assignments*.

Models are used to structure the problem and to represent the relationships between the different factors influencing the outcome of a decision. Decision analysts develop a formal mathematical model representing the underlying logical relationships of a decision problem which shows what affects what. These models provide an insight into the consequences of implementing the different alternatives, which can be complex and dynamic, or rather simple (Howard, 1983a).

There are, however, also matters which influence the outcome of a decision which cannot with any certainty be established. Any uncertainty which remains is characterized by probability assignments in this model. Any factor which influences the outcome of a decision in a non-discrete way has to be assigned a probability of occurring. Finally, this part of the decision basis shows us *what we know*.

3.3.3.5   Preferences

The alternatives and information on the outcome of the implementation of these alternatives is not enough for a well-structured decision process. As Figure 8 shows, the third of the three steps in the decision analysis cycle is that of appraisal. Appraisal has to do with assigning values to outcomes, which is required to determine the best of the available courses of action and allocation of resources.

The preferences of the decision maker(s) are represented in several dimensions as well. First of all, the personal values of a decision maker are taken into account. Under certain circumstances a specific outcome may be more valuable to one person then another. When returning to the example provided in the first paragraph of this section, amputating a persons hand, there is a big difference when looking at who this hand belongs to. For a concert pianist, the value of being able to use his hand is tremendous. Without his hand, he will not be able to function in his profession, whereas this value is a lot lower for the general person.

Second, there is the issue of time preference. The time value of money, combined with the required availability of funds, is a much debated issue in business and time value should also be taken along in decisions. The decision maker can have a preference for the value of an outcome instantly rather then somewhere in the future, which influences the final outcome of this decision.

Last, there is the aspect of risk preference. Whereas value and time are certainly important, another quite important aspect is that of risk. People have a natural tendency to reduce, or when possible completely avoid, risks, which is why we have insurance companies in the first place. The amount of risk involved with an alternative, combined with the amount of risk someone is willing to take, influences the final decision as well. Each of these three aspects determine *what we want.*

3.3.4 Using the Decision Basis

As Figure 9 shows, this basis of decisions is analyzed and logically evaluated. With the subsequent appraisal of the alternatives the choice is made to either refine the alternatives or to take real action and implement the decision as we can see in Figure 8. Each of the aspects in the decision basis is required to be able to make a sound decision, and as the first of the two models in this section shows it might be required to adapt the decision basis with new information to be able to make a solidly weighed decision.

3.4 Identifying Influencing Factors

The goal of this research is identifying the factors influencing the adoption of traceability in development projects. Up until now, we have discussed traceability and development projects and the previous section introduced a framework with regard to decision making. Several different authors have already researched the implementation of traceability, amongst which Ramesh and Jarke (Ramesh, 1998; Ramesh and Jarke, 2001). They, however, focused on the operational implementation in projects where traceability was implemented, whereas this research looks at the factors influencing the adoption of traceability instead of the implementation of it, which has only been discussed in a fragmented way. This section provides an overview of these factors identified from literature and their placement into a relevant framework.

3.4.1 Framework Justification

The section on development projects showed us that if one wants to adopt traceability in a development project this should be started before the actual development begins. In the project plan the choice has to be made whether or not traceability is to be adopted in a project, and when looking at the first definition of decisions as provided in the previous section we see that the adoption of traceability in this context is just that: a decision. In fact, it is a discrete decision where one has to decide whether or not to adopt traceability.

3.4.1.1   Framework Selection

Literature on both development projects and traceability introduced several aspects which could influence the adoption of traceability. To gather a complete picture of these factors the process in which they play a role is further examined. This process can be clearly identified as a decision making process, which helps us structure the different aspects which influence the process regarding the decision of adopting traceability and helps identifying the factors involved in this. Through the use of a structured method a relatively complete overview of these factors can be developed from the available theory.

Section 3.3 introduced the classical decision making theory (CDM), as well as briefly touching some other streams in decision making theory. CDM focuses on decision making of the individual with a clear input-output orientation. The orientation on the influence (input) and its consequences (output) of aspects make this model very suitable for this research.

3.4.1.2   Framework Use

Classical decision making is, as discussed previously, a normative decision making practice. The theory as discussed by Howard identifies a process by which a decision is structured and should be structured for that matter. The goal of this research, however, is not to define what decision *should* be made, but *how* this decision is reached. The model is therefore not used in a normative way, but in a way of describing the process. It is not intended to be followed to see how a decision should be made, but to identify the aspects involved with making this decision.

Identifying factors influencing the adoption of traceability connects closely to the decision basis and its development. As we can see in section 3.3, the decision basis is formulated, evaluated and appraised, where this decision basis and its components are the base for each of these actions. It is only the decision basis which introduces new factors into the equation, the steps following the formulation of this basis add nothing to it and only use the existing alternatives, information and preferences to determine the ideal outcome. Arriving at the decision base, however, offers some interesting prerequisites which constrain the outcome of the decision making process.

With this knowledge the modeled process of decision analysis, and specifically the development of the decision basis, is applied to the decision of adopting traceability in a project to identify the specific realization of the issues identified. The next sections provide an overview of the different factors found when simulating this decision process, after which a complete overview of the different factors identified from theory is presented. The fact that a generic simulation is performed leads to different factors which influence the adoption decision, but they have to be filled in for specific projects to reach the outcome.

3.4.1.3   Factor Representation

As stated above, different factors are identified during the simulation of the decision process. For each factor a description is provided, explaining the factor, after which the rationale behind this factor including its sources. To be able to perform valid empirical research on these factors, they have to be made operational so they are measurable. With this measurability, we can see what their value is in practice, and what the influence of the value of this factor on the adoption of traceability is.

Description	A short description of the factor.
Rationale	The source of this factor and the reason why it influences the adoption process.
Measuring	The values this factor can take on when measuring it.

Table 2 – Factor Representation

Something which should be noted here, is that the influence of a factor is not based on its actual value, but on the perceived value of it by the project manager. This perceived value can be quite different from the actual value, because of matters such as wrong or non complete information or bias.

3.4.2 Decision Definition

Before simulating the decision analysis process, we need to identify which the problem is that will be reviewed. Development methodology literature discussed in section 3.2, as well as general traceability literature, showed that deciding on the adoption of traceability should occur before the actual development begins. PRINCE2 Shows that there are several points in this startup phase of a project which could be seen as the making of this decision. In the end, it is the project board which authorizes the project initiation document which states how a project will be executed. This is not, however, a specific decision on adopting traceability, yet one which spans the entire project plan.

During a project, separate roles in the development team can decide for themselves whether or not to adopt traceability in practice, which should also occur before the actual development tasks are executed. However, the adoption of traceability generally requires an investment of resources in the form of time spent by the member of the development team, and when tools are used also in the form of these costs. Because of this, the decision for adopting traceability is again transferred to the project manager. On another note, if traceability is to be applied project wide, in many of the different development products, it has to be coordinated. Traceability throughout the entire process has to be implemented top-down as it is, leading to the responsibility of the project manager.

Putting traceability into this project or quality plan, which happens during the initiation stage, is the action which precedes the approval of a project initiation document. During the *initiating a project* – phase in PRINCE2 the project initiation document is developed in which the option to adopt traceability (or the option not to adopt it, for that matter) is dealt with by the project team. In the end, however, it is the project manager which is responsible for the project initiation document and its contents.

Decision Problem	"Should the concept of traceability be applied in this project?"
Decision Maker	Project Manager
Decision Moment	When developing the project initiation document

Table 3 – Decision Definition

3.4.3 Problem Identification

Returning to the framework identified in Figure 9, the first thing involved with decision analysis is the identification of the actual decision problem. Without the identification of the problem, there is no decision to be made. Identifying a problem requires awareness of the issue. There are two ways of becoming aware of the issue, which are both described. More on these two ways is discussed in section 3.4.8.

3.4.3.1   Development Organization Awareness

Description	The development organization has to be aware of the existence of traceability and the possibility of adopting it.
Rationale	Knowing the problem is a requirement for any decision and in this case knowledge of traceability is a prerequisite. The choice whether or not to adopt traceability is made in the development organization. If this organization is not aware of the concept, it will never adopt traceability. Several roles within the development organization can create this awareness with the decision maker (the project manager), which are also discussed as *stakeholders*. The entire development organization can aid in the purpose of creating awareness with the project manager, who finally makes the discussion.
Measuring	This factor can be measured by checking whether or not it was discussed with the project manager during the project's initial phases. Precondition is that those that were aware did take this effort.

3.4.3.2   Customer Awareness

Description	The customer can make the development organization aware of the decision, by demanding the use of traceability.
Rationale	Besides the developments organizations own initiative to adopt traceability into the project, it can also be a demand of the customer. The customer should be seen in a broader sense here, not just as the manager. The entire organization behind the customer, such as the IT-management department, is

	involved here. RUP identifies *acceptance criteria* which have to be formulated by the customer for a development project (Rational, 2006), which are also part of the customer's quality expectations in PRINCE2 (OGC, 2005). These criteria are concrete demands of the customer which can contain demands on traceability and when presented create, increase or maintain awareness with the decision maker.
	A note here is the fact that a customer can also be aware of the existence of traceability, but might not mention it to the project team due to the fact that he does not believe in its necessity or added value. This means that he has already made a somewhat similar adoption decision which lies outside of the scope of this research, being a different decision with a different decision maker. In this research, the adoption from the side of the development project is regarded and the customers wishes are regarded as a variable which can not be externally influenced. Awareness can be created by the project team of course.
<u>Measuring</u>	This factor can be measured by checking whether or not any demands with regard to traceability from the customer were known with the project manager.

3.4.4 Elicitation

When awareness of the fact that there actually is a choice between applying the concept of traceability or not in the development project exists with the project manager, the next stage is the development of the decision basis. For this, the elicitation of information is required for the decision maker. This information is elicited from different sources. It is these sources that can aid the decision maker in providing him with the information required.

3.4.4.1   Sources of Influence

<u>Description</u>	Different sources are available to the decision maker for eliciting information within the development organization. These are experts, members of the project team involved in this stage of the project, as well as the project board, and of course also the project manager himself.
<u>Rationale</u>	Literature offers little insight into the roles of members of a project team involved with the creation of the project plan. Unstructured interviews at Ordina show that its formation differs per project, but generally an architect, analyst and functional designer are involved. From the project board the senior user, which represents both the end-user and the IT-management department, is an important source of information required (OGC, 2005).
<u>Measuring</u>	This factor can be measured by determining which parties were consulted by the project manager during the preparation of his decision.

3.4.5 The Decision Basis – Choice

Deciding whether or not to adopt traceability in a development project is a discrete choice, with a yes/no answer. How it should be adopted or implemented is another decision to be made. Developing these alternatives is closely related to becoming aware of the problem.

3.4.5.1   Knowledge of Traceability in Development Organization

Section 3.4.3.1 describes that to create the awareness of the decision problem, knowledge of the concept of traceability is required. When this awareness exists with the decision maker, the fact that there are at least two alternative courses of action is also known.

3.4.5.2   Customer Demands

Section 3.4.3.2 deals with customer awareness. One of the main reasons to adopt traceability in a project is because it is a demand from a customer, therefore offering an alternative above that of not adopting traceability.

3.4.5.3   Technological Possibilities

Description	Being aware of the concept of traceability is not enough for two realistic alternatives to be available. Adopting traceability has to be possible and executable.
Rationale	To make sure that the alternatives are realistic, the technical support has to be adequate for the concept to be applied. For this decision, the decision maker has to be under the impression that the technical support is sufficient.
Measuring	This factor can be measured by discovering whether or not the project manager feels the option is realistic.

3.4.6 The Decision Basis – Information

The influence of the different sources besides the project manager himself is largest with regard to the delivery of information on the consequences of a decision. The outcome of the decision of traceability has to do with several matters. First of all, there are the financial consequences of adopting traceability. Second, adopting traceability in a development project might be required in quality standards, or possibly even with regard to compliance to certain official standards. On the other hand, the outcome of the decision to adopt traceability depends on several factors which in turn influence the value of traceability in the financial sense, yet are not discrete in occurrence, therefore requiring a probability assignment, such as the complexity of a project, the life expectancy of a system, the development method and the dynamics of the systems surroundings.

Whereas some of these factors clearly show in what way they influence the adoption decision the outcome of choosing an alternative, some can not be determined completely beforehand. Especially the last aspects which are presented in this part of the decision basis do not allow for a discrete calculation of their influence, they require the assigning of a probability to them.

3.4.6.1   Return on Investment

Description	The decision maker has to have a clear view of the costs and benefits involved with adopting traceability, as to predict the outcome of the selection of either alternative.
Rationale	In business, every decision can be approached as an investment decision. Both alternatives can be assigned costs and benefits, that in the in lead to a profit or a loss. The costs of adopting traceability are often apparent, lying in the resources required for each registered traceability relation. Many researchers have found that one of the main problems, if not the main problem with regard to adopting traceability in practice is the lack of perceived benefit with management, leading to a diminished support from management (Ramesh, 1998; Arkley and Riddle, 2005).
	The benefits of traceability lie in the better understanding of software. This drastically reduces the effort required to determine the impact of a change. As found at Ordina, using traceability can drop costs due to impact analysis by over 25%, and impact analysis often accounts for over 70% of the entire change effort (Ordina!T Excellence, 2004).
	Understanding both the costs and the benefits involved with adopting traceability is required to be able to determine the outcome of the decision.

	PRINCE2 discusses this as the balance between risks, cost, time, advantages and savings (OGC, 2005).
Measuring	This factor can be measured by discovering whether or not the project manager is aware of the advantages and drawbacks of traceability in the financial sense. The existence of a business case shows the consideration of this, yet sometimes there is only an informal business case in the mind of the project manager.

3.4.6.2 Quality Standards

Description	Several quality standards require the adoption of traceability. The adoption of these standards influences the outcome of the decision
Rationale	As discussed in section 3.1, both CMM and ISO 9000 demand the use of traceability in development projects (ISO 9000-1, 1994; Carnegie Mellon SEI, 1999). When an organization wishes to adhere to these standards, in the case of CMM at the level where traceability is required (2 and beyond), adopting traceability is required. The organization can be both the development organization and the customer organization. This factor is closely related to those in 3.4.5, customer demands and development organizations awareness.
Measuring	This factor can be measured by looking at certification of the organization.

3.4.6.3 Compliance

Description	Legal standards require traceability in systems. Having to adhere to these standards leads to an influence of the adoption of traceability.
Rationale	Besides quality standards such as ISO and CMM, there are also legal standards which companies have to adhere to. One of these standards is the Sarbanes Oxley act of 2002 which applies to all companies tradable on the NYSE (US Congress, 2002). This standard demands traceability from all systems in use of this system to ensure transparency. This factor is closely related to those in 3.4.5 as well.
Measuring	This factor can be measured by looking at the required adherence to legal standards in the customer organization.

3.4.6.4 Project Complexity

Description	Higher project complexity leads to an increased value of applying traceability.
Rationale	When the complexity of a project increases, it also becomes harder to comprehend the system for developers. This complexity has to do with the familiarity of the development organization with the technology used. Traceability links between code and other deliverables aid in both the bottom-up and top-down comprehension of code by programmers, increasing their productivity through being able to both derive code from the preceding products and to place chunks of code in perspective (Antoniol et al., 2002).
Measuring	Project complexity can be judged from high to low by the project manager.

3.4.6.5 Development Method

Description	The development method applied could lead to an increase value of applying traceability
Rationale	Section 3.2 of this chapter showed that several different streams of development methods exist, each with its own characteristics. The characteristics of a method influences, amongst other things, the amount of

	changes which occur during the development project itself. Incremental and iterative development methods lead to more changes on already developed parts of the system being performed during the development project, therefore increasing the value of adopting traceability. Besides simply adding to the total increase of value, the fact that these benefits lie in the development stage also improve the likeliness of the adoption, as further discussed in 3.4.7.2.
Measuring	The development method used is part of a projects description

3.4.6.6 Product Life Expectancy

Description	The length of the life expectancy of a system influences the value of applying traceability, since the amount of changes required for use increase linear with the period it is in use.
Rationale	As discussed in the factor presented in 3.4.6.1, return on investment, the main financial benefit lies in the heavy reduction of the time required for impact analysis when changes occur. The longer that a system is in use, the higher the number of changes which occur during its lifespan, therefore again leading to a higher return on investment.
Measuring	The expected lifespan of the system as stated at the start of a project.

3.4.6.7 Dynamics of the environment

Description	The dynamics of the systems environment influences the value of applying traceability, causing more or less changes required during its lifespan.
Rationale	The frequency of risks is determined by the amount of changes in its environment. These changes in the environment can consist of changing interfaces, changes in business process layouts, changes in organizational structures, and many other matters. The more dynamic the environment of a system, the higher the amount of changes which is to be expected and the higher the expected return on investment for adopting traceability.
Measuring	The dynamics of a systems environment are hard to measure. In this research, it is judged by the project manager.

3.4.7 The Decision Basis – Preferences

With the alternatives identified and the factors which deal with the information part of the decision basis, what's left is the preferences of the decision maker. Different aspects of an outcome can be valued in different ways by decision makers. An organization which stresses quality influences the decision maker, but on the other hand a decision maker can have personal preferences. Some outcomes benefit the decision maker himself personally, or are quite important with regard to his personal value pattern. A project manager might also feel compelled to simplify the tasks for the project team, allowing them to focus solely on the main tasks and not getting distracted by recording traceability.

When looking beyond the borders of a project, and looking at a product itself, the main benefits of traceability lie beyond these borders. The benefits of traceability lie there where most changes are made, which is not in the project itself.

3.4.7.1 Stakeholder Preferences

Description	Individual preferences of stakeholders, especially the manager of an IT department, might not be the same as those of the entire organization, yet they can influence the decision in a political process.
Rationale	The outcome of a project influences many different parties. Each of these parties might have an influence on the outcome of the decision, which they

	would want to turn in their own favor. The manager of an IT department, which is generally a member of the project board (OGC, 2005), might be bound by a tight budget, which means that the solution has to be within that budget, whereas adopting traceability might mean exceeding the budget. He could be receiving a bonus at the end of a year with regard to his control of this budget, which would influence him to keep development costs low. This way, what is best for the customer organization is not necessarily what is best for individuals involved. Daft defines this as politics, where in this context power is exercised to influence the decision to strive for a self-serving purpose (Daft, 2001).
<u>Measuring</u>	This factor is hard to measure, if not impossible. Whereas it does potentially influence the decision, this will be a concealed influence.

3.4.7.2   Process Flow

<u>Description</u>	Traceability, when performed, creates another task for the development organization members which influences the flow of the project. More tasks might endanger project progress.
<u>Rationale</u>	Adopting traceability increases the workload for those involved with it. It creates additional tasks which are to be performed during the work in development, which are often seen as extra and optional (Jarke, 1998). A project manager might feel that letting the developers focus on their core business by reducing the process complexity would create a better end result.
<u>Measuring</u>	This factor is measured by discovering the attitude of the project manager towards the influence of traceability on the development process.

3.4.7.3   Benefits Outside Project Borders

<u>Description</u>	Benefits of adopting traceability do not lie just within the borders of a project. Conflicting interests influence the decision whether or not to adopt it.
<u>Rationale</u>	In many lifecycles of a system, the work on it is performed by different organizations. Often, development is done by another party then the IT management of the system. Projects aim to be successful, being done on time and within budget. Adopting traceability in a development project often creates more work to be performed, requiring both money and time. Figure 10 shows three graphs, showing the net cash flow as a consequence of traceability during a systems lifecycle. The first graph shows the cost of creating one traceability link, and the second adds the benefits of the use of this link over time. Finally, the third graph shows the total return on investment over time (Cleland-Huang et al., 2004). We can see that the costs are made early on in a systems life, being initial costs required to create the links. The profit of traceability comes along when the links are used in change processes which occurs later on in the systems life. The benefits lie not with the development project, yet with the management of the system later on in its lifecycle.
	As discussed before, one of the main inputs for using traceability is that of the customer, in this case the IT management department. First of all, this information has to be made available. Second, the development organization has to be willing to supply what the other party wants, when this costs them an investment of which the benefits might not be apparent to the development organization (Ramesh, 1998; Arkley and Riddle, 2005).
<u>Measuring</u>	This factor is measured by finding the goals of the project. If these are to complete the project, that is something completely different from creating a project of the highest value to the client.

Figure 10 – ROI of Traceability during a Systems Lifecycle (Cleland-Huang et al., 2004)

3.4.8 Overview of Influencing Factors

The factors found in literature to influence the adoption of traceability have been modeled in Table 4. Each of these factors has been identified by studying literature on the different subjects related to the adoption and by performing unstructured interviews with members of different development projects at Ordina. It is these factors that form the analysis criteria that are validated during the next phase of this research, the empirical validation through interviews.

For each of the factors, the table below shows which actors are involved with it, which are influenced by it or might possibly influence it themselves. Development projects always have a customer, which has a demand for a system to be developed, and an organization which then develops this system. The force field between the customer and the supplier (customer organization and development organization) is managed by the project manager, which identifies the different main actors involved with the process of adopting traceability. The relationships between these actors are shown in Figure 11. A project manager is not shown in the figure here, but it can be seen as a party operating between the two organizations. In the focus of this research he is regarded as a member of the development organization. The factor *development organization awareness* deals with the awareness of the entire development organization with regard to the decision, but the main focus here lies on the project manager, a member of the organization but in the end the one who makes the decision and has to be informed of it.
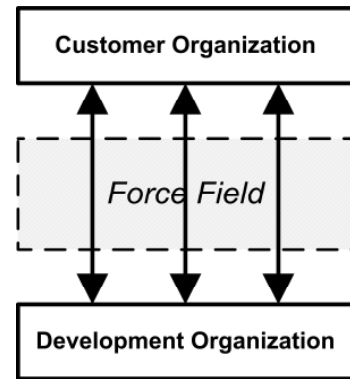
Figure 11 – The Field of Play for Project Management

Table 4 shows that whereas the project manager is involved with nearly all of the influencing factors, the other factors are generally divided between the different organizations. For this reason, it appears imminent that it is the project manager which is to be interviewed for validation of the framework presented here.

	Project Manager	Customer Organization	Development Organization
Development Organization Awareness	X		X
Customer Awareness	X	X	
Technological Possibilities	X		X
Return on Investment	X	X	
Quality Standards	X	X	X
Compliance	X	X	
Project Complexity	X		X
Development Method	X		X
Product Life Expectancy	X	X	
Dynamics of the Environment	X	X	
Stakeholder Preferences		X	
Process Flow	X		X
Benefits Outside Project Borders	X	X	

Table 4 – Overview of Influencing Factors

4. Adopting Traceability in Practice

Chapter 3 of this thesis introduced a theoretical framework. The factors which influence the adoption of traceability according to literature were identified here. This chapter deals with the validation of this theoretical framework and how this validation took place.

The first part of this chapter shows how this validation was approached. Through interviews the process as found in practice was researched. The selection of research subjects and the way of interviewing is discussed in the first sections, after which the results of these interviews are presented.

4.1 Case Study Research

In chapter 3, the adoption of traceability was reduced to a decision and factors influencing this decision were introduced. These factors had their origins in existing theory and concepts and have not been validated in practice. The next step in the research is to validate these factors and where necessary alter the identified factors. Confronting theory and practice, thereby validating the initial framework created in the research, requires information form practice of which the gathering is presented here.

4.1.1 Sources

Comparing theory and practice requires two objects. Theory was researched and can be found in section 3, practice appears intangible. Somehow, practice has to be made measurable by collecting data about the way things occur in real time, in this case the way the adoption of traceability is dealt with in practice. Yin identifies six different important sources of evidence, means of collecting this data (Yin, 1994). Documentation, archival records, interviews, direct observations, participant-observation and physical artifacts are discussed here. Each of these methods (note that there are many more methods available) has its strengths and weaknesses and not all can be used in every research.

In this research, interviews were selected as the primary source of data. The research goal requires a context-dependent insight into the data, so a collection method has to be able to take the context into account and look into this context. Interviews are targeted in the sense that they focus directly on the case study topic, but also flexible enough to provide insight into the context. Another important reason for using interviews in this research is the availability of sources. Documentation could not provide the information required for the research, and the same applies to archival records. Direct and participant observation would take too much time, and no physical artifacts are available for the purpose of this research. With documentation and artifacts, one would only be able to check whether or not traceability was applied, not *why* it was applied which is the central question of this research.

4.1.2 Case Study Selection

As discussed, case studies were selected as the method for collecting data, and specifically by using interviews to gather information on specific cases. The adoption of traceability is different for every development project, because no two projects are similar with regard to goals and context. For this reason, different projects are the objects of research. The expected high influence of the project manager himself on the decision leads to the fact that each of these cases has to involve a different project and a different project manager, to get a good overview.

When investigating these projects, the sources of data as discussed in the previous section are of importance again. Interviews can provide an insight into the decision making process, but also into the context of the entire project. The decision in this research was stated as one being made by the project manager involved in creating the *project initiation document*. The other actors in this field are the customer organization and the development organization. Demands from the customer organization are those that are communicated

towards the project organization, and can therefore be covered by the project manager. The influence of the development organization on the decision can come from many different roles and is definitely something which is looked into in the interviews. If the first series of interviews showed that there are any very important people from the development organization with a very high influence on the decision, these are to be interviewed as well.

The goal of the case studies was to validate the theoretical insights developed by creating an insight into the practice of system development projects, and in particular the decision of adopting traceability. The best way of getting this insight was to use samples taken at random, with a minimum of preconditions. The interviewees had to have been involved in the creation of a project initiation document for a systems development project in the role of project manager. To get a good overview of the practice, project managers at different levels were examined.

At Ordina, there are six roles project managers can fulfil. These depend on one's background, experience and competences and are the following:

- Project Leader I (PL I)
- Project Leader II (PL II)
- Project Manager I (PM I)
- Project Manager II (PM II)
- Program Manager I (PRM I)
- Program Manager II (PRM II)

These roles are presented here in an ascending order of experience and competences, Program Manager II being the highest role achievable for a project manager. In this research, only the first four roles were looked into. At Ordina, only one program manager is employed (out of over 100 project managers in total) and he is generally too far away from the projects to be involved with this decision.

The first group of interviewees was randomly selected by a business unit manager of the project management department. Nine people were selected and were contacted for interviews. These people were subsequently contacted by the researcher and interviews were planned, providing them with a minimum of information beforehand to make sure the interviewee gave the answers as they came to him at that moment in time.

4.2 Data Collection Approach

Interviews can be performed in several different ways. Yin identifies open ended interviews as well as focused interviews. Where the first type of interview allows the interviewee to express his opinions as well as facts to provide the researcher with new insights through a relatively unstructured conversation, focused interviews are shaped after a list of topics which is to be discussed. This type of interview may still remain open-ended, but is generally based on a case study protocol (Yin, 1994).

The case studies performed here were focused interviews which followed a set protocol. A high-level protocol was made to structure the interviews and a more operational list of subjects was created as well. This list of subjects contains questions for each subject, but these questions did not have to be posed literally. The sequence of the subjects was not set either, because it could be influenced by the more open first part of the interview, but should be adhered to as much as possible. These protocols can be found in Appendix III (Wester, 1987).

Wester described several important matters for when using interviews. He states that using a protocol for interviews is very important, and that the interviewer should be well acquainted with the subject of the interview. When using interviews for this kind of explorative research, they should be semi-structured, as was the case here. Providing the interviewee with confidence by listening actively and pursuing avenues opened by the interviewee through questioning a certain subject further is quite important. Answers should

not just be accepted, but one has to look deeper at the subject to find whether these reasons were correct, yet at the same time one should be careful not to pose any leading questions (Wester, 1987).

In this research, a clear choice was made to deal with the results of the interviews anonymously. Although this makes it impossible to exactly repeat the process by a third party, it truly improved the quality of the interview results. Several subjects, such as knowledge on the concept and stakeholder preferences are issues which people might be afraid of being held accountable for their personal actions, which was not the goal of this research.

During the interviews, the interviewee was asked to focus on one specific project where he was involved in the decision of adopting traceability in a software development project as a project manager. The focus in the interview was on this specific case, although other more general insights were not to be obstructed. After the interview had finished, the interviewer attempted to write a report on the interview as quickly as possible. This report was emailed to the interviewee and he or she was asked to provide feedback whether or not it was a correct representation of the interview, and his or her feedback was processed (Emans, 1990).

To test the method of interviewing and the interview protocols, a pilot case study was performed. Any problems with regard to data collection could be found and the method for data collection could be adapted. How this pilot case study and the other case studies were performed can be seen in the next section (Yin, 1994).

4.3 Data Collection Experiences

Where the next section, section 4.4, presents the results of the interviews and the next chapter, being chapter 5, analyses these results, this section discusses the experiences of the researcher during the collection of data. This section describes the way the data collection actually occurred and any extraordinary matters.

The data collection started by performing a pilot interview, as suggested by (Yin, 1994). A random project manager was selected (with the known prerequisites) and the interview was performed with a focus which lied more on the process then the product. The process appeared to be sound, but some minor tweaks could be made afterwards with regard to the protocol and the basic information which was collected. The quality of the data was also high enough to regard the pilot case study as a respondent for the overall research.

Section 4.1.2 already showed that 9 people were selected for the interviews, completing the total number of interviews to 10. These people were all contacted, but two of them were not available for interviews for personal reasons. The other people were given a short introduction into the topic of the interview and were told how their names were obtained (through their own managers). A date and time was set, as well as the location. The interviews took place at various locations, half of them were at customer locations and the other half at the headquarters of Ordina. The reports of these interviews were always drawn up the same day, usually within four hours after the interview.

In the interviews, one thing became apparent straight away. In the interview protocol, there already was the option of performing an exploratory interview. In this case, the interview was only partly a case study, since it only tested the first of the factors: "development organization awareness". If this factor turned out negative, and the development organization showed no awareness of the existence of traceability, there was no decision to review. In this case, the interviewees were not regarded as respondents, but as informants in the research. During the pilot interview, this was not the case. During the following set of interviews, however, it became apparent that this was quite an important issue and occurred quite often.

The interviews showed that the project managers were indeed the people that made the decision. Influence from the customer was perceived by them and although they did provide the roles that influenced a project initiation document, none of these people actually influenced the decision to apply traceability. No interviews with other people were therefore

required. Due to the fact that out of the first eight interviews (including the pilot interview) only three people were aware of the existence of traceability, one of the main principles of research became apparent. One has to alter his strategy sometimes, through the constant comparison of theory and practice. The first hypothesis already showed as a factor of influence, and therefore made it impossible to validate the remaining hypotheses (the other factors discerned from literature). For this reason, more interviews were planned. Nine more people were approached, of which three finally were suitable interview candidates. In this case the requirements of the respondents were higher, they had to be just that: respondents. This meant that they had to have been aware of the decision which was to be made which required knowledge on traceability. In total, 17 people were approached of which only 6 were familiar with traceability. Of the remaining 11 people, 5 were interviewed and 6 were not interviewed beyond the point of validating the first hypothesis.

4.4 Interview Results

This section provides the results of the interviews. Each interview was marked up in a report which reflected the interview and was validated by the interviewee afterwards. Due to the difference in the outcomes of the interviews, a separation has been made between those interviews that were with respondents, and those that were informants. This split is not completely correct, because every interviewee was partly a respondent. This because of the fact that every interviewee was used for validation of the first hypothesis, so from that perspective every interviewee is a respondent. Because the outcome of the interviews is so completely different and the value of them as well, the difference has been made. In appendix V the results of the interviews with the respondents have been recorded, which are further shown in section 4.4.1. Appendix VI shows the reports of the interviews with informants and are summarized in section 4.4.2.

4.4.1 Results Respondents

4.4.1.1 Interviewee Background

Table 5 shows the background information of the different respondents. Their role, as explained in section 4.1.2 is the first bit of background information. Next, both their experience in project management and in software development in general is presented. Their background both in the fields of education and work is presented, after which a short description of the project studied in the case study is presented (organisation, product, team size, project duration, adoption of traceability). Finally, the percentage of projects in which this project manager adopted traceability is provided.

Respondent	A	B	C	D	E	F
Current Role	PM I	PL II	PM I	PM II	PM II	PM I
Experience in Project Management	10 Years	8 Years	10 Years	8 Years	15 Years	2 Years
Experience in Software Development	24 Years	21 Years	17 Years	8 Years (only as PM)	23 Years	12 Years
Education	Study: WO Mathematics / Computer Science)	Study: HTS Computer Science	Study: HTS Computer Science	Study: Policy and Organizational Studies	Study: Teacher Mathematics / Economics. Later studied HBO Business Informatics	Study: Chemistry
Work Experience	Worked in technical automation (a.o	Worked in systems development and IT Management	7 years as an IT-consultant	Work involved with IT-strategy	Worked as: Developer, Designer, Analyst	Worked as: Programmer, Functional Designer, Team Leader, Architect
Customer Organization	Large Chemical Company	Bank	Public Organization	Large Non-Profit Organization	IT-Supplier for health organizations	Large Financial Institution
Product	Forum Application	Computer - Telephone Application	Adminstrative System	ERP-system	1st Line Support System	Batch Conversion System
Project Length	6 Months	4 Months	9 Months	18 months	24 Months	8 Months
Team Size	3 People	12 People	17 People	6 People	24 People	14 People
Traceability Applied in this Project?	Yes	No	Yes	Yes	Yes	Yes
% Of projects which adopted traceability	50%	0%	35%	?	100% (of larger projects)	100% (where he was PM)

Table 5 – Basic Information Respondents

Complete reports of the interviews can be found in appendix V, but first each interview is discussed shortly, showing the most important issues found in the interviews.

4.4.1.2 *Respondent A*

The interview with respondent A was characterized by the depth of the content. The interviewee was very well acquainted with traceability and performed it in nearly every project he executed nowadays. The reason why this interviewee always adopts traceability in development projects is to be able to verify the requirements satisfaction in end products. Although the customer did demand traceability in this case, it was something he intended on using anyway. The prevention of delivering an "inadequate" product quite weighed up to the low costs of recording traceability in his opinion. Advantages of delivering a traceable product beyond customer demand and the use in the development project were not important to him.

4.4.1.3 Respondent B

Respondent B did not adopt traceability in his project, nor did he do this in any project he was in charge of. The effort required for adopting traceability was considered too big (15% additional cost, coming from creating the links and reviewing them) whereas the advantages it brought along in the project were calculated to be around 2%. The interviewee had a very clear budget for this project and not staying within its limits was not acceptable to his employer. Any advantages gotten from traceability after the project finished were irrelevant to the project manager. On top of that, time pressure was very high and did not allow for what was in his opinion extra quality work. Finally, not only did his boss, the IT supplier, demand a profit to be made by staying within budget, the project manager was also held accountable for this.

4.4.1.4 Respondent C

The third respondent felt adopting traceability was quite natural in larger projects. In this case, the reason for adopting it had mainly to do with being able to guarantee the ability to verify whether you have delivered the product agreed upon in the contract. Because the project was performed on a time and materials basis, any extra work coming from traceability was not a problem. Verification of requirements was very important to the interviewee; he did not really perform a financial cost/benefit analysis.

4.4.1.5 Respondent D

Traceability was seen as important in two ways by the interviewee. First of all, the verification of requirements was incredibly important. On the other hand, the management information provided by traceability with regard to the time spent and the progress of the project was irreplaceable to this respondent as well. Benefits which lie outside of the scope of a project are not interesting to the project manager, but are interesting in a commercial point of view, pleasing the customer in the long run. However, in the end a project manger is responsible for delivering the right product (fulfilling the requirements of the customer) on time and within budget.

4.4.1.6 Respondent E

The fifth respondent applied traceability in all of his larger project, including this one. Being able to justify your work and verify the requirements was one advantage of traceability seen by the respondent, but the main advantage was being able to see the consequences of changes and determining the costs involved with them. Especially in larger projects, this was very important to him. Traceability does require a cost/benefit analysis, but in larger projects the benefits outweigh the costs in development already. In the end, every project comes down to the final number, so traceability has to be worth it, which it was regarded as such in this project.

4.4.1.7 Respondent F

Traceability is something which is quite important for projects according to respondent F, but it is not critical. It is a concept which is mainly used to reduce the complexity of large projects and to improve the impact analysis for change management. The focus of this lies purely inside the project and what happens outside of this does not matter to the project manager. He feels that it is not directly the responsibility of a project manager to add traceability, that it is more likely to come from project leaders and team leaders, or from architects, and especially if these architects are also team leaders. This is also what he feels happens most in practice. The interviewee chose to adopt traceability only partly, for another part the architect of the project clearly pushed it forward. He feels there is a very clear link between the added value of traceability and the size of a project, because the size makes a project a lot harder to fully comprehend, where traceability helps in reducing this complexity. The cost of adding traceability is nearly zero, so the return on investment should always be positive.

4.4.1.8 Overview Interview Outcomes Respondents

Table 6 provides us with an overview of the different factors that were looked into and whether or not they influenced the decision in the case studied. A "+" in the table means that this factor was relevant in the decision and positively influenced the decision to adopt traceability, whereas a "-" means this factor negatively influenced the decision. The "E" found in the table, shows that this factor was merely seen as an enabler of the adoption of traceability. A "0" means that this factor did not weigh in on the decision to adopt traceability. Note that this table shows just the end result, and not the reasons for this weighing in or not. This will be further discussed in chapter 5. Two factors in this table did not appear in chapter 3, but were added during the empirical research.

Factor / Respondent	A	B	C	D	E	F
Development Organization Awareness	E	E	E	E	E	E
Customer Demand	+	-	-	-	-	-
Technological Possibilities	E	E	E	0	E	E
Return on Investment	+	-	0	+	+	+
Quality Standards	E	-	0	0	0	0
Compliance	0	0	0	0	0	0
Project Complexity	0	0	0	0	0	0
Development Method	0	-	0	0	0	0
Product Life Expectancy	0	0	0	0	+	0
Dynamics of the Environment	0	0	0	0	+	0
Stakeholder Preferences	0	-	+	-	0	0
Process Flow	E	-	E	0	E	E
Benefits Outside Project Borders	-	-	0	-	-	-
Time Pressure	N/A	-	0	-	-	0
Contract Type	N/A	-	+	-	0	0

Table 6 – Respondents – Influences of Identified Factors in Practice

Not all of the factors and their influence could be portrayed in the table above. In 3.4.4.1 the different sources of influence were introduced, and these were looked for in the empirical validation. Table 7 shows the number of times different roles were mentioned in the interviews, whereas appendix VII shows an overview of which people were influencing the decision in which case.

Role	#Mentioned
Project Manager	6
Architect	1
Program Manager	1
Customer	1

Table 7 – Influencing Roles Identified by Respondents

4.4.1.9 Overview of the Main Motivation for Adopting Traceability

During the interviews, it became apparent that each respondent had his own motives for adopting traceability. The motives generally come from the goals of a project manager, which were clearly described by respondent D: "In the end, a project manager is responsible for delivering a product which satisfies the customers demand, to do this on time and within the set budget". This definition is also found in the PRINCE2 method for project management (OGC, 2005).

Respondent A	Respondent B	Respondent C	Respondent D	Respondent E	Respondent F
Traceability Adopted	Traceability NOT Adopted	Traceability Adopted	Traceability Adopted	Traceability Adopted	Traceability Adopted
Verification of requirements: delivering the product which satisfies the customers demands.	Costs were seen as too high. The goal of the project was to make a profit.	Verification of requirements.	Providing management information on the progress of the project, as well as verification.	Improving impact analysis, and also the verification of requirements.	Reducing the complexity of the project and improving change processes.

Table 8 – Main Motives for (not) Adopting Traceability

The motives of the project managers to adopt traceability, or not to adopt it as in the case of respondent B, which are presented in Table 8, are consistent with the goals described above. Time, money and adherence to requirements are the factors which influence the decision most it appears. How the different factors are influenced by this is discussed in chapter 5.

4.4.2 Result Informants

Besides the respondents in the research, five interviews were also performed with people who are regarded as informants to the interview. They had no knowledge on traceability and therefore did not make any decision with regard to its adoption. Still, the interviews with these professionals were still valuable, due to their estimated impact of traceability on their work. Some basic information on these informants is shown in the table below.

Informant	A	B	C	D	E
Current Role	PL I	PL II	PL II	PL II	PL I
Experience in Project Management	5 Yearrs	7 Years	10 Years	10 Years	3,5 Years
Experience in Software Development	14 Years	20,5 Years	20 Years	20 Years	None
Education	Study: HTS Electronical Engineering and Informatics	Study: HBO Nurse & AMBI Computer Science	Study: MBO Electronical Engineering & COBOL-developer schooling	Study: Teacher Arts & Crafts & COBOL-developer schooling	Study: HBO Communication Systems
Work Experience	Designer and IT Consultant	Worked in various development roles for different employers.	Several different roles in software development projects	Went to work in IT. After programming also became designer and analyst.	Application or Functional Management

Table 9 – Basic Information Informants

Like the results of the interviews with respondents were shown in Table 6, the informants predicted whether or not they felt that something would play a role in the adoption of traceability. Table 10 shows the outcome of these predictions, which can be traced back to the interview reports in appendix VI. These outcomes are no hard proof of anything, but do provide an indication of what project managers feel as important. They pose as their own hypotheses. As the table shows, none of the interviews discussed each and every factor, often because the interviewee had insufficient knowledge to discuss this. One should note that this table can not be directly compared to Table 6, since these are only opinions instead of the real

life observations presented in Table 6. An additional symbol found in this table is the "D", which means that this factor was a disabler for the decision to be made. Many of the factors were not discussed by the interviewees, they were marked as "N/A". The rest of the symbols have the same meaning as those in Table 6.

Factor / Informant	A	B	C	D	E
Development Organization Awareness	D	D	D	D	D
Customer Demand	+	N/A	+	N/A	+
Technological Possibilities	+	N/A	N/A	N/A	N/A
Return on Investment	+	+	+	+	N/A
Quality Standards	N/A	N/A	N/A	+	N/A
Compliance	N/A	N/A	N/A	N/A	N/A
Project Complexity	N/A	N/A	N/A	N/A	0
Development Method	0	N/A	+	N/A	N/A
Product Life Expectancy	N/A	N/A	N/A	N/A	+
Dynamics of the Environment	N/A	N/A	N/A	N/A	+
Stakeholder Preferences	N/A	-	N/A	0	-
Process Complexity	0	N/A	+	N/A	-
Benefits Outside Project Borders	-	-	0	-	-
Time Pressure	N/A	-	-	+	-
Contract Type	N/A	-	-	N/A	-

Table 10 – Informant Opinion of Influencing Factors

As was the case with the interview results of the respondents, here we find the possible influencing roles are displayed in a separate table, and the raw data of this is shown in appendix VII. The difference with the table regarding the informants is that this table shows what the informants feel are potential influences on the decision, whereas the other section showed the actual influences.

Role	#Mentioned
Project Manager	4
Customer - Manager	4
Architect	3
Analyst	3
IT Management Department	3
Development	3
Program Manager	1
Quality Assurance	1
Interface Designer	1
Key User	1

Table 11 – Possible Influencing Roles Identified by Informants

4.5 Data Analysis

The analysis of the data gathered in this research, consisting of both theoretical and practical data, is presented in the next chapter, chapter 5.

5. Adoption Analysis

This research created a confrontation between the existing theory and the data collected in this research. Through this constant confrontation, alterations in the research could be made and previously unseen avenues could still be pursued. Whereas this report is structured as though the research was performed in a linear "waterfall" method, that is not the way things turned out in practice. After the pilot interview not many changes were made, but after having performed several interviews some new factors were identified as influencing the decision on whether or not to adopt traceability, which lead to them being incorporated into the research. Chapter 3 provides an overview of the theoretical framework as it was *before* it was validated, whereas this section provides an overview of the validated framework.

In chapter 4, it already became apparent that there is a difference in the people interviewed with respect to how the outcomes of these interviews were to be treated. The first hypothesis of this research, *development organization awareness*, turned out to be a big influence on the empirical research through a large lack of knowledge. The difference between respondents and informants is basically the very limited knowledge informants have of traceability in practice. This section provides an overview of the different factors which influence the adoption of traceability such as they were found in practice, as well as a classification of projects and the factors influencing specific projects.

5.1 Validated Influencing Factors

The theoretical framework presented in chapter 3 provided thirteen different factors which could influence the adoption of traceability. In this chapter, each of these factors is confronted with the findings in practice. The occurrences of each factor in the case studies researched is taken along here, as well as the context in which it was found. The number of times a factor occurred is presented in chapter 4, whereas the context is found in the interview reports. The opinions of the informants were taken along as well here.

5.1.1 Framework of Factors

This section discusses each of the factors described in chapter 3, and the way they were perceived in practice. The input from the respondents, informants and the theoretical framework are combined to see whether or not these factors are of importance with respect to influencing the adoption of traceability.

5.1.1.1 Development Organization Awareness

Awareness of the existence of traceability in the development organization was identified as a prerequisite for the existence of the decision to adopt traceability. Where this factor might seem trivial, its validation showed not only that it was definitely an influencing factor but also that it a major factor(see tables 6 and 10). The fact that the previous chapter is divided into two parts presenting the outcomes of the interviews, one part on the respondents and one part of the informants, already shows the fact that this factor is a valid one. The mere existence of informants, project managers that had never heard of the concept of traceability, shows that they never reached the decision under investigation, which in this case had to do with awareness and knowledge.

From the first eight interviews which were planned, five interviewees were classified as informants. They had no knowledge on traceability as a concept which could be applied in systems development. Although it is not possible to draw any quantitative conclusions from this research on how many project managers do and do not know what traceability is, awareness of project managers is quite an important factor because without this awareness it is impossible to make this decision. In the five interviews with informants we can see that they all show *development organization awareness* as a disabling factor.

The awareness of project managers can come from two different sources, as presented by the force field in Figure 11 in section 3.4.8, the customer organization and the

development organization. The factor which is discussed here focuses on the awareness of the development organization, of which the project manager is seen as a member. The description of this factor in chapter 3 focused clearly on the influence which the entire development organization could have on the project manager, by bringing traceability to his attention. Chapter 4 shows two tables, containing the roles which both the respondents and the informants felt that could, or actually did, influence the decision. Appendix VII shows the way the different interviewees saw this. In only one of the cases did any of these people ever discuss traceability with the project manager before the development started, which was an architect. The fact that the informants did not know anything of the concept also shows that nobody ever bothered them with it. Parts of the development organization might be aware of the existence of traceability and its advantages or drawbacks, but these were never communicated to other roles in the project except for the case of respondent F. More on these influencing roles is discussed in the factor *sources of influence*, factor 5.1.1.3.

As long as traceability is not something which is standard in development projects, a decision has to be made to adopt it or not. Seeing as it is something which occurs project-wide, this decision should in general reach the project initiation document, either through the project manager himself (which was the case in nearly every interview with a respondent), or through the other people development organization which occurred only once. One might expect traceability to be enforced by people from this organization, as we found with the informants, but this is rarely the case. Respondent F showed one exception to this, where the idea was carried by the functional and technical architects.

Development organization *awareness* might not be the ideal term for this factor. Although it covers the final outcome, it does not show the process involved in it. This factor is not just about awareness, it is also about *communication*. Knowing of its existence is not enough if this knowledge and awareness is not transferred to the deciding parties. As long as traceability is not a standard practice in software development, which it is far from, it will always have to be communicated on to the entire development organization, most likely including the project manager, and people will have to feel responsible for this.

5.1.1.2   Customer Awareness

Besides the influence and knowledge of the development organization, the customer also has quite an important influence on the decision to adopt traceability. Nearly every project manager stated that if a customer demanded traceability, he would adopt it. However, very few customers actually demanded traceability. Whereas the IT management organization of the customer, be this an in-house department or with outsourced IT management, would most likely be the party demanding traceability, this party is often not involved in the initiating phases of a project. Few of the interviewees had contact with this party, and if acceptance criteria were given, they almost never included traceability.

The interviewees regarded customer awareness as a causal factor. If the customer demanded traceability, he would perform this (as long as any required budget for this was created). On the other hand, if the customer did not demand it, it made things easier not to adopt it, enforcing the negative decision on this subject. The latter was mostly the case in this research, as can be seen in the table displaying the results of the research.

5.1.1.3   Sources of Influence

In chapter 3 one of the factors identified was that of the sources which would be able to influence the situation. Section 4.4.1 provides the reader with an overview of the people involved with the decision on adopting traceability. In the same chapter, but then in section 4.4.2, the different roles which were expected to potentially influence the decision by the informants was shown. These tables showed quite some differences. In only half of the cases researched did anyone other then the project manager influence the decision to adopt traceability, as seen by the interviewees. Informants only mentioned the program manager as a potential influence once, whereas he was an influence in one of the cases, but the architect was seen as a large potential influence. This was clearly the case with respondent F.

Informants mentioned the customer and the customer IT department as potential influences as well, which was also discussed in the previous paragraph. They were not found in five out of the six cases, but one case did see this influence.

Many of the people which were seen as potential influences by the informants were not found in practice. As the factor *development organization awareness* already showed, few people outside the project manager discussed this with him which is supported by the outcome of the research into the factor discussed here. At the moment, only the project manager, the program manger, the customer and the architect were found as people influencing the decision, whereas more would be expected.

5.1.1.4   Technological Possibilities

Technology which supports traceability is something which is quite important to the project managers. If there is insufficient support for traceability in the opinion of the decision maker, this would influence the decision in a negative way. Nearly all of the respondents felt, however, that the technical support of traceability is quite adequate. For this reason, this positively influenced their decision to perform traceability, although it was not really a decisive argument. Technological possibilities were more seen as an enabler of the process. The use of text processors and spreadsheets was always seen as enough support, although tools were deemed as interesting by several respondents. In the case of the adoption of tools the issue of return on investment would become a lot bigger though according to them, a more thorough cost/benefit analysis would have to be performed.

5.1.1.5   Return on Investment

Theory stated that the decision to adopt traceability could in practice be approached as an investment decision, and this is exactly what was found in practice. Although not all respondents performed a quantitative analysis of the costs and benefits involved with adopting traceability, they did weigh the pros and cons in a financial sense. This happened mainly because in the end, they were responsible for finishing the project within budget. This lead to the question whether or not adopting traceability would aid in reaching this goal in several of the cases, in which it was answered as true in most cases.

One respondent, however, expected around 13% higher costs in development due to the adoption of traceability, which was one of the main reasons not to adopt it. What some project managers, in this case two informants, showed as missing in their toolkit was being able to determine whether or not traceability was worth performing at all, especially in their project. This lack of knowledge influences the decision in a negative way.

The financial benefits perceived from traceability were different for each case. Often, the verification of traceability was seen as a lot more important then the main benefit mentioned in theory, being the simplified impact analysis. An overview of the main reasons for project managers to adopt traceability is provided in section 4.4.1.9. Steering the project with better management information, both with respect to the development progress and the correctness of the product was seen as the main financial advantages by one respondent, whereas one person also saw the reduction of tests required as an advantage and only one person performed traceability mainly for the impact analysis advantages.

5.1.1.6   Quality Standards

Quality standards can be found in two places. First of all, the development organization can be following a certain standard, but on the other hand the customer organization could also impose its standards on the project. In the latter case, this could be one of the causes for a demand by a customer to perform traceability. In the research, however, it was often found that (unofficial) quality standards did not demand traceability which meant that this influenced the decision negatively, it did not *have* to be adopted. Only one case was found where the respondent was subjected to an ISO 9000 certified process, but this did not demand traceability. If traceability was performed however, there were strict guidelines with regard to review processes which influenced traceability in a negative way.

The absence of standards does not positively influence the adoption of traceability, the existence could either force its adoption or negatively influence the decision (as seen with one of the respondents).

Organizations which do work through certification such as CMM above level 2 would have this influencing the decision, since traceability is a must in this case. This was not found in any of the cases, but is indispensable for organizations which have regular audits on their CMM level.

5.1.1.7   Compliance

What applies to quality standards is somewhat similar to what applies to compliance. Regulations and laws such as the Sarbanes Oxley act and Basel II demand from organizations that they develop their systems in a traceable way. In the empirical research, no cases were found where this was demanded yet, although this would be expected in projects in the financial sector. In this case, it would become part of the customer demand, yet not as a demand from the IT management department, but from the risk management department as one interviewee remarked. Like quality standards, this is a demand from the customer which can not just be rejected by the supplier, therefore influencing the decision. The fact that this factor was not observed is *not* a guarantee that it is not an issue.

5.1.1.8   Project Complexity

The complexity of a project and a system were also a factor which theory stated as an influence on the decision regarding adoption of traceability. In practice, this factor was not found as an influence, none of the project managers stated this as an issue. This factor has not been proven in practice as one which influences the decision, but this could be because of the levels of abstraction of the project manager and those performing the operational development work, where this factor really counts according to Antoniol (Antoniol et al., 2002). For the remainder of this research, this factor is not regarded as one influencing the decision. If the development organization would provide more influence in the decision it could be, but not in the situation as found in practice. This factor could exist, but its influence is limited.

5.1.1.9   Development Method

Like the previous factor, project complexity, this factor has not been proven in practice. It influenced the decision only once, and only one informant felt it might influence his decision. This factor is not rejected as clearly as the previous one, but here again it might be that the project manager looks at thing from a too abstract level to take technical matters such as these into consideration. This does not mean that it would not be an interesting factor, it simply shows that in practice it is not a relevant factor.

5.1.1.10 Product Life Expectancy

Only one respondent was aware of taking along the expected period of use of the system under development into account with regard to the decision on adopting traceability. He felt this weighed in in the cost/benefit analysis, which is also what the theory prescribed. Whereas the other respondents did perform a cost/benefit analysis, they often did not see the advantage in the form of the improved impact analysis, so this factor did not apply to them. When one were to recognize this as an advantage of traceability the informants felt that life expectancy of the product would matter.

On the other hand, the life expectancy has to do with matters which occur outside of the scope of the project, which is limited to just the development of the system. This is discussed in section 5.1.1.14, which deals with the scope of a project and matters involved in this.

5.1.1.11 Dynamics of the Environment

As discussed above, in only one case did the project manager identify impact analysis as an advantage of traceability. Because of this, the others did not take the dynamics of the environment, and the correlated amount of changes, into account when deciding on adopting

traceability. Because they did not adopt traceability to improve impact analysis but for different reasons, this factor did not apply. Again, this factor also influences the changes outside of the project scope, as well as the changes occurring during the development itself, which could influence the effect of this factor.

5.1.1.12 Stakeholder Preferences

Where during the preparation of the interviews it seemed very hard to test anything with regard to stakeholder preferences, this was not the case. The different stakeholders involved in the decision could have personal motives with respect to the outcome of the decision which weighed in, and several of these were identified.

As discussed, the goal of a project manager is to deliver the correct product, on time and within budget. In many of the interviews, budgets came forward as very important issues. The form of contract available was something discussed very often and is further discussed in section 5.1.2.2. Project managers, as was found during the interviews, were not only judged on their performance with regard to how they delivered their projects, they were also partly financially dependent. If a project manager remains further within budget, this provides him a larger bonus after the project is finished. For many project managers, this was an influence on the decision to adopt traceability, especially in the case where traceability was not adopted. The preferences of another stakeholder, the IT supplier which was the respondents boss, also came into play here, because their motive in this project was simply to make a profit, and therefore had a scope with a rather short time horizon.

This factor turned out to be quite an important influence in the different interviews. It is closely related to the view the respondent has on the return on investment of traceability however, since for project managers it is often all about the money, the final number is what counts. If he feels traceability will not lead to many extra costs, this factor will not necessarily be of influence, whereas it becomes quite important if he feels there are additional costs involved.

5.1.1.13 Process Flow

The flow of the process was definitely regarded as an influencing factor by the different project managers. In one case the project manager perceived the adoption of traceability as a negative influence on the process, traceability making the operational processes more complicated. In most other cases, however, the contrary was found. The project managers did not perceive the adoption of traceability as a problem with respect to the flow of the process. In the end, this factor again has to do with the perception of the decision maker of its impact and can only be influenced by experience and demonstration.

5.1.1.14 Benefits Outside Project Borders

A factor which was not necessarily quite clear in theory became all the more apparent in practice. The scope of a project, as defined by PRINCE2, is limited to the development and does not involve the use of the product (OGC, 2005). The satisfaction of the customer is only checked at the completion of the project, the project manager is generally not responsible for any aftercare. As one of the interviewees remarked, this is quite important commercially however. A customer which remains satisfied, even after the delivery of the product, is a customer which returns to the company.

Many of the project managers did not automatically think of traceability as something that had an improved impact analysis as the main advantage. For them, the fact that most of the benefits generally lie in the IT management phase was irrelevant, yet still they were very clear that to them all that mattered was the project itself and not anything beyond this. Four out of five informants also felt that any benefits obtained away from the project itself were irrelevant and would not be taken along in the decision, therefore negatively influencing this decision. Not in the way that advantages found outside of the project are reasons for not adopting it, but in the way that these advantages, which offer benefits when applying traceability in total, are not taken along in the decision to adopt.

5.1.2 Additional Factors

Next to the original factors identified in theory, the interviews also showed some different factors with regard to the decision on the adoption of traceability. These were found during some of the first interviews already, so they could be tested in most of the other interviews.

5.1.2.1 Time Pressure

A very clear issue which came forward during one of the first interviews was time pressure. In this specific case, the project had a very strict deadline and the project manager had the feeling that implementing traceability would increase the time required to develop the system. This last thing is quite important, it again has to do with the perception of the project manager on how traceability would influence the project. If there are few payback-moments in the project itself identified by the project manager, he will see it as something which mainly costs time and money and which does not provide him with many benefits. If time pressure is an issue in a project, this therefore leads to a negative influence on the adoption of traceability. Many informants also stated that traceability would probably be one of the first things that was dropped as soon as time pressure became an issue and a small form of panic appeared. "Quality issues" such as documentation and traceability are seen as a lot less important then functional development, which is critical to the project. This again fits into the goal of project managers in general, delivering the right product on time and within budget, which says nothing about quality unless specifically demanded by customers. A connection can be found to the flow of the process, and also to the ROI here, where the largest impact is that on the flow of the process.

5.1.2.2 Contract Type

As discussed when looking at the stakeholder preferences factor, the type of contract was identified by several interviewees as quite important. With regard to software development projects, Lauesen identifies two following different types of contracts:

- Fixed Price

A fixed price project is based on a quotation provided by the supplier. This can be the consequence of a tender where a request for proposal was sent out by the customer, or because the customer directly approached the supplier. A fixed price is determined for the project, any additional costs are for the supplier, but any money less then the agreed price which is spent is also for the supplier.

- Time and Materials Based

The second type of contract is related to variable costs, instead of fixed price. A registration of the hours is kept and the price paid by the customer is determined by the actual time and materials used in the development project (Lauesen, 2002).

Section 5.1.1.12 discussed the factor of *stakeholder preferences*, which is closely related to this factor. The goal of project managers, which was identified as delivering the right product on time and within budget. This latter part, staying within budget, is quite important with regard to the type contract. If a project is fixed price, any additional costs in development are avoided if they are not a requirement of the customer. On the other hand, if a project is not fixed price, it does not matter whatsoever. What is important here, however, is the impression which the decision maker has of the return on investment of traceability in the development project itself. If he feels traceability will add costs to the development project which is based on a fixed price, this will influence his decision in a negative way. If traceability has been taken along in the quotation however when it would add to the cost of the project, or if the budget is flexible, this is not an issue for the decision.

The preferences of a stakeholder are also closely related to the return on investment. In the end, it is all about the money, in this case as well.

5.1.2.3   *Project Size*

A factor which has not been tested extensively, but did come forward in several interviews, is that of project size. Many of the project managers which were acquainted with the concept of traceability stated that they applied it mainly in larger projects. This had several reasons, being the following:

- Knowledge is more widespread and should be made explicit in larger projects.

- Projects become more complex due to their size, causing problems for those working on operational aspects.

- The longer a project lasts, the larger the benefits. Where the factor "product life expectancy" looks at the life of the product, the life expectancy of the project also matters with regard to the amount of changes found.

- For a project manager, larger projects are harder to keep track of, to keep a good overview. Traceable development offers more management information.

When looking at the adoption of traceability by the respondents, there was also a trend which could be found with regard to the size of projects. Traceability was seldom adopted in small projects, but in larger projects this percentage got a lot higher. This research looked into the factor of *project complexity*, which focused on the technology used and the familiarity with this. The interviews, however, that complexity is mainly caused by project size. More research into this factor would be advisable, although it is already briefly discussed in literature, as we could see in section 3.1.2.

5.1.3 Framework Completeness

Many different factors were identified and researched. This does not mean, however, that all different factors have been identified, because there are many context-dependent factors which influence this decision. What this research does show, is the most important factors that influence the adoption of traceability in the current practice.

Development Organization Awareness
Sources of Influence
Quality Standards
Customer Awareness
Quality Standards
Compliance
Return on Investment
Dynamics of the Environment
Project Size
Product Life Expectancy
Stakeholder Preferences
Contract Type
Benefits Outside Project Borders
Process Flow
Technological Possibilities
Time Pressure

Table 12 – Overview of Most Important Factors

Table 12 provides an overview of the most important factors identified, as well as the other factors which relate to this one. The interrelations described in the previous sections are shown here. In the end there are five categories of factors which truly influence the adoption

of traceability. Awareness of both the development organization and the customer organization, the perceived return on investment by the project manager, any preferences this stakeholder has and the way traceability influences the process during the development project are the factors which are most relevant, most other factors contribute to these factors.

5.2 Project Types

During the empirical part of this research, one of the main conclusions which can be drawn is that not every factor is relevant in each situation. This has a lot to do with the motivation of the project manager and his knowledge and perception of the advantages of traceability. Still, with the main factors identified as influencing the outcome of the decision it is possible to make a classification of different project types with regard to the adoption of traceability.

The second part of the central research question deals with how one should deal with the adoption of traceability, if and how one should influence it. This section provides a basis on how this adoption should be dealt with and what the influence is that one could have.

5.2.1 Introducing Different Project Types

In general, one could say that there are only two kinds of projects. Those which did adopt traceability during development, and those that did not adopt it. That, however, is only the outcome of it and this research looks into the *why* of the adoption of traceability.

One of the main factors influencing the decision with regard to the adoption traceability in practice is whether or not the customer demands this. This is the first variable introduced in this model. Second, we have the important prerequisite for the project manager of being able to make the decision and having the required information, which is that of *development organization awareness.* Finally, the third variable introduced here is the outcome of the decision of a project manager, which depends partly on these first two variables. If one were to map these three factors on the outcome of the decision, we would get the tree-like diagram found in Figure 12.
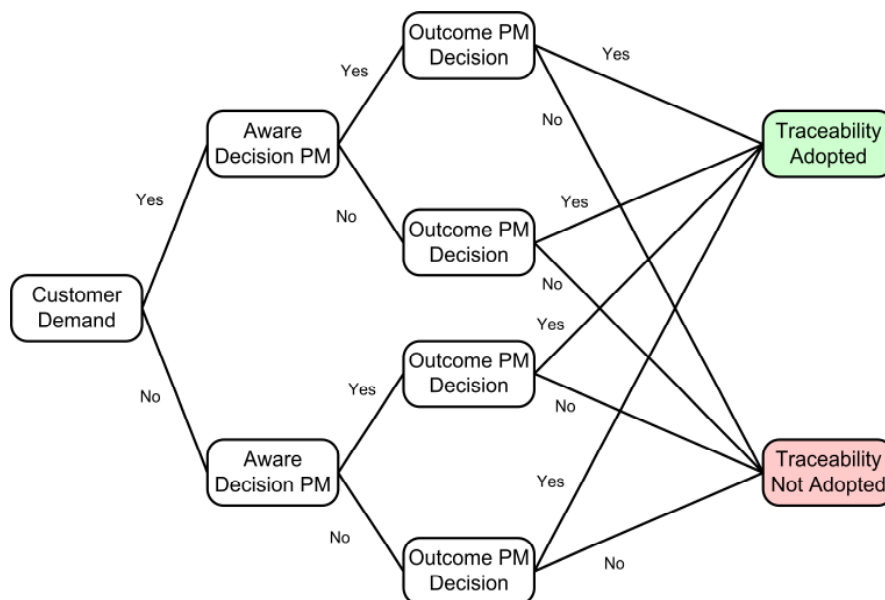
Figure 12 – Theoretical Project Types

What this figure does not show is the interdependencies of the different variables. For instance, if there is no awareness in the development organization of traceability, the project manager is not aware of the decision to be made and will never make a decision. In this case, traceability will not be adopted project wide, although it is possible that parts of it are developed in a traceable manner. Another factor of importance here is that system

development is still a commercial activity. One attempts to satisfy the needs of the customer, fulfilling his requirements. Therefore, if a customer demands the use of traceability in development, the supplier will always attempt to fulfil this requirement. If he does not feel traceability should be performed in this project, the supplier will convince the customer that it is not necessary and if this does not work he will basically comply with the request from the customer. This was also found in the interviews with informants.

Project Type #1: Customer Demand (1), Traceability Adoption (1)

Project Type #2: Customer Demand (0), Aware Decision PM (1), Outcome PM Decision (1), Traceability Adoption (1)

Project Type #3: Customer Demand (0), Aware Decision PM (1), Outcome PM Decision (0), Traceability Adoption (0)

Project Type #4: Customer Demand (0), Aware Decision PM (0), Traceability Adoption (0)
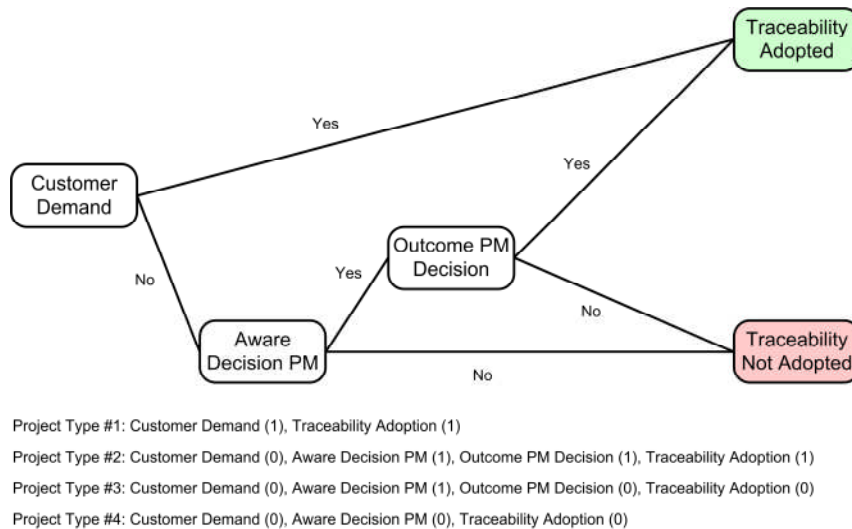
Figure 13 – Project Types in Practice

The figure based on theory is therefore not one which reflects the different projects found in practice. In practice, there are the projects in which the customer demands traceability in which case it is always either adopted, or the demand of the customer is dropped. Second, there are the cases in which the project manager is not even (made) aware of the existence of traceability, in which case he will never adopt traceability for the entire project. Finally, there is the type of project where the customer does not demand traceability, the project manager is aware of the decision and actually makes a balanced decision to adopt it or not. This has been displayed in Figure 13.

The different types of projects are discussed here, and the relevant influencing factors are also discussed including the expected value of them is possible. This will be done for each type of project, in the sequence as provided in Figure 13.

5.2.2 Traceability Demanded by the Customer

The first type of project shown in the model is that where the customer demands the adoption of traceability by the project. Traceability will, in this case, always be adopted. The governing factor in this type of project is that of *customer awareness*. The awareness of the customer is the reason here for the adoption of traceability. This factor can be because of the awareness of its importance by the customer organization (quite possibly the IT department responsible for IT management), due to quality standards or compliance issues such as Sarbanes-Oxley or Basel II, which is expected to increase sharply in the future.

Influencing Factors	Expected Value
Customer awareness	Customer demands traceability
Quality Standards	Possible
Compliance	Possible

Table 13 – Factors Influencing Project Type 1

5.2.3 Adoption through a Positive Project Management Decision

In the second type of project, we are dealing with the situation where the customer does not demand traceability, but the project manager is aware of the fact that he has to make a decision. The factor *customer awareness* is a small influence here, but only in the way that there is no demand of the customer, whereas *development organization awareness* enables the project manager to make the decision. In this awareness, he can already be steered into a certain direction through the existence of and adherence to quality standards for the development organization.

Return on investment is an important factor here, where one of the main issues is the perception of the use of traceability to the project manager. The motivation of the different project managers found in section 4.4.1.9 shows that not all project managers perceive the same benefits, and in the research it was also found that not all managers perceive the same costs involved with traceability. In this type of project, the project manager will most likely see traceability as a positive influence for his project.

Stakeholder preferences can also play a role here, yet they are strongly influenced by the perceived return on investment. A project which is not based on the fixed price principle will less likely lead to negative influences in this case, yet the fact that a lot of the benefits lie outside the borders of the project remains an issue. The scope of the decision maker will be limited to his project, and if he sees improved impact analysis as a clear advantage this factor is an issue to be reckoned with.

Finally, the way the project manager sees the influence of traceability on the *process flow* is quite important. If he feels it adds activities which make the process more complex, it will be something which he might not like. Time pressure is also something which comes into play here, especially if the project manager feels that traceability will cost time which might not be available. Lastly, if there is no sufficient technological support for the adoption of the concept in the eyes of the project manager, he will most likely not adopt traceability.

Many different factors have been presented here, and not all of them influence the decision in a positive way. The different influencing factors, where some might not be of influence at all, weigh in on the final decision, where the decision maker determines which way the scales will tip.

Influencing Factors	Expected Value
Customer awareness	Customer does not demand traceability.
Development organization awareness	The project manager is able to make an aware decision.
Quality Standards	Possible, for the development organization.
Return on investment	Positive, this is the main reason to adopt traceability. Determined by motives and possibly *product life expectancy*, *project size* and *dynamics of the environment*.
Stakeholder Preferences	Unknown. This factor (and any related factors) could have any value and is taken along in the decision.
Process Flow	Unknown. This factor (and any related factors) could have any value and is taken along in the decision.

Table 14 – Factors Influencing Project Type 2

5.2.4 Negative Project Management Decision

This type of project is somewhat similar to project type 2, where the project manager took a positive decision. The same factors are of influence, but their expected value is different. Returning to the goals of project managers, time and money are important which is seen in the *return on investment* and *process flow*, which are more likely to be perceived as negative in this kind of project. Personal preferences are also more likely to tip the scales in a negative way here, and might carry a heavier weight then in the previous project type.

Influencing Factors	Expected Value
Customer awareness	Customer does not demand traceability.
Development organization awareness	The project manager is able to make an aware decision.
Quality Standards	Possible, for the development organization.
Return on investment	Negative, this is the main reason to adopt traceability or not to adopt it. Determined by motives and possibly *product life expectancy*, *project size* and *dynamics of the environment*.
Stakeholder Preferences	Unknown. This factor (and any related factors) could have any value and is taken along in the decision. More likely to be negative.
Process Flow	Unknown. This factor (and any related factors) could have any value and is taken along in the decision. More likely to be negative.

Table 15 – Factors Influencing Project Type 3

5.2.5 Lack of Awareness

Finally, there is the type of project where there is no specific demand of traceability by the customer and no awareness of the development organization is found. For this reason, no decision can be made of which the project manager is aware, and no traceability will be performed project wide.

Influencing Factors	Expected Value
Customer awareness	Customer does not demand traceability.
Development organization awareness	The project manager is unable to make an aware decision.
Quality Standards	Not demanding traceability of the development organization.

Table 16 – Factors Influencing Project Type 4

5.2.6 Control in Different Environments

The projects discussed so far all assumed that the project manager had total control over the environment in which he went to work. In many of the projects in which the project managers went to work however, they arrived in an existing development organization of which the members generally belong to another company. In this case, it might be difficult to be influence the organization instead of just taking over the way people were working. Several informants felt this was something which they often encountered. This is definitely

something which one should take into account, the amount of influence which one has on the procedures. Foreign environments often offer less control or require more effort to create it, whereas project completely performed by the organization of the project manager offer more support unless there is a standard way of working.

6. Towards Improved Adoption

The goal of this research is twofold. The first part of the research dealt with identifying the factors influencing the adoption of traceability, which resulted in the findings presented in chapter 5. Here, the second part of the research is presented, focusing on the recommendations which were drawn up to deal with these factors, managing the adoption of traceability. Towards improved adoption does not necessarily mean more adoption, it means that the adoption should be better thought over.

This chapter starts with the recommendations as presented to Ordina, another product of this research. It contains the actions recommended and supported through this research and the alternative solutions. The recommendations made are presented first, after which the different alternatives are discussed and the choice for this solution is justified. The recommendations to Ordina have been made written down in a separate report of advice. This chapter presents these recommendations answering the second part of the research question. Those who are only interested in the recommendations made should read the separate report sent to Ordina.

6.1 Recommendations

To Ordina, a set of recommendations on dealing with the adoption of traceability has been presented. This section provides an overview of these recommendations which consist of both the activities recommended to be performed as well as the people which have to perform these actions.

6.1.1 Enforcing Traceability

The first decision to be made is whether or not one should influence the adoption of traceability at all. Enforcing the adoption of traceability should be done if there is a perceived added value in this. The actual costs and benefits have never been truly quantified, which is something that would be wise when making this decision. On the other hand, all those that got in touch with traceability in the research almost always adopts it in their larger projects. They apparently feel that traceability offers a lot of added value in projects and should be adopted in these larger projects.

> *Recommendation 1: The adoption of traceability should be influenced in a positive way.*

The promise of traceability is amongst others that it reduces the costs of IT management, and one might not want to reduce these costs. Any work performed by an IT supplier which has to be done on maintaining a system is paid by a customer and leads to more income for this supplier. This argument, however, is not very strong. Ordina is not the only party which performs maintenance on systems, and it is often not the case that any system developed by Ordina or its employees also leads to the application management of this system by Ordina.

The strategy of Ordina states that it wishes to develop a lasting relationship with its customers, creating value for its stakeholders (Ordina N.V., 2006b). One of its governing principles is creating strategic partnerships with its customers, delivering solutions which provide a visible added value to this customer. Connecting this to traceability, we see that this can play a role in this. Traceability is something which adds value to the customer, by lowering the costs in maintenance, as well as possibly adding value to the developing organization. On top of that, Ordina wishes to standardize its processes and improve on its quality in the service provision of the ITS-division (Ordina N.V., 2006a).

This goes directly against some of the issues found in practice, where the scope of a project itself, as defined in PRINCE2, is regarded as governing by those taking the decisions. People should look beyond the length of their own nose and take the entire lifecycle of a system into mind and the total consequences for a customer. Being able to show this to a customer will also greatly improve the commercial relationship between the parties. If Ordina wishes to focus on quality, this is an opportunity to do so.

For these reasons, Ordina should indeed enforce the use of traceability. Not supporting and facilitating its use would be a lost opportunity and would not fit into the strategy of the company.

6.1.2 Sponsors and Champions

To successfully implement a change, such as the influencing of the use of traceability in this case, someone has to enforce the change and has to make sure it is implemented. This person has to see the need for the change and champions it, in literature also referred to as the idea champion. On top of that, a sponsor is required to remove organizational barriers and protect the idea within the situation.

> *Recommendation 2: The business unit Requirements should function both as a champion and as a sponsor for this project.*

At Ordina, someone has to pick up the issue of traceability if something is to be done with this, and a champion and sponsor are required for this. Several parties could take this role, because adopting traceability would influence many different parties. Literature poses application management as the main beneficiary of traceability, due to the influence of traceability on the impact analysis. This business unit would be a party which might be willing to influence this issue, but as discussed in the previous section projects developed by Ordina are not necessarily also maintained by them, and therefore not necessarily end up with the application management business unit. It might therefore be better if the issue would be picked up by a group that has to do with both parties; both development and IT management. The problem here is that at Ordina this is not something of one business unit, but more of the general management of the ITS-division or SI&D which is described in chapter 1. One has to wonder if this issue has a high enough priority for them.

Looking at things from the development organization, several parties could pick up this issue. Analysts from the requirements business unit deal with requirements and their verification. Designers and architects, from alignment and technology consulting, also deal with traceability. Architects were even mentioned as an important influence and a party which instigates the use of traceability in one interview. Developers, from the different development centres, are involved as well and benefit from the reduced complexity. Also testers, from the testing business unit, are involved in the process and are supported by methods such as TMap (Pol et al., 1996). Finally, there is the business unit of project management, the business unit where the decision on applying traceability or not is located.

Any of these business units could put traceability on the agenda, and several other departments and people as well probably. The most suitable candidate is the requirements business unit. This is the business unit that sponsored this research, that saw the need for it. In a recently released vision document of this business unit it stated that it stands for "the professionalization of the software development process suitable for a national project champion as Ordina" (Ordina N.V., 2006a). It wishes to add value to the development process through the unit and its members, and traceability offers the opportunity for just that. Adopting this project and increasing the adoption of traceability at Ordina would put the business unit in the spotlight and would show that its intentions are not just that: intentions and words. Most of its members already know what traceability is as found during an

informal research at a business unit meeting where at least 80% of the members knew what traceability was. The outcome of this research can be found in appendix II. The fact that this research took place within this business unit caused increased awareness of the subject and made it live for its members. This is an opportunity to take centre stage and put the unit in the spotlight for all of the company.

All in all, this business unit seems to be the one with the most feeling for the subject and the best "fit" with its vision. This unit should provide a champion for the project, who pulls the weight of the project, and it should also be the unit sponsoring the research. Its management should make sure that there is plenty of support for it, that the project receives the resources it requires.

6.1.3 Nature of Work

Chapter 1 already discussed the fact that the employees of Ordina perform their work in two different situations. First of all, there are jobs where the employee of Ordina is put to work within another organization. Second, there are the separate projects performed by Ordina where it creates a temporary organization which performs all of the tasks required to complete the assignment.

> *Recommendation 3: The adoption of traceability should first be influenced in projects performed completely by Ordina.*

The empirical research showed that the control which one has over the adoption of traceability differs for the two forms of work. Projects involve employees from one organization, the same as that of the project manager. When a project manager, or someone in another role for that matter, is employed by another organization than the other people in the development organization, he often has to deal with existing patterns and ways of working. In these situations, it is harder to determine the way things are performed and to influence the adoption of traceability.

Due to the higher amount of influence and control one has on projects, as opposed to situations where people are rented out, it is recommended to influence these situations first as they have a higher chance of success. Section 6.2 deals with alternatives to this set of recommendations, in which the other situation is also discussed.

6.1.4 Dealing with Decisions

Chapter 3 introduced the notion that the adoption of traceability has to do with decisions. In chapter 4, we saw that this decision was absent in many of the cases, and that in each of these cases this lead to a negative result on the adoption of traceability. In the other cases, the decision was there and different factors influenced the decision.

> *Recommendation 4: Taking the decision on adoption should be obligatory and the decision makers should be influenced through the identified factors.*

The decision itself can be influenced in multiple ways. One could influence the factors identified in this research which influence the outcome of the decision. This would create an unknown outcome however, since one is not sure if the factors are influenced enough to lead to a positive decision where suitable. On the other hand, one can make the decision obligated *and* influence these factors. By influencing the standard processes available at Ordina one can force potential decision makers to reach this decision. By informing them properly on the influencing factors the decision will be made on a more correct decision basis. This is further discussed in section 6.1.6.

Forcing the decision into the process is a structural solution, whereas merely influencing the decision leaves the choice on the making of the decision with the decision maker himself. Making the decision obligated for all makes sure that the alternatives are weighed properly and the decision is not simply disregarded, which is so often the case in current practice.

6.1.5 Developing the Business Case

The goal of this process as stated in the beginning of this chapter is to make sure traceability is adopted more where required. For this, some people will have to be convinced of its use to create a solid basis of support an to obtain their cooperation where required. Whenever someone has to be convinced of something, this requires a solid business case. This business case is a combination of facts which shows the outcome of a situation, stressing the costs and benefits of it (return on investment, also identified in chapter 3 and found in practice). For traceability, this business case is not clear yet. Some research has been done on the advantages of traceability, amongst others by Ordina !T Excellence which calculated the advantages of traceability through the use of metrics (Ordina!T Excellence, 2004). Still, there is no clear overview of the costs and benefits of traceability. To chart the waters of advantages and drawbacks of traceability, more research is recommended.

> *Recommendation 5: A task force should be created, consisting of motivated people from several different departments, with the task of developing a solid business case on the adoption of traceability in development projects.*

One way of getting this required information to make the business case would be setting up a task force, a temporary team or committee designed to solve a short-term problem involving several departments (Altier, 1987). This small, horizontal team should consist of people from different business units which have to do with traceability. Of course someone from the requirements business unit should be useful here, yet the addition of a project manager, an architect and someone from application management would be wise. These people would already have to be motivated by the project and should have a positive attitude towards traceability, they should not be people randomly chosen because they are available. The task force requires sufficient management support. It has to be able to make its own decisions, and it should be provided with the necessary facilities for performing its activities.

Instead of a task force the work could also be performed by a student, for whom this would function as an internship or his final project. This alternative is not advisable however, due to the required time for such a research, whereas results on the short term would be preferable. Having only one person involved on it would also reduce the support created in the organization.

The goal of the task force would consist of two main issues; creating an overview of the advantages and drawbacks of traceability for all different parties and finding the numbers required for developing the business case.

6.1.5.1 Creating an overview of advantages and drawbacks

> *Recommendation 5a: The first task of the task force would be to create an overview of all the advantages and drawbacks of traceability, to see if these are measurable and to determine its 'face value', if its truly a drawback or advantage or not.*

It is this task which makes it especially important to have a task force comprised of people with different competences and experience in different roles, so the advantages are regarded from different perspectives. This research already provides a good start with regard to the advantages and drawbacks of traceability as seen by the different stakeholders. An

overview of those issues identified already is presented in Table 17, it is up to the task force to determine the completeness of these issues and to see if any are missing. The next task is to see whether or not these issues (drawbacks and advantages) can be quantified, since numbers are easier to compare and to base judgement on.

Issue	Advantage/Drawback	Relevant for:
Improved Impact Analysis	Advantage	Customer, Supplier
Management Information	Advantage	Project Manager
Perceived Impact on Process Flow	Drawback	Project Manager, Development Organization
Verification of Requirements	Advantage	Project Manager, Customer
Cost of Traceability	Drawback	Customer, Supplier
Additional Effort Required for Traceability	Drawback	Customer, Supplier
Reduced Complexity of the Project	Advantage	Designer, Developer, Tester, Architect
Compliance	Advantage	Customer
Quality Standard Adherence	Advantage	Customer, Supplier

Table 17 – Advantages and Drawbacks of Traceability

6.1.5.2   Discovering the numbers on traceability

One of the main problems with "selling" traceability to an organization is that the costs and benefits are not completely clear and cannot be expressed in numbers. As Palmer already stated, it is impossible to determine the actual costs and advantages of traceability by comparing two projects, since projects are never exactly the same (Palmer, 1997). Cleland Huang, Zemont and Lukasik attempted to provide an overview of the costs of traceability in different ways of tracing in software development, but they themselves already state that they base their numbers on estimates (Cleland-Huang et al., 2004). They estimate the costs of creating a link, and state that these numbers are just that, estimates, and were not taken from real projects or research. The same applies for the costs made because one has to perform an impact analysis where this link is actually used, they were also based on estimates. Other advantages were not taken along in their overview either.

Recommendation 5b: The task force has to identify the costs and financial benefits involved with traceability in development projects.

What would be required to be able to present a decent business case, would be to have actual numbers showing the costs of traceability. On the other hand, one would also have to attempt to provide an overview of the benefits of traceability and should try to express these in financial terms. As discussed by Palmer, this is not possible by simply comparing different projects, one with and one without traceability, due to the fact the context of these projects will be different. Therefore, the costs have to be identified in another way.

The effort made by Cleland Huang, Zemont and Lukasik is quite an interesting one, yet it is based on estimates and does not take all the advantages of traceability into account (Cleland-Huang et al., 2004). They only seem to look at those costs (and also prevented costs) which were easiest to express in financial figures, which should be combined with the advantages mentioned in literature and those found as the motivations for choosing traceability which were made clear in this research. For this, several possible sources are available.

First of all, it is possible to perform a *test project*. This relatively basic project would be monitored closely, to see what the added costs of traceability and its direct paybacks are. This would be a good way to monitor the indirect benefits of traceability, yet still would not provide absolute numbers on traceability which are indisputable. Figure 14 provides us with an overview of what such a test project would entail and what activities belong to it. With the data gathered in this test project the basis for the numbers used is a lot stronger, but it is still not infallible due to lack of comparison.

Where it is not possible to compare two complete projects due to their differences, it *is* possible to simulate situations from projects. By having certain activities in a project performed twice, once *with* and once *without* traceability, one would be able to measure the costs and benefits involved with this. This would require the close *observation* of the two situations. Figure 15 illustrates what this type of experiment would look like. Several of these experiments would have to be performed with variations of the tasks performed, the roles involved and the techniques used to identify the costs related to different situations. Those same experiments could be used to determine some of the figures involved with the benefits of adopting traceability.

> A rather transparent project is selected to monitor quite closely. In this project, traceability is adopted and the relationships between elements of the different development products are traced to one another, where relevant.
>
> During this monitoring, the people performing the tasks are asked how much time they feel they would have spent on their tasks had they not been keeping track of traceability information, as well as how often they use this information and how many time they feel this saves.

Figure 14 – Test Project

Performing an impact analysis both with and without traceability in place in a way similar to that described in Figure 15 (with the required variations) would lead to information on what the exact benefits of traceability with regard to the impact analysis, again developing more trustworthy figures.

As discussed, it is nearly impossible to compare different projects. For this reason, analysing statistical information from different projects from the past is not an option, due to the fact that these are not really comparable.

Where this type of research looks at the costs and benefits related to individual traceability links. To determine the total return on investment, one has to view the entire picture however. The number of required traceability links has to be determined, as well as the percentage of links that is actually used in a project. Chapter 3 already indicated that factors such as *dynamics of the environment* and *product life expectancy* play a role here, but another factor that comes into play here is the combination of *project size* and the occurrence of *scope creep*, which is the change found in requirements and project scope as it comes along. The longer the period required for development (project size/length), the more changes are to be expected in the original requirements (scope creep), causing again more changes. At Ordina, some calculations on the effects of traceability have already been done by !T Excellence, so it would be wise to consult this group as well. Impact analysis is

> Observation would be a suitable way for determining the exact costs and benefits involved with traceability. The observation experiment would involve two similar situations.
>
> In the first situation, a designer would get part of a specification of requirements which has to be worked into a design. He performs his tasks as usual, and the time required for this is recorded.
>
> In another room, next to the one in which the previously mentioned designer is performing his tasks, another designer, with the same skills and experience (roughly) performs the same tasks, yet he does this whilst keeping track of traceability. The time he requires for this is also recorded and the two recorded times are compared to figure out the actual cost of adopting traceability in this situation.

Figure 15 – Observation Experiment Example

the key benefit of traceability in literature, but the other benefits and expected costs identified should also be looked into for a complete business case.

When the numbers required to develop a decent business case have been gathered, one of the most important tasks of the task force has approached. With the advantages and drawbacks identified and the quantifications of all of these advantages and drawbacks where possible, a business case should be developed to convince all those required for the changes to be made. This would show when traceability would be worthwhile, taking for example project size into account. A business case like this would approach one of the desires of some project managers, which constituted a model which would show if traceability is a valid option in an individual case. More on this can be found in section 6.1.6.1.

6.1.6 An Obligated and Informed Decision

Section 6.1.4 already discussed that the recommended strategy for tackling this problem is obligating the decision on adoption to be made, by implementing it into the standard operating procedures in development projects. By doing so, the main problem found with regard to the adoption of traceability is also addressed, which is the lack of knowledge on the subject causing a lack of awareness with the decision maker.

Recommendation 6: Decision makers should be obligated to make an informed decision by embedding this decision into standard development procedures and informing these decision makers.

Ordina is currently reshaping its offers for the core of ITS service provision, with a focus on a few key issues. Innovation of the system development and management process in a technology-driven way, combined with innovation of the development approach and standardization of partial processes and deliverables to achieve improved quality and reduced costs are the issues which are spear points here.

Forcing the decision to adopt traceability to be taken requires it to be a standard procedure in development. Right now, it is seen (if seen at all) as something which could also be done, which is optional and does not necessarily have to be looked at, not taking the decision seriously. Putting it into existing development methods would remove this possibility and would obligate decision makers to take this decision seriously. Influencing the decision makers by informing them of the actual facts with regard to the adoption of traceability ensures that the right decision is taken more often.

6.1.6.1   Adjusting Development Methods

Part of the strategy of Ordina is to offer a number of propositions, consisting of standard development methods, tailored by Ordina and customizable for each customer. The different development methods can be found at http://www.ordinasoftwarefactory.nl and in appendix VIII.

Recommendation 7: Every development method in the software factory should be approached individually to see how traceability could best be embedded in it.

To make traceability a standard component of software development projects within Ordina, it has to be made a part of these development methods and the generic parts of the development process. Each development method has a specific contact person who can be reached through one single contact person at Ordina (currently Edwin Damen). Each of these people which are in charge of the development methods has to be convinced, where the business case comes back into play. This business case, combined with top management

support, is required to make the "owners" of these methods see the light of traceability if this is not part of the method yet. Each method has to be checked for the best application of traceability individually, and should be approached like that: *individually*. When these methods have been altered, one should also look at the generic parts of the process, consisting mainly of the specification of requirements. Specifying the requirements is one of the first steps in the process of the software factory, as can be seen in Figure 18.

Every project is different. The business case developed by the task force should show how traceability influences projects in different ways, e.g. with regard to size and environment. Several project managers already stated that it would be useful to have a decision aid which would help them determine whether or not traceability would be worthwhile in a project.

> *Recommendation 8: For each project an individual decision has to be made, supported by a decision aid.*

This decision aid, which should be used before the start of a project, could take several different forms. It could be a checklist, an automated tool, a method, a spreadsheet or simply a manual. In the end, it would help create a short feasibility study on whether or not to adopt traceability in an individual project. As its name states, it would aid a decision maker in his decision on adopting traceability in a development project. When deciding on traceability has been made a part of these standardized procedures, it is important that it is also adopted where required. One has to make sure that people do not only have these guidelines, but also adhere to them. It is important that, especially when the adoption of traceability into these development methods is still recent, there is also a check that the decision aid (and therefore the decision) is actually applied in the projects and becomes a standard element in it.

6.1.6.2 Rearranging Quotation Processes and Sales

Another way of influencing decision to adopt traceability or not from the current decision maker would be to pull the decision forward. Instead of letting the project manager decide this, the sales process could also remove this decision for him. If they were to put traceability into the quotation, it would have to be adopted in the actual project.

Traceability should be taken along in a quotation if the cost of adopting traceability is higher then its gains in the development project. As shown in Figure 10 in section 3.4, the costs of traceability are made in development, whereas its measurable benefits are generally found with the occurrence of change processes. Several project managers indicated that if traceability costs more then its gains are they might not employ it in a fixed price project. For this reason, it would be useful if in the quotation traceability would be addressed.

> *Recommendation 9: If the costs of adopting traceability in a development project were to be higher then its gains, it should be taken along in the quotation for fixed price projects and the sales personnel has to sell the concept to the customer.*

For determining whether or not the costs would be higher then the gains, a method and/or tool would have to be developed, similar to that discussed in recommendation 8. This would help in determining whether the adoption of traceability would incur additional costs in the development stage or not. If the developed business case shows that traceability would already be profitable in the development phase, it would not have to be taken along in the quotation. In this case, it would simply be up to the project manager to decide whether or not he would want to adopt it, but a positive advice could be included by the bid manager.

On the other hand, if the costs of traceability do outweigh the benefits in the development stage, any additional costs would have to be sold to a customer. It would be wise to develop a component of a quotation (or bid) that states why traceability would be beneficial to the customer. If this generic component would be developed, it would greatly reduce the effort required for selling the concept to a customer. On top of that, for risk mitigation purposes one could also consider offering traceability as an option in a quotation when additional costs are involved, leaving the decision with the customer.

Summarizing, every fixed price project should be looked at individually to see if traceability is worthwhile. This should be done in the sales process already, but also in the subsequent development project. Making the decision is therefore forced on the decision makers, sometimes even moving the decision to others.

6.1.6.3   Influence through Information

In the end one wants the project to adopt traceability where the outcome of this is positive, so the factors which delude the decision makers should be taken on. The previous chapter showed which of these factors were the biggest influence on the decisions and are discussed here. Project type 4, which is caused by a lack of awareness with the development organization is to be avoided, whereas adopting traceability due to customer demand is of course encouraged. With regard to project types 2 and 3, in which case the outcome is based on the project managers decision, these are perfectly acceptable as well if based on the correct facts. How each of the corresponding factors should be approached is discussed below.

> *Recommendation 10: The decision makers should be informed of the actual facts concerning the decision to be made.*

Development Organization Awareness

The main influencing factor identified in this research was the awareness of the development organization. With a lack of awareness no traceability could be adopted, and this was the case in many of the interviews performed. This type of project (type 4) always leads to no adoption of traceability, although this could possibly be very beneficial to the project.

The most obvious way of dealing with this factor would be to inform and instruct the decision makers on the existence of traceability and its advantages and disadvantages. For this, the results from the research of the task force as described in the recommended course of action would again be very helpful. Being able to not only explain the purpose of traceability, but also to show a clear business case giving a clear overview of the costs, gains, advantages and drawbacks of traceability is required here.

The instruction of project managers, which are seen as the decision makers, can be done quite quickly. A single afternoon or evening would be enough for this program, which would have to be further developed. What should be looked into is whether or not all the people fulfilling the role of project manager are covered by providing this instruction to the project management business unit, or that additional units or selections of people should also be taken along. The instruction could contain the following items:

- Introduction by management to show their support and place the topic into the strategic context of Ordina
- Presentation on the basic idea of traceability by someone, possibly from the task force
- A talk from a project manager which adopts traceability in practice
- A more detailed presentation on the advantages and drawbacks of traceability, with additional focus on the factors influencing the adoption identified
- An interactive demonstration of traceability in practice.

Through this program, the decision makers do not only become aware of the existence of traceability, but also get a good amount of knowledge on which they can base the decisions they have to make in projects. One important issue, however, is that there is a constant change of personnel at Ordina, with a lapse of employees of around 14%. With the current growth of the project management unit added to this, one would also have to keep in mind that these new people also have to be instructed on this issue, or the situation will simply reoccur.

A possible solution for this would be to develop a "traceability introduction kit", which would be provided to all new employees and all people assuming the role of project manager for the first time. This kit would contain the essential elements of the presentation. On top of that, refresher course might be offered every so often and someone should be available for questions on the issue.

The decision makers are not the only people which can influence the decision. The factor specifically deals with the awareness of the entire development organization and it does not have to be instigated by the decision maker himself. Other people from the development organization could also start the discussion on adopting traceability, especially in Ordina projects where their expected influence is larger. The instruction provided to the project managers could therefore also be provided to people in other roles in the development organization. This research showed that the architect, analyst and team leader are often in the position to offer suggestions to the project manager in the initiation phase of a project, so providing the introductory presentation to other people would also be very useful.

In this case, the decent spread of people in the task force is very important. Having people from each of the departments/roles would have the following advantages:

- They are able to see why this is useful to their co-workers in that role and to adapt the presentation to this
- They can function as the idea champion in their respective departments
- In this function, they can be the person which people can address with questions, lowering the threshold for this.

Customer Awareness

What the theory developed in this research showed is that the awareness of a customer is also quite an influence on the projects. If he or she demands traceability, it will always be adopted. Within the customer organization, it would often be the role of IT management, quality control or risk management (when related to compliance-issues) to demand the adoption of traceability.

Being a true strategic partner, which is the vision of Ordina, means that you want the best of both your customer and yourself in the long run. Developing quality software and maintaining it at lower costs does help your customer in this way. Where the previous section (0) dealt with the awareness of the development organization through informing and teaching them about traceability, the same could also be done for the top 40 of preferred clients of Ordina, again part of their strategy. This introduction into traceability should then be performed by a combination of an account manager and an expert with regard to the content of the subject, traceability. Using the information gathered by the task force on advantages and drawbacks again plays a key role here.

Perceived Return on Investment

The perceived return on investment, which was identified as quite an important factor influencing the actual decision to adopt traceability (found in project types 2 and 3), can also be influenced. This is where the information gathered in the subsequent research by the task force is not just useful, but it is required. With this information a correct overview of costs and direct benefits can be created, where the indirect benefits should also be stressed. This overview should then be provided to all decision makers with regard to the adoption of traceability, possibly through the introduction discussed in section 0. With the correct information, the decisions made are more likely to be correct and not just based on "gut feeling", and these feelings often differed strongly between people.

Stakeholder Preferences

Another factor influencing the adoption of traceability is that of stakeholder preference. This factor is often closely related to the perceived return on investment, since higher costs often lead to personal drawbacks. Creating a clear overview of these costs might already help with regard to this factor.

On the other hand, one of the issues found was that of the type of contract. Project managers often felt that traceability cost more then it brought up, yet there was no room for this in the budget. It would therefore be very important to take away this issue by taking along traceability in the forming of the budgets for fixed price projects. For this, bid projects should be influenced in the same way as this section prescribed so far. Adding traceability (if there actually are additional costs for it in development) to the quotation would require sales skills to convince the customer of the justification of the additional costs, but would also take away these issues for project managers. If there are not additional costs however, this should also be communicated to them to take away this perception. On top of that Ordina has to show them that they have to look beyond the scope of a project in this case and should look at the total return on investment.

6.2 Alternative Actions

Section 6.1 presented the recommendations towards Ordina on tackling the adoption of traceability in practice. These recommendations contain the solution which would suit the current situation best, yet there are also alternative actions which can be taken. This section presents these alternative solutions, but only the ones which differ greatly. Small differences have already been discussed in the previous section. The next section, 6.3, discusses the choice between these different actions and why these recommendations were made. An overview of the alternative courses of action can be found in appendix IX.

6.2.1 Taking no Action

The first alternative which has to be considered and is discussed in section 6.1.1 is deciding not to pursue the adoption of traceability actively. This would not change anything with regard to the current situation, where no active stimulation of the adoption of traceability takes place. This would not be disastrous for Ordina, since traceability is not critical for projects and it is not a de facto standard yet, yet it is a missed opportunity. It would be wise to still research what the added value would be, especially because of the facts that (a) those people which know what traceability is seem to always apply it in larger projects because they are convinced of its added value and (b) traceability now is more of an issue with the employees due to this research.

6.2.2 Influencing the Decision in Ordina Projects

Section 6.1.4 showed that there are actually two methods of influencing the outcome of the process when focussing on projects. The recommended course of action prescribes the obligation and influencing of the decision. One could also use just part of this, only influencing the decision, which is discussed in section 6.1.6.3. In this case, the decision remains intact and stays with the project manager. What is influenced is those factors which are of importance to the project manager, the factors influencing the decision.

Like in the recommendations in section 6.1.5, a group of people is required which will carry the idea and support the concept. It is their task to gather the required information and inform and instruct the organization, to actually influence the relevant factors. The composition of this task force should again be diverse, with people from different roles, the people should have a strong drive with regard to the topic and sufficient management support is required.

When attempting to increase the use of traceability through influencing the decision, it would be wise to offer a standard method for keeping track of traceability. This can be through specific tools, or by simply using standard office productivity software such as Word

and Excel. Defining a standard method would aid the adoption in general and would be a task for the task force involved with the influencing of the adoption.

6.2.3 Influencing the Decision outside Ordina Projects

So far, we only discussed the adoption of traceability in Ordina projects. As chapter 1 described, a lot of the work is also performed by posting people at other companies, for an hourly fee. In this situation, the control of the situation is a lot less, especially for people without formal authority. It is also impossible to introduce a completely new development method in nearly all cases, so this way of influencing the adoption of traceability which is recommended in this report is nearly impossible.

This chapter introduced two different methods for influencing the adoption of traceability. Obligating the decision to be made through embedding it in standard methods is hard to achieve, so the method which is left is that of influencing the factors which influence the decision. This can occur in almost the same way as described in the previous section, but there are a couple of differences. First of all, the influence of people other then the decision maker himself will be a lot more limited, so more focus should lie on informing the project managers (and possibly the architects). The same information is required for them however, the target audience is simply smaller. Second, it is not necessarily useful to inform the customer, since this is not really an "Ordina-thing". Influencing him through the project manager seems more logical.

One does have to wonder if you want to influence this type of work. People are simply hired to work at a customer, with his processes. Changing these might not necessarily be something the customer is waiting for. On the other hand, this would show that Ordina is a professional organization with capable people that focus on quality issues willing to advise the customer, which creates a better relationship.

6.3 Choosing between Alternatives

This chapter has described four major alternative courses of action for influencing the adoption of traceability. In short, they are:

- Not influencing the adoption of traceability
- Obligating an informed decision in Ordina projects
- Influencing the decision in Ordina projects
- Influencing the decision outside Ordina projects

An overview of these decisions, including the major actions involved in them and their interrelations can be found in Appendix IX. This appendix also shows which actions are recommended to perform.

The first alternative is equal to the current situation, where little to no influence is exerted by Ordina on the adoption of traceability in software development. It would not require any changes to what is currently happening, but would also mean passing by an opportunity to improve itself.

Influencing the decision to adopt traceability in Ordina projects is an ambitious course of action. One can see however that this consists of a superset of the actions required to influence the decision outside Ordina projects, so these two should always be combined.

Including the decision on traceability in standard development methods is an alternative which is not only feasible without too much effort, it is also a structural solution to the adoption of traceability. Knowledge is kept in procedures that remain, whereas people come and go in organizations. Awareness is not an issue anymore, people are made aware by the imbedding of the issue into standard procedures, they now *have* to make a decision and they are informed of the facts as well.

Besides just picking one alternative, it is also possible to combine alternatives. Alternative "X", which involves not pursuing the issue any further, cannot be combined of

course, but influencing the decision is possible to combine with forcing it. For within projects, this combination is somewhat redundant because of the fact that the decision is removed from the project. Influencing it for non-projects is useful however.

The recommended action for Ordina is that it should start by embedding it into its standard procedures. This is something which is relatively easy to do, but would most likely yield very good results. Later, adding the influencing of decisions outside projects would also be an option, if a solid base has been made within Ordina projects. A complete overview of the recommendations can be found in Table 18 – Overview of Recommendations

1	The adoption of traceability should be influenced in a positive way.
2	The business unit Requirements should function both as a champion and as a sponsor for this project.
3	The adoption of traceability should first be influenced in projects performed completely by Ordina.
4	Taking the decision on adoption should be obligated and the decision makers should be influenced through the identified factors.
5	A task force should be created, consisting of motivated people from several different departments, with the task of developing a solid business case on the adoption of traceability in development projects.
a	The first task of the task force would be to create an overview of all the advantages and drawbacks of traceability, to see if these are measurable and to determine its 'face value', if its truly a drawback or advantage or not.
b	The task force has to identify the costs and financial benefits involved with traceability in development projects.
6	Decision makers should be obligated to make an informed decision by embedding this decision into standard development procedures and informing these decision makers.
7	Every development method in the software factory should be approached individually to see how traceability could best be embedded in it.
8	For each project an individual decision has to be made, supported by a decision aid.
9	If the costs of adopting traceability in a development project were to be higher then its gains, it should be taken along in the quotation for fixed price projects and the sales personnel has to sell the concept to the customer.
10	The decision makers should be informed of the actual facts concerning the decision to be made.

Table 18 – Overview of Recommendations

In short: the adoption of traceability should be improved by embedding the decision into the standard procedures of projects. For this, a strong business case should be developed where a clear opportunity lies for the business unit requirements for further profiling.

7. Conclusions and Reflection

Concluding, this chapter shows the results of the research and answers the research questions. It also reflects on the way the research was performed and presents recommendations for further research

7.1 Conclusion

The purpose of this research was *to create an insight into the factors influencing the adoption of requirements traceability in development projects and to draw up recommendations on going about the factors influencing this adoption*. Existing literature on the area of (requirements) traceability only briefly have touched upon this subject, almost all of the attention went out to the operational problems with regard to the adoption of traceability. This research goes one step back in this process, by looking into the way a decision has been made on whether or not to adopt traceability in development projects.

Ramesh, amongst others, discussed that a project manager should be involved in this. He is not only responsible for the budget and should manage any added costs due to traceability, but also performs a coordinative function in the project (Ramesh, 1998). This research identified the project manager as the person making the decision to adopt traceability, being influenced by both the customer organization and the development organization here. This research has shown this was indeed the case, although one respondent felt it could also be the responsibility of the architect.

7.1.1 Influencing Factors

This research looked into several different scientific areas for finding the factors which might influence the decision on the adoption of traceability. An extensive research of literature in the area of requirements traceability in general was performed which identified several factors which might possibly influence the adoption. Another field which offered a further insight into the issue at hand was looking at development projects. This was done from two different angles, being software development processes (RUP) and project management processes (PRINCE 2).

Decision theory was introduced to put all the information that was found into perspective and to structure it. How exactly is a decision made? What influences this decision? These are the questions which are answered for generic decision problems by these theories. With this framework for decision making found in literature a set of factors influencing this specific decision was created.

In the empirical part of the research, consisting of 11 interviews, these factors were put to the test. One factor was found to be the main contributor to the low adoption rate of traceability, being the awareness of the decision maker that he actually was a decision maker. Many of the interviewees did not know of the existence of traceability, they had never heard of it or seen the concept. This again was reinforced by the fact that all but one of the respondents that did know what traceability was applied it in nearly all of their larger projects, not in the smaller ones. Other factors which were found as big influences were the awareness and demands of the customer, the perceived return on investment, the interference in the regular development process and the preferences of the decision maker.

The theoretical framework offered many different factors, of which most were also found in practice. For some, however, this was not the case. For instance, the complexity of a project with regard to the familiarity with the technology of the development team was not really seen as an issue. The development method used was also not seen as an influence, none of the methods used prescribed traceability and none of the decision makers were more likely to adopt or not adopt traceability due to the development method.

On the other hand, there were some factors which were not found in literature explicitly, but were found in practice. A factor which remained ill-defined in literature, being

stakeholder preferences, became a lot clearer. Project managers are motivated by achieving the goal for which they are held accountable, which is delivering the right product on time and within budget, as found in section 4.4.1.9. This budget is quite important, in the end everything comes down to money. Therefore, a fixed budget will lead to the furthest reduction of costs possible by project managers, and a perceived higher cost then benefit in the development phase of traceability will be an argument supporting a negative decision. The *type of contract* is a factor which was not found in literature, but was found in practice. Another factor which literature did not provide was the size of a project. Larger projects become more complex for all parties and traceability aids in the lowering this complexity due to creating a better overview.

In the end, the most important factor influencing the adoption was the awareness of the development organization. If this organization and therefore the decision maker is not aware of its existence, traceability will never be adopted. Customer awareness is also an important factor, where a customer demand will always lead to the adoption of traceability. Return on investment, because in the end it is all about the money. Finally, stakeholder preferences and the influence on the process flow are also quite important and influence the decision on adoption. The table below shows these key factors and related factors.

Development Organization Awareness
Sources of Influence
Quality Standards
Customer Awareness
Quality Standards
Compliance
Return on Investment
Dynamics of the Environment
Project Size
Product Life Expectancy
Stakeholder Preferences
Contract Type
Benefits Outside Project Borders
Process Flow
Technological Possibilities
Time Pressure

Table 19 – Overview of Most Important Factors

7.1.2 Influencing the Decision

The second part of the research goal, and a separate research question, involved the "how to" of influencing the adoption of traceability. With the factors identified, and the fact that the decision to be made has been identified, one *is* able to influence this decision.

Four different courses of action have been identified which can be taken, or a combination of these courses of action, but one is clearly recommended. The best way for influencing the adoption of traceability is by taking away the choice of making a decision act from individuals, but embedding it into the standard operating procedures. Ordina has several different development methods for different development techniques, and embedding the choice of traceability into these methods with clear rules would first of all create awareness for the development organization and demand adoption where relevant.

Embedding traceability into these methods will not happen automatically, and will require some effort. The "owners" of the methods will have to be convinced of the use of

traceability, for which a decent business case will have to be developed. To enforce its desire to position itself firmly as one of the leading business units working in a professional way this would be the perfect task for the requirements unit.

7.2 Reflection

The research performed and presented in this report can be qualified as explorative research. A new list of key factors was created, instead of the testing or application of existing theory. What should be noted, therefore, is that this research does not fully cover to the problem identified. It is a first exploration of the field, and should be looked into further by testing this theory. More on further research in this area can be found in this section, in part 7.2.3.

7.2.1 Research Approach

Every research is performed in its own way. The quality of the research is important however, to make sure the research and its outcomes are of use to other people. The research and its outcomes have to be valid to be of use, and Yin has classified four different types of validity for research (Yin, 1994). Each of these types is briefly discussed here and related to the research reported on in this report.

7.2.1.1 Construct Validity

The first type of validity identified by Yin is that of construct validity. Construct validity has to do with the way the data on the research object was gathered. Yin states that it is very important to create a chain of evidence, so one can see how the information was gathered and if there is a way to repeat this exact research. For privacy purposes, no personal information on the interviewees is published in this report, but it is available with the author. With this information, the chain of evidence can be reconstructed for this research.

Next to this chain of evidence, during this research all of the respondents and informants reviewed the draft case study reports and provided feedback on them, assuring that the reports were a true reflection of the actual interviews. This feedback was worked into the interview reports, which were consecutively analysed for the purpose of this research.

7.2.1.2 Internal Validity

Internal validity deal with whether or not X actually causes Y, or that Z is another possible cause for Y. In this case, X consists of the different factors influencing the adoption of traceability, which is Y. Again, we return to the fact that this is an exploratory research. Due to the individual nature of decisions and the relatively small size of this research, one can never claim that the factors identified are all the influences on the adoption and that nothing else (Z) comes into play here. With its explorative nature, this research simply states that $X_1 \ldots X_n$ are some of the reasons causing Y, and are most likely the largest reasons, but this is not guaranteed. The context of the decision appears to be quite important, so one can never fully claim to identify all of the influencing factors in a research such as this one.

7.2.1.3 External Validity

Opposed to internal validity, external validity deal with the question of whether something can be generalised. This type of validity is about whether or not the results of the case studies can be applied to all the situations fitting the research profile. When taking another sample, would the same outcome be found? Although there is no way of proving this except for testing it by performing the same research on another sample. For this, repeatability is quite an important factor. To achieve this, all the case studies have been performed in a comparable way through a clear interview protocol, which can be found in appendix III and IV. The interview protocol prescribed how to go about the interviews, which areas to discuss and how to start and end them.

7.2.1.4   Repeatability

Finally, Yin discusses the concept of repeatability. Is it possible to repeat this research, and would one end up with the same results? Although the number of researched cases is relatively small, due to the generic operating procedures during this research (again, see appendix III and IV), this is quite possible.

7.2.1.5   Research Method and Experiences

The research method used involved the use of both a strong theoretical framework, as well as the gathering of information through case studies involving interviews. This approach was useful during the research, especially with regard to the knowledge gained during the theoretical part of the research. This knowledge proved very useful when actually taking the interviews and being able to discuss matters more in depth.

Something which would have improved the research, knowing what I know now, would have been to perform a survey before taking the interviews. By doing so, a better overview of the first hypothesis would have been created by getting an insight into the adoption and knowledge of traceability as found in practice. Validating this research can partly be done by performing a survey, but time did not allow that in this case.

7.2.1.6   Other Issues

Something which is quite important in scientific research, especially with softer research dealing with inter-human information gathering, is a lack of bias. For (Wester, 1987; Emans, 1990; Yin, 1994; Verschuren and Doorewaard, 2002), and many authors with them, the lack of bias is required for the researcher. One should never impose his own opinion into the interviews, nor into any other activity related to gathering data. This was something which posed as a challenge to the researcher, but luckily I was aware of this beforehand and was able to deal with it in a proactive manner. It could have been removed from the research even more if more interviews had been taken following the interview protocol, paying attention to this issue and learning from past experiences.

7.2.2 Comments

The concept of traceability is wonderful, and those that know what it is and that have used it are generally completely convinced of its use. Still, there is no clear overview of the actual costs and benefits resulting from it. Is traceability truly as good as it promises? Or is it something which is a lot more expensive then envisaged? These questions remain with the researcher.

On another note, this is again a perfect example of theoretical concepts which are wonderful but seldom really seen in practice. Why this is? Some people have claimed that this had to do with a lack of time for reading up on new theoretical concepts, on the other hand some feel its simply because these concepts are simply not presented to those in practice. This research showed that awareness is something which is incredibly important.

7.2.3 Future Research

As discussed, this research does not provide a complete theory on the subject. It is merely an introduction to the topic, an exploration of the field as to speak, and offers the opportunity for quite some follow-up research.

The factors identified here have to be tested further, to see whether or not their validity holds. Even though many measures have been taken to assure this validity, testing it by expanding the size of the research would be wise. Besides simply performing more interviews and comparing these results, it would also be interesting to create a larger role in this research for the architect. In the last interview performed, this role was stressed by the respondent as an important one and should receive further attention in additional research.

Another interesting addition to this research, on the way of creating an operational help for people in practice dealing with this decision, would be the research recommended in

chapter 6. Looking into the true costs and gains of traceability, making them explicit and if possible assigning financial values to them. Developing an extensive business case would be very beneficial to practice, but requires more research. Evaluating the implementation of the recommendations would also be an interesting course of further research.

Compliance is seen by many people as a motive for traceability which will increase greatly in the coming years. Still, in this research, it was hardly encountered at all. This has to do with the specific projects which encounter traceability right now, which are mainly found in financial reporting systems of the companies which have to adhere to this specific regulation. More research into traceability and compliance issues is still required.

A factor which was not included in this research was the outsourcing of projects to other locations, developing the system at different locations. The value of traceability would seem to increase here, due to the increase of project complexity (which is meant as understanding and overview of the products). Looking further into the size of projects, and its relation to traceability is also recommended.

Finally, a direction which has also not been taken along in this research but which might be interesting is the parallel which could be drawn with the adoption of traceability. Many people see traceability as a form of extended documentation, and if seen as this it could create a parallel with the adoption of documentation and lessons could be learnt from this.

References

Altier, W. J. (1987). "Task Forces: An Effective Management Tool." Management Review vol. 76 (iss. 2): pp. 52-57.

Antoniol, G., et al. (2002). "Recovering Traceability Links between Code and Documentation." IEEE Transactions on Software Engineering vol. 28 (iss. 10): pp. 970-983.

Arkley, P. and S. Riddle (2005). "Overcoming the Traceability Benefit Problem". Proceedings of 13th IEEE International Conference on Requirements Engineering.

Beck, K., et al. (2001). "The Agile Manifesto." from http://www.agilemanifesto.org.

Becker, D. (2003). "Measuring Requirements Traceability From Multiple Angles at Multiple Lifecycle Entry Points". Proceedings of 11th IEEE International Requirements Engineering Conference.

Blaauboer, F. A. (2006). "Embedded Requirements in Functional IT Management". TR-CTIT-06-07. Enschede, Centre for Telematics and Information Technology.

Boehm, B. (1988). "A Spiral Model of Software Development and Enhancement." IEEE Computer Society Press vol. 21 (iss. 5): pp. 61-72.

Candida Pinto, R., et al. (2005). "A Process for Requirement Traceability in Agent Oriented Development". Proceedings of Proceedings Workshop on Requirements Engineering of WER 2005., Porto.

Carnegie Mellon SEI (1999). "The Capability Maturity Model, Guidelines for Improving the Software Process". Reading, Massachusetts, Addison Wesley,

Cernuzzi, L., et al. (2004). "Process Models for Agent-Based Development". Proceedings of International Journal on Engineering Applications of Artificial Intelligence (EAAI), Elsevier.

Cleland-Huang, J., et al. (2004). "A Heterogeneous Solution for Improving the Return on Investment of Requirements Traceability". Proceedings of 12th IEEE International Requirements Engineering Conference (RE'04), IEEE.

Daft, R. L. (2000). "Management". Fort Worth, Texas, The Dryden Press, 5th Edition.

Daft, R. L. (2001). "Organization Theory and Design". Cincinatti, Ohio, South-Western College Publishing, 7th Edition.

Dorfman, M. and R. Chardon (2001). "Early Experience with Requirements Traceability in an Industrial Environment". Proceedings of 5th IEEE International Symposium on Requirements Engineering.

Emans, B. (1990). "Interviewen; Theorie, Techniek en Training". Groningen, Wolters-Noordhof, 3[d] Edition.

Gotel, O. and A. Finkelstein (1994). "An analysis of the Requirements Traceability problem". Proceedings of ICRE '94.

Grady, R. (1992). "Practical Software Metrics for Project Management and Process Improvement." Englewood Cliffs, N.J., Prentice-Hall, 1st Edition.

Hoffer, J. A., et al. (2002). "Modern System Analysis and Design". Upper Saddle River, New Jersey, Pearson Education Inc., Third Edition.

Howard, R. A. (1966). "Decision Analysis: Applied Decision Theory". Proceedings of the Fourth International Conference on Operational Research, Wiley-Interscience.

Howard, R. A. (1983a). "Decision Analysis in Systems Engineering". in: "Readings on the principles and applications of decision analysis I". R. A. Howard and J. E. Matheson. Menlo Park, CA, Strategic Decisions Group. pp. 57-93.

Howard, R. A. (1983b). "The evolution of decision analysis". in: "Readings on the principles and applications of decision analysis I". R. A. Howard and J. E. Matheson. Menlo Park, CA, Strategic Decisions Group. pp. 5-16.

References

Howard, R. A. (1988). "Decision Analysis: Practice and Promise." Management Science vol. 34 (iss. 6): pp. 679-695.

Huffman Hayes, J., et al. (2003). "Improving Requirements Tracing via Information Retrieval". Proceedings of 11th IEEE International Requirements Engineering Conference (RE'03), Monterey, IEEE.

Hull, E., et al. (2005). "Requirements Engineering". London, Springer, Second Edition.

INCOSE. (2006). "INCOSE Requirements Management Tools Survey." International Council on Software Engineering, Retrieved March 6th 2006, from http://www.paper-review.com/tools/rms/read.php.

ISO 9000-1 (1994). "Quality systems - Model for quality assurance in design, development, production, installation and servicing." International Organization for Standardization, from

J. Huffman Hayes, et al. (2003). "Improving Requirements Tracing via Information Retrieval". Proceedings of 11th IEEE International Requirements Engineering Conference (RE'03), Monterey, IEEE.

Jacobson, I., et al. (1999). "The Unified Software Development Process". Reading, MA, Addison-Wesley,

Jarke, M. (1998). "Requirements Traceability." Communications of the ACM vol. 41 (iss. 12): pp. 32-36.

Kroll, P. and P. Kruchten (2003). "The Rational Unified Process Made Easy: A Practitioner's Guide to Rational Unified Process", Addison-Wesley Professional, 1st.

Lauesen, S. (2002). "Software Requirements; Styles and Techniques". Edinburgh Gate, Pearson Education Limited,

Lindvall, M. and K. Sandahl (1996). "Practical Implications of Traceability." Software – Practice and Experience vol. 26 (iss. 10): pp.

Lipshitz, R., et al. (2001). "Focus Article: Taking Stock of Natural Decision Making." Journal of Behavioral Decision Making vol. 14 (iss.: pp. 331-352.

Matheson, J. E. and R. A. Howard (1983). "An Introduction to Decision Analysis". in: "Readings on the principles and applications of decision analysis I". R. A. Howard and J. E. Matheson. Menlo Park, CA, Strategic Decisions Group. pp. 17-55.

Meredith, R. A. (2004). "On the Philosophies of Rationality and the Nature of Decision Support Systems." As in: M. N. Aydin, "Decision-Making and Support for Method Adaptation", Dissertation Thesis, University of Twente, 2006.

MIL-STD-498 (1994). "Military Standard. Defense Systems Software Development". Department of Defense, Washington D.C.

Niessink, F. and H. v. Vliet (1998). "Two Case Studies in Measuring Software Maintenance Effort". Proceedings of Proceedings of the International Conference on Software Maintenance, Bethesda, Maryland.

Norlund, R. (2003). "PRINCE2 and RUP: Loose Coupling Works Best". The Rational Edge. http://www.therationaledge.com, IBM Software.

OGC (2005). "Managing Successful Projects with PRINCE2". London, The Stationary Office, 4th Edition.

Ordina!T Excellence (2004). "Re.Align - Drastische vermindering van applicatie onderhoudskosten zonder migratie of aanpassing van code", Ordina NV.

Ordina N.V. (2005). "Jaarverslag 2005", Ordina N.V., from http://www.ordina.nl

Ordina N.V. (2006a). "Internal Memo", Ordina N.V., from Internal Sources

Ordina N.V. (2006b). "Ordina Corporate Website." Ordina N.V., from http://www.ordina.nl.

Oxford University Press. (2006). "Compact Oxford English Dictionary." Oxford University Press, Retrieved May 3[d] 2006, from http://www.askoxford.com.

Palmer, J. (1997). "Traceability". in: "Systems Requirements Engineering". R. Thayer and M. Dorfman. Los Alamos, California, IEEE Computer Society. pp.

Pierce, R. A. (1978). "A Requirements Tracing Tool." ACM SIGSOFT Software Engineering Notes vol. 3 (iss. 5): pp. 53-60.

Pol, M., et al. (1996). "Gestructureerd testen: een introductie tot TMap". 's-Hertogenbosch, Tutein Nolthenius,

Ramesh, B. (1998). "Factors influencing Requirements Traceability practice." Communications of the ACM vol. 41 (iss. 12): pp. 37-44.

Ramesh, B., et al. (1995). "Towards Requirements Traceability Models". Proceedings of Conference and Workshop on Systems Engineering of Computer-Based Systems, Los Alamitos, California, IEEE Computer Society.

Ramesh, B. and M. Jarke (2001). "Towards reference models for requirements traceability." IEEE Transactions on Software Engineering vol. 27 (iss. 1): pp. 58-93.

Rational (2006). "Rational Unified Process", version 2003.06.15, IBM

Robertson, J. and N. Robertson (2004). "Volere - Requirements Specification Template, Edition 10.1". London, The Atlantic Systems Guild.

Schramm, W. (1971). "Noes on case studies of instructional media projects." As in: Yin, R.K. (1994). "Case Study Research; Design and Methods". Thousand Oaks, Sage Publications Inc., 2nd Edition.

Stout, G. A. (2001). "Requirements Traceability and the Effect on the Systems Development Lifecycle", The Revere Group.

US Congress (2002). "Sarbanes-Oxley Act of 2002". Washington, USA, Congress of the United States of America.

Verschuren, P. and H. Doorewaard (2002). "Het Ontwerpen van een Onderzoek". Utrecht, Lemma Uitgeverij, 3d Edition.

Wester, F. (1987). "Strategieën voor kwalitatief onderzoek". Muiderberg, Coutinho, 1st Edition.

Yin, R. K. (1994). "Case Study Research; Design and Methods". Thousand Oaks, Sage Publications Inc., 2nd Edition.

Appendices

I. Appendix I: Ordina Organizational Structure
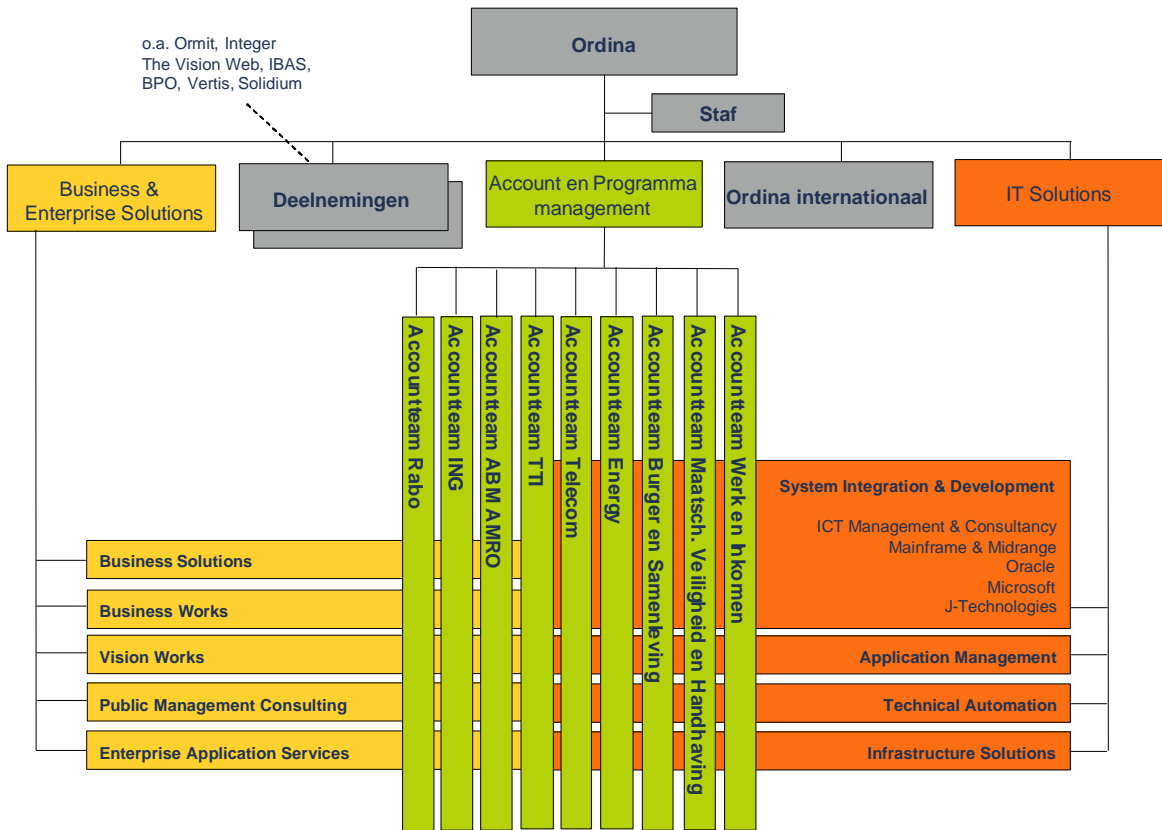
Figure 16 – Ordina Organizational Structure

II.   *Appendix II: Survey Business Unit Requirements*

This appendix presents the findings of a survey taken with the requirements business unit during a unit meeting in may 2006. The analysts present were asked the following questions:

- Do you know what traceability is?

- Have you ever had to deal with traceability?

- If you had to deal with traceability, how many projects did you perform in the last 2 years and in how many was traceability found?

The results of this survey are presented in the table below. The figures drawn up because of it are not figures which can be seen as exact numbers on the adoption of traceability, but they do present an overview of the amount of projects using traceability and the familiarity of the analysts with traceability.

	Number of project in the last 2 years	Projects with traceability
Number of Analysts present	37	
Number of analysts that feel they know what traceability is	29	
Percentage of the analysts present		78,38%
Number of people which ever had to deal with traceability	6	
Percentage of the analysts present		14,86%
Individual questionnaire of those analysts that ever dealt with traceability	**Number of project in the last 2 years**	**Projects with traceability**
Person 1	1	1
Person 2	2	1
Person 3	2	1
Person 4	1	1
Person 5	3	1
Person 6	1	1
	10	6
Average number of projects per person	1,67	
Total number of projects performed by analysts present	62	
Number of projects with traceability	6	
Percentage of projects with traceability		9,73%

Table 20 – Survey Analysts on Traceability

III.   Appendix III: Interview Protocol

Introduction
- Introduction of the researcher (study, background)
- Random social talk
- Subject and goal of the interview
- Explain that the results will be dealt with anonymously
- Show that a report will be made from the interview. This report is to be sent to the interviewee and his feedback on the interview would be most welcome
- State that the length of the interview is approximately an hour, ask if more time is available
- Explain the structure of the interview:
  o Start of with some basic information on the interviewee
  o Continue with discussing the concept of traceability and the knowledge of the interviewee on the subject.
  o The interviewee is given the freedom to describe the process and to discuss what were the influencing factors here.
  o Next, the factors identified from literature which have not been discussed (enough) yet are further looked into.
  o If the interviewee has no knowledge on traceability at all, the interview proceeds into a more explorative form.
  o Finally, a summary of the conversation is provided and the relevance fro the research is provided.

Conclusion
- Are there any subjects you would like to emphasize or that we have not discussed so far?
- Thank the interviewee for his time and provide the planning for report of the interview.

IV.   *Appendix IV: Interview Questionnaire*

Name	
Current Role	
Number of Years of Experience in this Role (Ordina / Total)	
Development Project Experience	
Background (education / work)	
Project Description (organization, product, #members, durations)	
Number of development projects performed by interviewee	
Number of projects with explicit traceability beyond the link between requirements and testing	

Traceability in general

- What does the project manager know of traceability? Have u ever heard of the concept of traceability within software development?
- What do you think that traceability is about? (Freedom for the interviewee to show what he knows of the topic, how he sees it, the importance of it).
- Followed by an explanation of the way traceability is perceived in this research
  - If the interviewee does not know traceability and has never encountered it, the interview becomes an explorative interview. The factors as presented in the "structured" part of the interview are followed, but a lot more explanations and descriptions are provided. The focus of these interviews lie on the "what if"-questions.

Traceability in this project

Here, the interviewee gets a lot of freedom for telling how he has experienced the process where the decision on applying traceability in this specific project is taken and what effected this decision.

Has traceability been adopted in this project?

- What happened in the startup- and initiation phases of the project?
- How did traceability come forward here?

Discussing the identified factors

This part of the interview is more structured. It further discusses the different issues which played a role during the adoption of traceability in this case, if they haven't been discussed already.

Development Organization Awareness

- Did anyone in the projectteam ever mention traceability?

Customer Awareness

- Did the customer ever specifically demand the adoption of traceability?
- Was there a set policy for this at the customer organization?
- Was there ever any mention of the "maintainability" of the system?
- Was there any discussion about this, or other matters, with the IT management department when developing the project initiation document?

Sources of Influence

- Which people do you feel had influence on the choice of whether or not adopting traceability?

Technological Possibilities

- Did you ever look into the technical possibilities to support keeping track of traceability? What were your conclusions of this?
- Did you already have a clear opinion on the technological feasibility of keeping track of traceability before this project started?

Return on Investment

- Did you ever look at the specific costs of adopting traceability?
- Did you ever look at the potential benefits of it, and how did you see these benefits?

Quality Standards

- Is the interviewee familiar with quality standards and their implications?
- In what way did the development organization work with quality standards?
- In what way did the customer organization work with quality standards?
- Did any of this influence the adoption of traceability?

Time Pressure

- Was there a strict deadline on this project?
- Did time pressure influence matters such as quality issues?
- Did time pressure have anything to do with choosing to adopt traceability?

Compliance

- Were there any (legal) demands with regard to traceability from the environment of the customer?

Project Complexity

- How complex would you describe the project? Did it use a lot of new things the development organization was not familiar with?
- Did this influence your decision?

Development Method

- What development method was used in the project? How did this influence the adoption of traceability, if it influenced this at all?

Product Life Expectancy

- What was the expected life of the product under development? Did you look at this during your project?

Dynamics of the Environment

- Would the environment of the system be classified as dynamic? Did you consider this when determining how to approach this project?

Stakeholder Preferences

- What was the type of contract for this project?
- What were the consequences of remaining within budget or crossing it?
- Did you think adopting traceability would influence adherence to the budget?

Process Flow

- Did you feel traceability would influence the way the operational processes are executed?
- Did you think this was a problem which you would rather avoid?

Benefits outside Project Borders

- Was there any contact with the IT-management organization during the preliminary stages of the project?
- Did the customer value this contact? Was it initiated from their side?
- Did you see a problem in the fact that traceability might require an investment in development which would be profited from in IT management?

V. Appendix V: Respondent Interview Reports

Report Interview 2006-05-23 (A)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in this Role (Ordina / Total)	> 10 years
Development Project Experience	24 years
Background (education / work)	Mathematics/Informatics, working in technical automation, in general a technical background
Project Description	The project took place at a large chemical company. It dealt with a discussion forum application which required adaptation with regard to moderating permission for users. The interviewee first functioned as the project manager from the business side, but later also took over as project manager for the implementation which was responsible for matters such as traceability.
Number of development projects performed by interviewee	25
Number of projects with explicit traceability beyond the link between requirements and testing	13

Interview Transcript

Knowledge on Traceability

Upon asking for his knowledge of traceability, the interviewee is very familiar with the concept of requirements traceability (under this name). He feels it is imminent to perform traceability to be able to verify adherence to requirements. For this reason, he is used to performing it in nearly all projects he works on nowadays. He feels that all projects employ traceability, but that sometimes these relations are documented in a very informal way. Implicit traceability is not uncommon.

The interviewee feels that a decision whether or not to use traceability does not necessarily have to be made before development starts, unless you use specific tools. He is not used to using tools, but mostly performs traceability through numbering requirements and using tables in technical documents which link these numbers to the chapters of documentation to which they relate. Making the adoption decision can also be made later on in a project because the project manager feels that you can still start to apply traceability later on, recovering your losses. He does feel that this only works on smaller projects however.

The use of traceability is mainly seen in verification of requirements in your end product and delivering a quality product.

Traceability in this specific project

This project made use of traceability between requirements, functional specification, design, and code, and also between requirements and test cases. Documenting the

relationships between these elements happened through tables in documents. The decision to use traceability came quite natural. It was a given for the interviewee to keep track of these relations, he always does this. On top of that, it was a requirement from the client in this case. During the development of the project plan, it was already clear that traceability would be adopted.

After this open-ended part of the interview where the interviewee was free to talk about whatever happened with regard to the adoption, several areas were further discussed.

Development Organization Awareness

The project manager himself saw traceability as a "must". The rest of the organization was not really involved in making the decision to trace, it came natural.

Customer Awareness

The customer was clearly aware of traceability, due to the fact that delivering a traceable product was a clear demand. Traceability was not a demand by default in this organization, however. It was project specific, of which the reason is the immaturity of the organization where software development was concerned. Demands on "maintainability" of the system were quite global. Traceability was not mentioned specifically in this context, but it was in the general project context.

Sources of Influence

N/A, the decision was made by the project manager himself and he required no other input, except for that of the customer which demanded traceability in this project.

Technological Possibilities

Traceability is not hindered by technological factors according to the project manager. In this case, traceability was performed by using simple tables linking numbered requirements to chapters in documentation, and chapters to other chapters of documentation. No specific tools were required.

In case of the use of tools, this decision has to be made beforehand. People have to get acquainted to using the tools and an investment is required for this. The interviewee saw no need for using these tools yet however, they weren't even required to keep decent track of traceability.

Return on Investment

During development, delivering a product which adheres to the requirements already weighs up to the costs of traceability. Not delivering a "faulty" product is quite important and the low costs of recording traceability relations the way the interviewee is used to does not lead to high costs.

Using official tools, such as rational RequisitePro and ClearCase, would require an investment which lies a lot higher, due to training and license costs. In this case, a more balanced decision would have to be made, but this situation never really existed for the interviewee.

Quality Standards

The interviewee is well acquainted with standards such as the DoD, CMM and ISO. At the project at hand no standards were really applicable.

Compliance

Not relevant in this case, no compliance standards available.

Project Complexity

This project was not specifically complex and this did not weigh in on the decision to adopt traceability. The technology wasn't really new, understanding of the system was quite high for the developers according to the interviewee.

Development Method

This method used during this project was a one which concerned two iterations.

Product Life Expectancy

The product has a life expectancy of at least 3 years with maintainability of the used technology of 5 years as a requirement, but this did not weigh in on the decision made.

Dynamics of the Environment

The product did not appear to be in a very dynamic environment, this did not really weigh in on the decision made.

Stakeholder Preferences

The client demanded the use of traceability himself and the project manager also wanted to adopt it if it had not been a request. No political influences or personal motives were spoken of by the interviewee.

Process Flow

The project manager did not see the adoption of traceability as a hindrance of the process, yet as one which created more understanding.

Benefits outside Project Borders

The project manager clearly stated that he felt only responsible for the result of his own project. There was very little communication with the people responsible for IT-management and they did not come up with any pressing demands.

He feels that IT-management does not care much for traceability in general and expected that they would not keep the traceability up to date in the future, unless the maintenance would be performed by the original development team..

Other

The project manager returns to the subject of using tools for keeping traceability information. In large projects, this could be quite useful in his opinion. This would depend, however, on several things. The more changes occur, the higher the added value. He feels that iterative development methods, where he specifically mentions RUP, would benefit most from these tools.

Report Interview 2006-05-31 (B)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in this Role (Ordina / Total)	8 Years (new at Ordina)
Development Project Experience	21 years
Background (education / work)	HTS Computer Science, has been working in development and IT Management for all of his professional career
Project Description	The project took place at a large bank. It concerned the development of a telephone service to customers which was built because a competitor introduced a similar service. The project took 4 months to complete and involved a project team of 12 people.
Number of development projects performed by interviewee	10 with interviewees responsibility
Number of projects with explicit traceability beyond the link between requirements and testing	0

Interview Transcript

Knowledge on Traceability

Requirements Traceability, in the opinion of the interviewee, is the translation of functional requirements to design, code and tests and showing the interrelations which can be found here. The links between these items could most basically be kept through numbering requirements and linking to these requirements. There are other methods known however.

The interviewee feels that one is most likely to find traceability:

- With customers that maintain their own software
- With customers that identified problems with maintaining software in previous projects
- With customers which foresee many changes for the product.

Traceability in this specific project

In the project at hand, the interviewee decided not to adopt traceability. The effort required for adopting traceability was judged as too big, and the associated costs would be too large for the project to stay within budget.

In the project, the customer felt quite strongly about their brand name and therefore had quite a few demands with respect to quality, but these mainly had to do with availability, security and performance. Many different tests were executed for the project, but traceability would have cost too much time in the opinion of the interviewee. The customer had a very strict requirement that the project definitely had to be finished within the set period (4 months) and that nothing should interfere with this. From the developing organization (a large IT supplier) there was also a clear demand: the project had to be profitable.

After this open-ended part of the interview where the interviewee was free to talk about whatever happened with regard to the adoption, several areas were further discussed.

Development Organization Awareness

The project manager was quite aware of the existence of the concept of traceability in development projects.

Customer Awareness

The customer did not demand the adoption of traceability in this project. It was also not a set policy to do this at the customer organization, although this did become a standard requirement somewhere after this project. There were requirements with regard to the availability and performance of the system , but none with respect to traceability.

Contact with the party which was to maintain the product after completion was nonexistent until the factory acceptance tests were performed, which was after more then half of the time of the project had passed.

Sources of Influence

The project manager did not discuss adopting traceability with anyone, except for the account manager of the IT supplier he was working for. He wanted to know about the expectations of the customer organization with regard to the way the product was to be delivered.

Technological Possibilities

The project manager did not see any hindering of adopting traceability by the availability of technical support and knew of the existence of tools to support keeping trace of it. Adopting traceability and keeping track of it in a basic way, by cross referencing to other numbered items in other documents, would create a lot of work in the field of reviewing these references.

Return on Investment

Adopting traceability would create an additional overhead cost of 15% to the development project according to the project manager. The direct benefits of traceability for the project were judged to be only 2% however, coming from the reduction of tests which had to be performed.

The project manager is aware of the fact that traceability brings a lot of advantages to analysing the impact of changes. It would reduce the time required for this and increase its quality. In the project itself, however, he did not think this would bring many benefits. Verifying the adherence to requirements was not an issue either, since the requirements for the product were rather limited and easy to test.

Quality Standards

The customer organization did not have any quality standards such as ISO 9000 or CMM to which it had to adhere, only their own quality demand. The IT-supplier, however, was ISO 9001 certified. This did not force the project manager to adopt traceability however, it only showed how processes had to be performed. There were some optional standards with regard to traceability and how to act when adopting it, but these only applied if one decided to adopt it.

Compliance

No compliance issues played a part in this case.

Project Complexity

Whereas there was a lot of new technology involved with the project, this did not weigh in to the decision for adopt traceability according to the interviewee.

Development Method

The method used during development was a method as used by the customer organization, which was comparable to a waterfall-method. This did weigh in the decision to adopt traceability, if a process were to be iterative it would increase the likeliness of adopting traceability according to the interviewee.

Product Life Expectancy

The life expectancy of the product was at least five years, yet this did not weigh in the decision. The monetary aspects were seen as prevailing.

Dynamics of the Environment

The environment could be seen as dynamic, but this did not play a part during development. The goal was simply to develop a system quickly, expandability of the product was not really an issue (except for capacity expansion) for example. Maintainability was not really an outspoken issue for the customer.

Stakeholder Preferences

The project was fixed price and based on a quotation supplied by the IT supplier. This quotation did not consider applying traceability and the added costs of this. One of the goals of the project, for the IT supplier and the project manager, was to remain within budget and therefore make a profit on the project. Not achieving this goal would not be a positive influence to the project managers career, the project HAD to be profitable.

Process Flow

The main disadvantage of adopting traceability was seen as providing extra work. It was not just the keeping track of relations, but also the reviewing of this work and testing this which caused this extra work. Reviews were demanded by the quality system of the IT supplier.

Benefits outside Project Borders

The development organization did not have any real contact with the IT management organization during the preliminary stages of the project. The customer did not feel this contact was important, and they simply wanted their system fast due to the fact that they were now lagging behind one of their competitors. Maintainability was not an issue, and the advantages of traceability in maintenance would be to the cost of the development organization.

Other

Customer organizations generally do not involve IT departments enough in development projects. They should make them an important stakeholder in the processes preceding the actual development and should allow them to make demands with respect to maintainability.

Report Interview 2006-06-02 (C)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in this Role (Ordina / Total)	10, of which 6 years at Ordina
Development Project Experience	17 years (of which 10 as a project manager/leader)
Background (education / work)	Study: HTS Computer Science. Afterwards: 7 years as an IT-consultant, after which the interviewee became a project leader/manager
Project Description	The project took place at a large public organization. It involved the development of a large administrative system. The system took 9 months and the project team consisted of 17 people.
Number of development projects performed by interviewee	Five medium sized project (10.000–25.000 hours) and many smaller projects.
Number of projects with explicit traceability beyond the link between requirements and testing	Most medium sized projects, in different measures

Interview Transcript

Knowledge on Traceability

The project manager was not familiar with the name of traceability. When the concept is explained, he recognizes it and its added value. The interviewee notes that it is very important to delimit the traceability and not to go too far in this. The interviewee sees the added value of traceability for projects, both in the verification and the impact analysis. An additional advantage seen by the interviewee is the overview gotten from it and the ability it offers for monitoring the project.

Traceability in this specific project

In the project at hand traceability was applied. It was not performed under this name, and the project manager did not really sees this as making a decision. It was something which simply occurred and was performed because this was standard, it appeared logical. No specific tooling was used to perform the activities.

When asked to re-examine this process, the interviewee thinks that he did make a decision, but that it was not necessarily one he was aware of making. Looking back at it, he feels that the reason to perform these activities were to guarantee the ability of verifying whether you have delivered the correct product agreed upon in the contract. Especially in this project, this was very important. The customer organization offered a use case model which was the basis for the end result of the project. This end result was specified quite clearly in the contract and seen as very important by the project manager.

After this open-ended part of the interview where the interviewee was free to talk about whatever happened with regard to the adoption, several areas were further discussed.

Development Organization Awareness

In the development organization, awareness of traceability was certainly seen. Even though it was not known under this name, every part of the development organization was familiar with it.

Customer Awareness

The customer showed not much awareness with regard to traceability. There was some contact with IT management, which was supposed to be performed in-house. Many different clusters came with different acceptance criteria, but none of these demands from the organization was with regard to traceability.

Sources of Influence

The following people were involved with creating the project plan and the internal project processes and had influence on this part of the project:

- Project Manager
- Project Leaders
- Architect
- Analysis / Design
- Construction
- Testing

It should be noted, however, that none of these people were really involved in making the decision to adopt traceability. This was the project managers own decision.

Technological Possibilities

Support from tools was not seen as an issue by the development organization. The ordinary tools such as Word and Excel were used.

Return on Investment

The interviewee did not necessarily make a breakdown of costs and benefits of traceability. The project dealt with subsequent calculation, so any extra costs were not an issue.

Quality Standards

Although there were a lot of demands with regard to quality, there were no set standards as policy within the entire organization. No demands with regard to traceability were standard either.

Time Pressure

Although time pressure was definitely high in the project, this was not something which influenced the decision of applying traceability.

Stakeholder Preferences

Because the project was not performed as a fixed price project, the potential extra time involved with the performance of tasks related to traceability did not have a consequence on the financial outcome of the project for the project manager / IT supplier.

Other

A system of which the maintainability is not high causes extra work for the IT management department. In some cases, however, this is not seen as a problem because it creates additional billable hours. For this reason, an IT management organization might not demand traceability. The form of contract does not only matter for development projects, but also for IT management.

The interviewee agrees with the notion that benefits which lie outside of the domain of a development project, such as those in IT management, might not be taken along by the project manager. His scope is simply that of a system development project and anything outside of this does not matter.

Report Interview 2006-06-07 (D)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in this Role (Ordina / Total)	8 (1 at Ordina, 7 at another consultancy firm)
Development Project Experience	None
Background (education / work)	Study: Policy and Organizational Science After this: Work involved with IT-strategy
Project Description	At a large non-profit organization, a system resembling an ERP-system. The project lasted for 18 months and involved 5-6 people.
Number of development projects performed by interviewee	Unknown
Number of projects with explicit traceability beyond the link between requirements and testing	Unknown, but in all larger projects

Interview Transcript

Knowledge on Traceability

Although the interviewee is not familiar with traceability in this name, he is quite familiar with the concept. He feels that there are two ways in which traceability is important. First of all, the link of requirements (or functional design) to test cases is very important to be able to show that you have done what a customer demands. On the other hand, the relationship between a product and its functionality (FO $\rightarrow$ TO) is maybe even more important because this provides management information. Without this information it is impossible to see what people are spending their hours on, on which product with what functionality. This is not just required for reporting and justifying hours spent, but also for being able to adjust the course of the project.

In smaller projects, the project manager feels that keeping track of traceability is a lot less important. What it all comes down to in the end is the cost/benefit breakdown, the financial result of the whole. Traceability is *needed* for the management information it supplies, but if the costs are too high, it is not applied.

The technical applications of traceability are nice, the benefits which come with it are nice as well, but the interviewee sees traceability solely as something which supplies information on what people are working on in a project and how this relates to a product and the possibility to verify what you have done (FO $\rightarrow$ Test).

The interviewee recognizes the advantage of the improved impact analysis with traceability, but feels that this would be an issue for someone closer to the operational side of the project such as a team leader.

Traceability in this particular project

In this project, the interviewee stepped in when the project was already underway, but was not functioning the way it should have been. For this reason, a temporary stop was put to all activities and the first thing that was done was creating a work breakdown structure which meant dividing the system into separate product and assigning functionality to these different products. Next, the links between functional design and technical design / code were kept to

show who was working how much on what functionality and therefore what product. The customer wanted to see how the hours were spent, so justification was required.

In this project, the interviewee was the person that decided traceability had to be implemented in the form described above, and feels that he was the only one involved with this decision. The reasons for the decision were:

- You have to be able to control/monitor/manage the project

- For this you need "management information"

In the end, a project manager is responsible for both what he delivers (does it fulfil the customers requirements and expectations), and how it is delivered (on time and within budget). Traceability is a strong help in this latter part.

After this open-ended part of the interview where the interviewee was free to talk about whatever he saw with regard to traceability, several areas were further discussed.

Return on Investment

The interviewee feels that there are costs involved with traceability, but the benefits from applying it are very big. It is almost a must to perform, but you should still always perform an analysis of the costs and benefits, because in the end the budget is still what matters.

Time Pressure

The interviewee states that time pressure is definitely an issue. The first priority of a project is to deliver what is demanded on time and within budget. Anything else, such as traceability, must make way for this.

Benefits Outside Project Borders

Benefits which lie outside of the scope of a project do not matter to a project manager. On the other hand, these benefits do matter from a commercial point of view. Delivering a quality product that is best for the customer insures his satisfaction and improves the chances of his return to the supplier.

Stakeholder Preferences

For a project manager, the most important issue in the end is delivering what was asked on time and within budget. Most projects work on a fixed price project, as does this one, and going over the budget requires justification, whereas spending less would lead to a bonus for the project manager. In the end, what matters is the number that results from adding all the plusses and minuses in a project.

Report Interview 2006-06-08 (E)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in this Role (Ordina / Total)	10 (of which 1 at Ordina) and 5 additional years as a project leader
Development Project Experience	8 years (and the 15 as project management)
Background (education / work)	Study: Teacher Economics / Mathematics Then took an internal trainings project at a company schooling him for IT. Studied HBO Business Informatics later. Worked as a developer, designer and analyst for 8 years before becoming a project manager.
Project Description	At an IT-supplier for health organizations an existing system that provided 1st line support to health personnel had to be rebuilt. The project involved 24 people and lasted for 2 years.
Number of development projects performed by interviewee	-
Number of projects with explicit traceability beyond the link between requirements and testing	All projects (100%)

Interview Transcript

Knowledge on Traceability

When asked for his impression of traceability, the interviewee responds that he feels it deals with keeping track of everything that is involved with the change of a certain requirement. The project manager applies the concept in each project, because:

it enables one to justify the cost of an item

it shows the relationship between different development products and the consequences of these relations when changes arrive.

When working in a customer organization (being rented out, not heading up your "own" development organization), one generally has to adapt to the procedures and way of developing that organization is used to. The interviewee does attempt however to introduce traceability if it is absent. When the project is one where the development organization is from the same organization as the interviewee, he has a lot more influence and traceability is always applied. The interviewee noticed that traceability is often a requirement from the customer organization (and more specifically the IT management department), but when it is not he will attempt to introduce it himself anyway.

If traceability is not adopted, the interviewee feels that this would have to do with the costs and benefits involved with it. Implementing traceability brings along costs, and you have to get the entire organization to work with it. To make sure this happens, you have to check this through reviews as well.

As stated, traceability is often a demand by a customer. If so, it is generally a demand from the IT management department of that customer, but this department has to be identified as a stakeholder for this to happen. If this department is not proactive and assertive enough, traceability could go down because of the different interests stakeholders might have where

this department is often required to fight for traceability, since they are the ones that benefit from it most.

The project manager feels that traceability would soonest be found in large projects. In smaller projects, traceability would be less of a priority. This mainly has to do with the investment one has to make to adopt traceability. Projects can always use word processors and spreadsheets, but in some cases tooling is useful or are applied because this is required. The disadvantage of applying tools lies in the investment required for them, consisting of training, licenses and setting them up for the project.

The interviewee feels that it is possible to adopt traceability halfway through a project, but only to trace all links created from then on. Links which should have been created before would require an effort which is a lot higher, due to lack of knowledge and familiarity with the context.

Traceability in this particular project

In the project at hand, traceability was applied. This was done to make sure the quality of the product was high enough to ensure a decent future, with respect to matters such as maintainability. Keeping the costs of development and IT management low enough required traceability, especially in this project where knowledge would disappear. At one point, time pressure and the budget became more of an issue and the supplier (another party then this project manager) wanted to drop several quality issues such as traceability. They did not see the return on investment clear enough and were tied by the set budget. The project board did not see the use of traceability as that strong an issue either, and traceability was abandoned during the project.

After this open-ended part of the interview where the interviewee was free to talk about whatever he saw with regard to traceability, several areas were further discussed.

Customer Demands

When a customer demands traceability in a development project, this demand comes mainly from the IT management organization. It is this party which benefits from traceability most.

Sources of Influence

According to the interviewee, deciding to use traceability should be done when writing the project initiation document. The people who could influence this decision are:

- Project Manager
- Quality Manager of the development organization
- Customer Demand – quality management of the customer organization (IT management)

In practice, however, this was not the case and the project manager simply made the decision on working this way.

Return on Investment

The interviewee feels that the costs and benefits of traceability already balance one another during development, especially in larger projects. It is an important factor however, since in the end the budget is quite important.

Quality Standards

In this case, the quality standards came from within the organization. When using set standards, such as those prescribed by the CMM, you *have* to adopt traceability if one wishes to be at any level above level 1 (adhoc), so it is not even an issue.

Compliance

The interviewee feels that traceability is a very hot topic within the financial sector, with banks. He feels that they have to cover their bases with regard to risks, including those caused by information systems. Risk Management would be a probable source for a demand for traceability in this context. Compliance issues with Basel II and Sarbanes-Oxley seem logical due to risk management to the interviewee.

Development Method

It does not matter much which development method is used according to the interviewee, the only difference is that some development methods prescribe traceability period. Different methods do not incur different amounts of changes.

Project Life Expectancy

If a project has a very short life expectancy, traceability is not applied. The longer the life expectancy of a project, the higher the expected amount of changes, but this would not necessarily be something the interviewee would take along. However, if traceability is part of a standard within an organization, this should not matter.

Dynamics of the Environment

The interviewee states that the stability of the environment is part of a cost/benefit analysis. A less stable environment will lead to a higher risk and will therefore influence the budget. He also feels this influences the decision to adopt traceability.

Time Pressure

In this project, traceability was let go of at one point because of time pressure. If time pressure is known before a project starts, this could be a reason not to adopt traceability. In this case, he would have the recommendation of picking it up afterwards, yet this is not often acted on in practice.

Benefits Outside Project Borders

If party A develops a system for customer B, but IT management is performed by party C, the interviewee would not adopt traceability if it would incur additional costs. If it were to be maintained by party A as well, this would be different. Selling a project which is developed more expensive then a competitor due to traceability is something which hardly ever occurs in practice.

Traceability should however, in the opinion of the interviewee, be part of the governing standards. If traceability is not implemented yet, the investments should come from another budget such as QA.

Contract Type

The interviewee does not feel that fixed price projects exist where he is forced on a certain budget without any influence from his side, but if this were to be the case and traceability would incur higher costs in development, it would be a reason not to adopt it. Still, traceability should come from another budget if not part of the standard methodology.

Process Flow

Adopting traceability does not make the process more complex and would not influence the decision whether or not to adopt traceability.

Other

In the end, the interviewee feels that the most important issue with regard to the adoption of traceability is what its benefits are to the project, how these compare to the costs incurred and whether or not this can be sold to the customer for any required budget.

Report Interview 2006-06-07 (F)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in project management	2
Development Project Experience	12
Background (education / work)	Study: Chemistry (University) After this: Started working as a programmer, after which he took on the roles of team leader, functional designer, architect, change manager and quality assurance.
Project Description	At a large bank, a batch system for converting data from one system to another was developed. The project lasted for 8 months and 14 people were involved.
Number of development projects performed by interviewee	2
Number of projects with explicit traceability beyond the link between requirements and testing	2

Interview Transcript

Knowledge on Traceability

The interviewee is well acquainted with the concept and term of requirements traceability. Being able to trace requirements to code is what he considers it to be, which is consistent with the definition used in this research project. Traceability is something which should be applied during development already, when a system is already in use realigning the code with other development products is quite expensive. In systems developed in the object oriented paradigm this is easier then for systems developed in Cobol, since the latter consists of flat text which is harder to tag with an identification.

Non-functional requirements are almost impossible to trace, a single requirement is effected by too many parts of the system to be able to link this correctly.

The project manager was involved in a previous project, where his role was that of functional designer and architect. When he and a colleague implemented traceability between different levels of requirements and design/architecture, the software architect involved with the project then initiated the implementation of traceability for other development products as well. In his role as change manager later on in this project he saw the use of traceability with regard to an improved impact analysis, but the initial reason for adopting traceability here was to reduce the complexity related to the project size (18 months, 30 people). Project management was not even involved in this decision, it was carried by several people in the project.

He feels that adopting traceability could be a demand from the IT management department of the customer, if they wish to reduce the costs of maintenance (TCO). Traceability is only one of the ways of doing this however, which should be noted quite clearly.

A clear distinction is made between the project manager and project leaders, where project leaders are internally focussed opposed to the external focus of the project manager. It

are the project leaders which could or should work on the adoption of traceability generally, but the project manager can also do this, enforce the adoption top-down. In general, however, most projects currently adopt traceability because the software architect enforces it, especially when he also has the role of team leader (which he generally does).

Traceability in this particular project

In this project, traceability between different levels of requirements and design was adopted on the initiative of the project manager, although according to him it would also have been adopted if this were left to the architects involved in the project. They implemented traceability for the other development products. The reason for applying traceability was reducing the complexity in the project, giving people the overview of how things are connected to one another, showing the rationale, and for being able to trace matters when changes occur or errors.

After this open-ended part of the interview where the interviewee was free to talk about whatever he saw with regard to traceability, several areas were further discussed.

Customer Demand

The customer did not demand traceability in this project, also due to the fact that the software was meant to be "thrown away" after use.

Sources of Influence

In this project, the choice of adopting traceability was made by the project manager and architect.

Technological Possibilities

The project did not make use of any specific tools, and none were required according to the project manager.

Return on Investment

The interviewee sees no real costs in adopting traceability, it does not really cause any extra work. When adopting traceability later on and then realigning matters, the costs are quite high. Because no costs were perceived by the project manager, no complex cost/benefit analysis was required.

Development Method

The interviewee feels that it does not matter which development method one uses, you want traceability independent of this. Cobol would be harder to reapply traceability on, but it did not matter in this project.

Product Life Expectancy

Because the product was meant to be used only once, the project manager did not have to concern himself with what happened to it when the project was completed. He would not have done this anyway, since to him the scope is merely the project and what happens after this does not matter, like Prince2 prescribes.

Project Size

The project manager feels that traceability mainly starts to be useful when projects get larger. The larger they become, the more complex they become in his opinion, as shown in the figure below. This project was large enough for traceability to be worth it, because the complexity had to be managed by providing a decent overview through traceability.
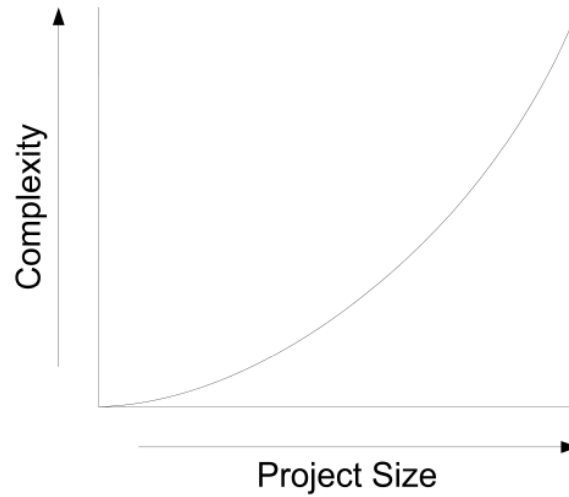

Figure 17 – Project Complexity vs. Project Size

Process Complexity

The project manager did not feel that traceability made the process any harder, so this did not really influence the decision in a negative way.

VI. Appendix VI: Interview Reports Informants

Report Interview 2006-05-30 (A)

Basic Information on Interviewee

Current Role	Project Leader
Number of Years of Experience in this Role (Ordina / Total)	5 years
Development Project Experience	14
Background (education / work)	Study: HTS Electronical Engineering and Informatics Before working as a project leader he was a designer, and afterwards worked as a connecting person between development and IT management.
Project Description	The project took place at a large utilities company. It took place in 2005 and the goal was the development of an analysis system. The project lasted for 6 months and had 5 people working on it.
Number of development projects performed by interviewee	many
Number of projects with explicit traceability beyond the link between requirements and testing	1

Interview Transcript

Knowledge on Traceability

The interviewee states that he does not know the concept of traceability in software development. After a short description of the concept, he recognizes it and states that he is familiar with it. He first got to know it when an application management group was created in Groningen. A designer delivered a traceable design, where he had numbered the requirements and then pointed to these numbered requirements in his design.

After having seen this and having identified the added value of this concept, he did not apply it in every project. He did use it in the formalization of requirements where interviews were analyzed and worked out into formal requirement statements. The interviewee also knows the concept from a tool called SDW, which applied a very top-down way of software development, but has not used this in practice.

The main added value of traceability identified by the interviewee is the ability to find ones way in the puzzle created during development for being able to cross off all the identified requirements. Verification of the requirements in the delivered work is seen as the largest extra.

Traceability in this specific project

The project at hand, at the large utilities supplier, did not make structured use of traceability. There was no question of adopting it or not, it simply did not occur. The decision to do this was not one the decision maker was aware of making. The project manager never considered requirements traceability as a concept or methodology which could be applied during this system development process.

In the project, the client had created clear descriptions of the different processes involved, which were transformed to a design where the structure with regard to chapters was kept similar as much as possible.

After this open-ended part of the interview where the interviewee was free to talk about whatever happened with regard to the adoption, several areas were further discussed.

Development Organization Awareness

The project manager was not really aware of the possibility of applying traceability throughout a development project. He did know of the concept, but did not consider it something which should be applied in this project.

The rest of the organization did not come up with the subject during the project.

Customer Awareness

The customer did not show any awareness with regard to traceability. It was not a specific project requirement.

If the customer would have demanded it, he would probably implement it.

Sources of Influence

The following people were involved with creating the project plan and had influence on this part of the project:

- Customer
- Project Manager
- Architect
- Analyst

Technological Possibilities

Through the manner of which the interviewee was familiar with the concept, simply adding identifiers to requirements and other products and keeping track of these in a word processor document, the interviewee saw little problems in adopting traceability. When embedding it into the existing development process, it does not involve a lot of work necessarily. This does depend on the familiarity of the development team with the concept, performing it for the first time might lead to a high initial investment with regard to resources.

Using special tools, in the opinion of the interviewee, would drastically increase the amount of extra work required. Not knowing the tool leads to people requiring training in the tool which would lead to a high initial investment.

Return on Investment

The main advantage identified by the interviewee is the ability to tick off requirements in design, design elements in code, requirements in test cases, etcetera. He feels this is independent of the development method used.

To the customer, this would bring the added value of not having to discuss matters. A traceably developed product shows exactly what has been done and what requirement has been satisfied where. A simple audit would end any discussions.

Quality Standards

The interviewee knows of standards such as ISO and CMM, but has not really encountered them in practice. He feels quality is important and such standards are quite a good step, but one should care about their process, not about certification.

Compliance

The interviewee does not know compliance issues with regard to traceability.

Development Method

The method used during development would not influence the adoption of traceability according to the interviewee. Traceability is applicable in each method and the interviewee does not feel it would work better with different methods.

Return on Investment (Revisited)

After discussing the added value of traceability with regard to impact analysis following a change request, the interviewee immediately sees the benefits of this. Being able to quickly determine the impact of a change is quite important in maintenance. He remarks that dealing with changes is often performed in IT management settings where the benefits would also be reaped, whereas most costs with regard to traceability would be made in development.

Benefits outside Project Borders

The project manager feels that there is too little attention to maintainability in general. In the project at hand, he and his team really wanted to deliver a quality product including documentation and everything. The IT-department at the utilities-supplier was quite happy with the way the product was being developed and delivered, but the customer was less happy. He only saw the direct costs of this, and was not looking at future rewards from delivering this quality project.

Process flow

Whereas the interviewee felt that adopting traceability might cost a lot more work at first, he feels that it might just be a small added thing looking back at this.

Other

The project manager feels that in general, the main advantage of traceability is the ability to verify adherence to requirements. The cost reduction which is to be made in development is not of direct interest of project managers and customers often do not look at this either. He also feels that using traceability could be employed to improve the monitoring of a project and being able to report on this.

Projects often look at functional specifications, but somewhat neglect non functional requirements which generally deal with "quality issues". These often are most important for IT Management, but are often overlooked.

Report Interview 2006-06-01 (B)

Basic Information on Interviewee

Current Role	Project Manager of an In-House development department at a customer.
Number of Years of Experience in this Role (Ordina / Total)	7, of which 4,5 years at Ordina
Development Project Experience	13,5 (and 7 as project manager)
Background (education / work)	Study: HBO-Nurse Afterwards, the interviewee got his AMBI-diploma and started working in development for different employers
Project Description	The project took place at a division of a large consumer electronics manufacturer. It enveloped the improvement of a web catalogue of the different products offered. Ten people were involved with the project and it lasted for 5 months.
Number of development projects performed by interviewee	Many
Number of projects with explicit traceability beyond the link between requirements and testing	0

Interview Transcript

Knowledge on Traceability

When asked, the interviewee answers that traceability, according to him, mainly has to do with documentation. Traceability of documentation and code are mentioned. He connects it to product history and archiving this, configuration management.

The interviewee agrees that traceability is something which could be very useful during software development, but it is not something which he automatically would have suggested using. He never really considered it as a separate issue.

Traceability in this specific project

The project at hand, at the consumer electronics manufacturer, did not make structured use of traceability. There was no question of adopting it or not, it simply did not occur. There was a clear link between requirements, use cases and design, but not towards the code. The decision to do this was not one the decision maker was aware of making. The project manager never considered requirements traceability as a concept or methodology which could be applied during this system development process.

After this open-ended part of the interview where the interviewee was free to talk about whatever happened with regard to the adoption, several areas were further discussed.

Development Organization Awareness

Traceability is not something which the project manager himself was focusing on, nor something he was aware of as something that could be applied project-wide. The development organization did not bring it to his attention either.

Customer Awareness

The customer did not show any awareness with regard to traceability. It was not a specific project requirement. There was a lot of communication with the IT management department which also had specific demands (acceptance criteria), but traceability was not discussed here. The organization had a standard way of working which did not include traceability, but was simply taken over.

Sources of Influence

The following people were involved with creating the project plan and had influence on this part of the project:

- Business (customer) (Business Process Owner)
- Project Manager
- Program Manager (head of the IS department)
- Business Process Analyst
- Quality Assurance Team Leader
- Development Team Leader
- Managed Operations Team Leader (IT Management)

Return on Investment

The interviewee is not really aware of costs and benefits associated with traceability, and a short explanation on this topic follows.

Quality Standards

The development organization worked with the CMM-standards. Every so often an audit was performed and the general level of the organization was CMM level 3 according to the project manager. He was not aware of traceability through this however.

Benefits outside Project Borders

The project manager mentions that at the moment, both development and IT management are performed in-house, except for a couple of outside suppliers. Management has decided, however, to outsource a lot of the IT management to a large Indian IT company, offshore. The project manager feels that traceability, and maintainability in general, will become a lot more important in this case.

The task of a project manager ends after the product has been accepted by the customer and the project is closed down. He feels he is not involved anymore afterwards.

Stakeholder Preferences

One of the issues the project manager mentions as an important influence is the fact that traceability would bring along an investment in development, whereas development is tied to a budget available to the customer.

Besides costs, the organization also imposed several strict deadlines. It was quite important that these deadlines were to be met, and traceability would in the eyes of the project manager possibly slow down the process. The higher the time pressure, the easier the attention for "quality issues" diminishes.

Other

At the organization in which the project manager is active, he feels that the best way to assure the adoption of traceability would be to have it implemented in a top-down manner,

with a lot of pressure behind it from management. A good business case which shows the advantages of traceability, especially when created in cooperation with managed operations, would enhance its adoption. The project manager is not sure if a bottom-up (or middle-out) adoption attempt would be successful.

Report Interview 2006-06-02 (C)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in this Role (Ordina / Total)	10 years
Development Project Experience	20 years (including 10 as a project manager)
Background (education / work)	Study: MS Electronic Engineering, retraining to COBOL-programmer at Ordina. Afterwards: several different roles in software development projects.
Project Description	At a large financial service provider, a system containing basic information on the different offices of this organization had to be expanded upon. The project lasted for 6 months and the project team consisted of 8 people.
Number of development projects performed by interviewee	Many
Number of projects with explicit traceability beyond the link between requirements and testing	0

Interview Transcript

Knowledge on Traceability

The project manager was not familiar with the name of traceability. At first, the interviewee stated that he understood the concept but after some more discussion on the topic it appeared this understanding had to be somewhat adjusted. The concept did seem logical to the interviewee, and the decision identified in the research was also recognizable.

Traceability in this specific project

The project at hand did not adopt traceability. The project manager was not aware of it and nobody notified him about it. He never consciously considered adopting traceability.

The interviewee expressed that the project was partly outsourced, the actual programming was performed by an outside-contractor. To this contractor, no demands were made about traceability and the work preceding programming (analysis & design) was not created in a traceable way either.

Factors influencing adoption according to the interviewee

The interviewee offered several factors which would influence the adoption of traceability. First of all, he mentioned the size of a project. Larger projects would have a higher likeliness of adopting traceability, due to the fact that more attention is given to the preliminary phases. Smaller projects would focus more on simply delivering what was asked, almost jumping the gun.

Second, the interviewee feels the clarity of the supplied requirements is an issue, because these are required for easier performance of traceability. Structured documentation is something which is a requirement for traceability anyway, you cannot refer to a section of an unstructured document. This does not just require the layout, but also the identification of single items through something like numbering. Third, budgets determine the option of being

able to make additional costs, such as performing traceability. If a budget is limited, matters such as traceability are the first to be dropped according to the interviewee. Being able to show that you require a larger budget, through a business case supporting traceability, would be very useful.

He feels that development products are now often loose pieces. There are no links connecting the different parts, which makes the possibilities for verification quite limited. Functional requirements are a lot easier to trace then non-functional requirements, since you generally cannot link these one-on-one to design elements and fragments of code.

Using traceability would require a control mechanism. This control mechanism could consist of rules enforced by a tool, or by a separate process where the links are verified. Using traceability also requires discipline with the people applying the links in traceability, since incorrect links are quite expensive.

For the adoption of traceability, it should be the organization involved with IT management that should pose demands with regard to traceability according to the interviewee. Few projects will perform it without this. The interviewee feels that a good business case should be available which shows that dropping the costs for maintenance is a consequence of applying traceability, and this should be made clear to the project manager. Still, the interviewee feels that traceability is already very important during development projects and the benefits in maintenance are only an added benefit.

Time pressure is given as a reason for stopping to perform traceability, or not even starting it. Quality is often a neglected issue, or the one easiest to abandon when time pressure increases. The functional requirements are implemented first, everything else has lower priority. Another identified benefit is the ability to improve monitoring and reporting on projects for project managers. The project manager also feels, however, that abandoning matters such as traceability and documentation will haunt you later on in the process, so it *should* not be an issue.

The development method chosen could influence the adoption. Iterative software development requires not just the creations, but also the maintenance of traceability links which could make the process more complex. Object-oriented methods do appear to be easier to adopt traceability in the languages such as COBOL according to the interviewee, because these provide more structured code.

Another quite important factor which deals with adopting traceability is whether or not one is dealing with a completely new system built from scratch, or whether it is an expansion on an existing system. Naturally, when a system is built from scratch one is able to start with traceability, whereas in the other situation it is quite hard to adopt traceability if it is not in place in the existing system already.

Finally, the interviewee feels that it would be very useful to have some sort of a feasibility study which could be performed for any project that would show whether or not traceability is useful for this specific product. This should often be performed in the bid-phase already, because that is what a contract is based on. Adding additional costs later will not be compensated.

Report Interview 2006-06-07 (D)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in this Role (Ordina / Total)	10, of which 0 years at Ordina
Development Project Experience	20 years (of which 10 as a project manager/leader)
Background (education / work)	Study: Teacher Arts & Crafts. Afterwards: went to work in IT. After programming also became designer and analyst before becoming a project manager.
Project Description	The project took place at a large government institution. It involved the development of a document creation system. The project lasted one year and involved 4 people.
Number of development projects performed by interviewee	Unknown
Number of projects with explicit traceability beyond the link between requirements and testing	Unknown

Interview Transcript

Knowledge on Traceability

The interviewee is not familiar with traceability. The name rings no bells, and an explanation of the concept is required. The idea is familiar to the interviewee, but not as something which is standard to apply in projects. The advantages of traceability are mainly seen in verification of the processing of requirements into the further development projects.

Traceability in this specific project

Traceability was not applied in this project as a concept. The link between functional requirements and test cases was specifically made explicit, but the link between requirements, design and code was not. No clear decision whether or not to apply traceability was made here, mainly because the interviewee did not feel this was her decision to make. The development organization should be performing their tasks the way they generally did, and if any decision was to be made this was to be made by the technical project manager.

A central point of interest in this project was that the business side came with a "requirements specification". These demands from the business side were quite important as something to grasp back upon. Being able to prove what you had to do and how you realized this was why this link between tests and requirements was created, but the project manager feels that more traceability would have been very useful to prove this. It would also be useful to prevent the wild growth of functionality and useless code by programmers.

During the start-up and initiation phases of the project, the people involved were mainly from the business side. Functional IT-managers took the place of analysts and created the functional specifications of the project, and management was required to create the necessary organizational support and for clearing the required budget. The requirements delivered did not involve any quality requirements.

After this open-ended part of the interview where the interviewee was free to talk about whatever happened with regard to the adoption, several areas were further discussed.

Development Organization Awareness

Awareness of traceability was found with the functional IT-managers which explicitly traced requirements to test cases in the acceptance tests. Developers and designers had their own database of documentation and their own standards, little was known to the project manager here. After the project initiation document was accepted a technical project manager was involved, which had the responsibility of executing the somewhat abstract project initiation document.

Customer Awareness

The customer showed no awareness with regard to traceability. IT Management was performed in-house, application management was performed by the IT department which also developed the product. The demands from IT Management were clearly communicated through and architect, but were mainly technical constraints and prerequisites, instead of clear demands with respect to maintainability such as traceability of the software.

Sources of Influence

The following people were involved with creating the project plan and the internal project processes and had influence on this part of the project:

- Project Manager
- Business Managers
- IT-management people
- Architect
- Programmers
- Interface-designers

The latter three people were part of a sounding board for the project manager, to see if things were possible and how much time it would take. None of these sources mentioned traceability. The way these people went to work themselves (the development organization) determined a lot of how things were performed.

Return on Investment

The interviewee feels that traceability is something which would be earned back anyway. If not in development, where there already is a lot of benefit through verification and creating an insight into the situation of the project and seeing the rationale behind development activities, then the benefit is certainly found during maintenance.

Quality Standards

There were some standards in the company with regard to how certain things had to be done, but no real standards with regard to quality were available. Standards such as ISO 9000 and CMM were not something which the organization was involved with. The same applied for compliance.

Time Pressure

Time pressure was quite low, especially for the functional IT-managers. This allowed them to keep a very clear link between requirements and test cases. The interviewee does feel that quality issues, including documentation and traceability, are one of the first things to disappear when time pressure rises in projects.

Stakeholder Preferences

The development and IT management were both performed in-house. The budgets for projects were pre-set, but with a good argumentation could be altered.

Benefits outside Project Borders

The interviewee feels that even within one organization there could be problems with benefits which lie outside the development project. This is completely dependant on the way budgets and cost allocation are dealt with within an organization.

Other

The interviewee feels that traceability is not necessarily regarded as a separate issue which has to be looked into by project managers. In her case, she felt that "the development organization would take care of that in their own way". Whereas she feels that traceability is a matter which has to be coordinated project wide, it is not something which is necessarily picked up by project management.

Report Interview 2006-06-07 (E)

Basic Information on Interviewee

Current Role	Project Manager
Number of Years of Experience in this Role (Ordina / Total)	3,5, of which 0 years at Ordina
Development Project Experience	None (except for project management)
Background (education / work)	Study: HBO Communication Systems After this: Application and Functional Management (4 years)
Project Description	-
Number of development projects performed by interviewee	Several
Number of projects with explicit traceability beyond the link between requirements and testing	None

Interview Transcript

Knowledge on Traceability

The interviewee is not familiar with traceability, but feels that he can imagine something with regard to the concept. He feels that traceability has to do with keeping track in program code what is changed at what time and for what reason. After an explanation of the meaning of traceability in this research project the interviewee responds that this seems to be a concept which resembles RUP with regard to the use of use cases during development. He has never seen or used the project himself however.

The advantages of traceability are seen mainly as being able to check on the issues which are coherent with the changes made in a change process. The advantages as explained by the interviewer, being improved impact analysis and verification, are seen as logical and are understood by the interviewee.

With regard to drawbacks in traceability the interviewee identifies the following issues:

- It requires time and energy to create the links and to maintain these links
- Lack of maintenance of links lowers the value of the existing links
- When applying traceability it has to be done well (thoroughly), or the value is lost
- The technical support of traceability is unclear, he does not know whether or not there are methods and tools available to provide this support.

The interviewee feels that the decision to adopt traceability or not is one which should be taken when drawing up the *project initiation document*. It impacts the way of working and should be decided on before development starts. The fact that it probably requires an investment also means that the project board has to decide on this.

After this open-ended part of the interview where the interviewee was free to talk about whatever he saw with regard to traceability, several areas were further discussed.

Customer Awareness

If a customer were to request for the application of traceability in a development project, the interviewee would first find out what exactly it is that he wants. He feels that there is no standard interpretation of the term traceability, so that would be his first task.

Sources of Influence

The following people could be involved with creating a project initiation document and could influence this part of the project:

- Project Manager
- Analyst
- IT-management people
- Architect
- Developers
- Executive
- Key users

The project manager is the person who actually writes the PID, it is his responsibility and his task to make sure he gets all the info required for this from the people mentioned above. It differs per situation whether or not he approaches these people.

Time Pressure

The interviewee feels that if there is anything that is cut off first when there is too little time or money available for a project it is documentation and quality issues.

Project Complexity

The interviewee feels that project complexity would not influence the adoption of traceability. The added risk of using new technology exists, but whether traceability would reduce other risks is something he is not sure of.

Development Method

Iterative methods, such as RUP, insure a better overview of what is happening then traditional development methods using a waterfall model, because the development is broken down into smaller pieces.

Project Life Expectancy

The longer a project lasts, the higher the chance of changes occurring and the higher the expected amount of changes for this system. On top of this, the risk of knowledge on the system disappearing with the disappearance of developers and maintainers is a lot higher.

Dynamics of the Environment

The interviewee feels that this factor is rather trivial, more changes in the environment of a system generally lead to more changes in the system, which would increase the added value of traceability.

Type of Contract & Stakeholder Preferences

In fixed price projects, the project manager would generally not adopt traceability, unless it is taken along in the contract, because of the added costs. Where projects are performed by project managers rented by the customer organization, he is very important in setting the budget for a project. If the project is taken on by a large IT supplier, it is the

'offertedesk' which is the important party with regard to setting the budget, and the project manager will often not be able to influence this.

A project manager is quite dependent on the budget, and especially its flexibility (type of contract, being able to change a fixed price, etc.) and in what way he and other stakeholders are held accountable for the end result. At his current employer there is actually a bonus for project managers when completing a project within the previously set budget.

Process flow

The interviewee does not feel that adopting traceability would make the process more complex, it would mainly create more work. Reviewing the quality of the created traceability is an issue he would be more worried about though.

Benefits outside Project Borders

The scope of a project manager is the project itself. Benefits achieved outside of the borders of the project is not what he is held accountable for and do not matter to him. This could be a very important hindrance for adopting traceability according to the interviewee.

Other

What the interviewee would like to see with regard to traceability is a feasibility study which one could apply in specific project plans. On top of that, he feels that it should be used as an "option" or "accessory" in quotations.

VII. Appendix VII: Influencing Roles

	Respondent A	Respondent B	Respondent C	Respondent D	Respondent E	Respondent F
1.	Project Manager	Project Manager	Project Manager	Project Manager	Project Manager	Project Manager
2.	Customer	Program Manager				Architect

Table 21 – Influences Identified by Different Respondents

	Informant A	Informant B	Informant C	Informant D	Informant E
1.	Project Manager	Project Manager	-	Project Manager	Project Manager
2.	Customer	Program Manager		Business Managers	Analyst
3.	Architect	IT Management Department		IT Management Department	IT Management Department
4.	Analyst	Analyst		Architect	Developer
5.		Quality Assurance		Interface Designer	Executive
6.		Developer		Developer	Key User
7.		Business Customer	-		Architect

Table 22 – Possible Influences Identified by Different Informants

VIII. *Appendix VIII: Ordina Software Factories*

Ordina has developed a software factory, to be able to develop software at a constant quality, at a predictable speed and which can be customized for each customer. To be able to develop software in this "factory", the processes have to be charted clearly. Figure 18 shows an overview of the application development and management services offered by IT Solutions at Ordina, which includes these software factories.
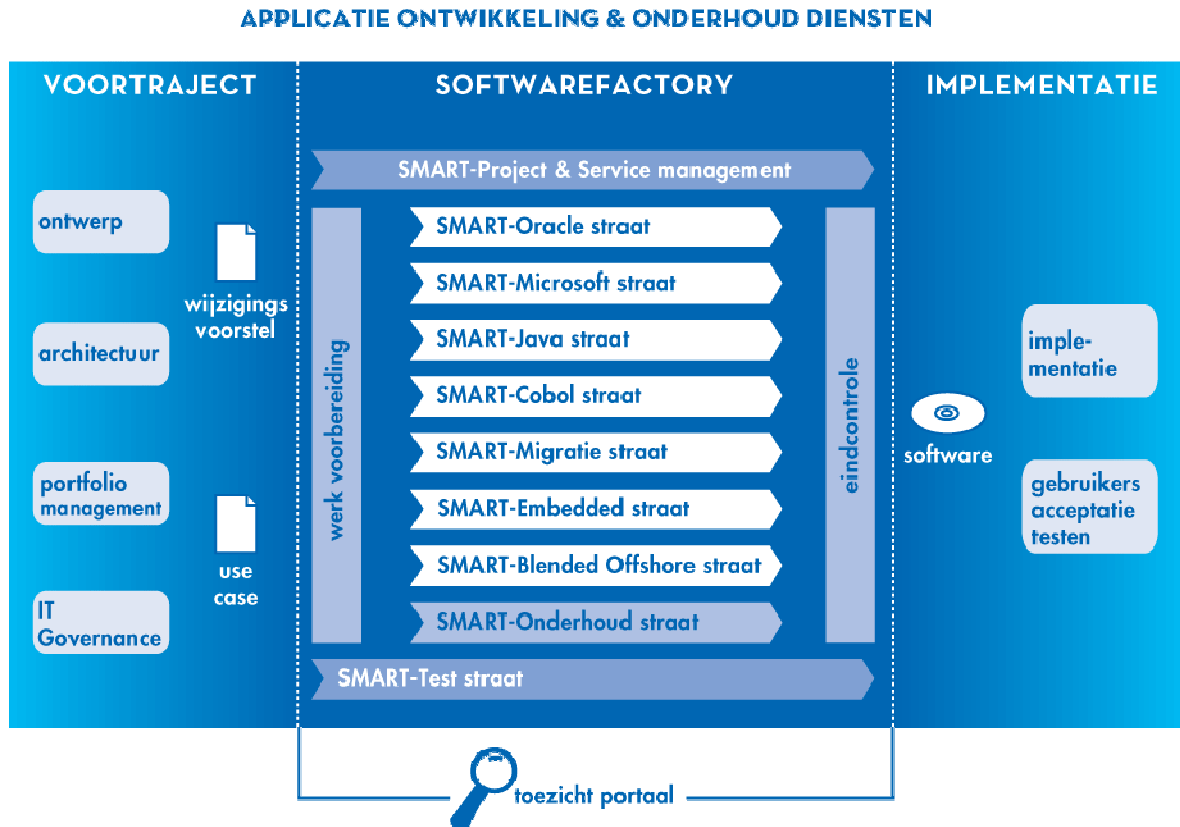
Figure 18 – Application Development and Management Services (Ordina N.V., 2006a)

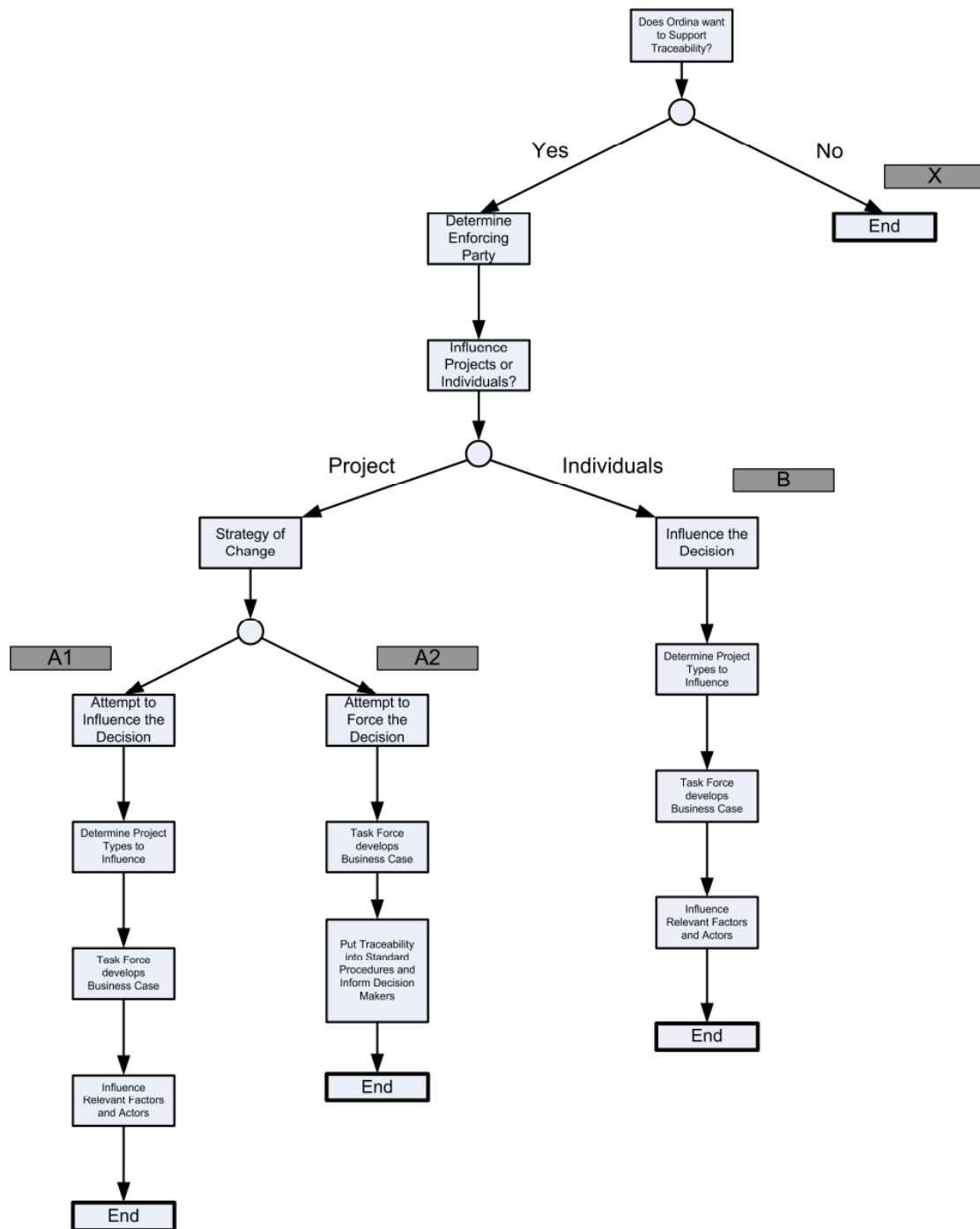## IX.   Appendix IX: Alternative Action Diagrams

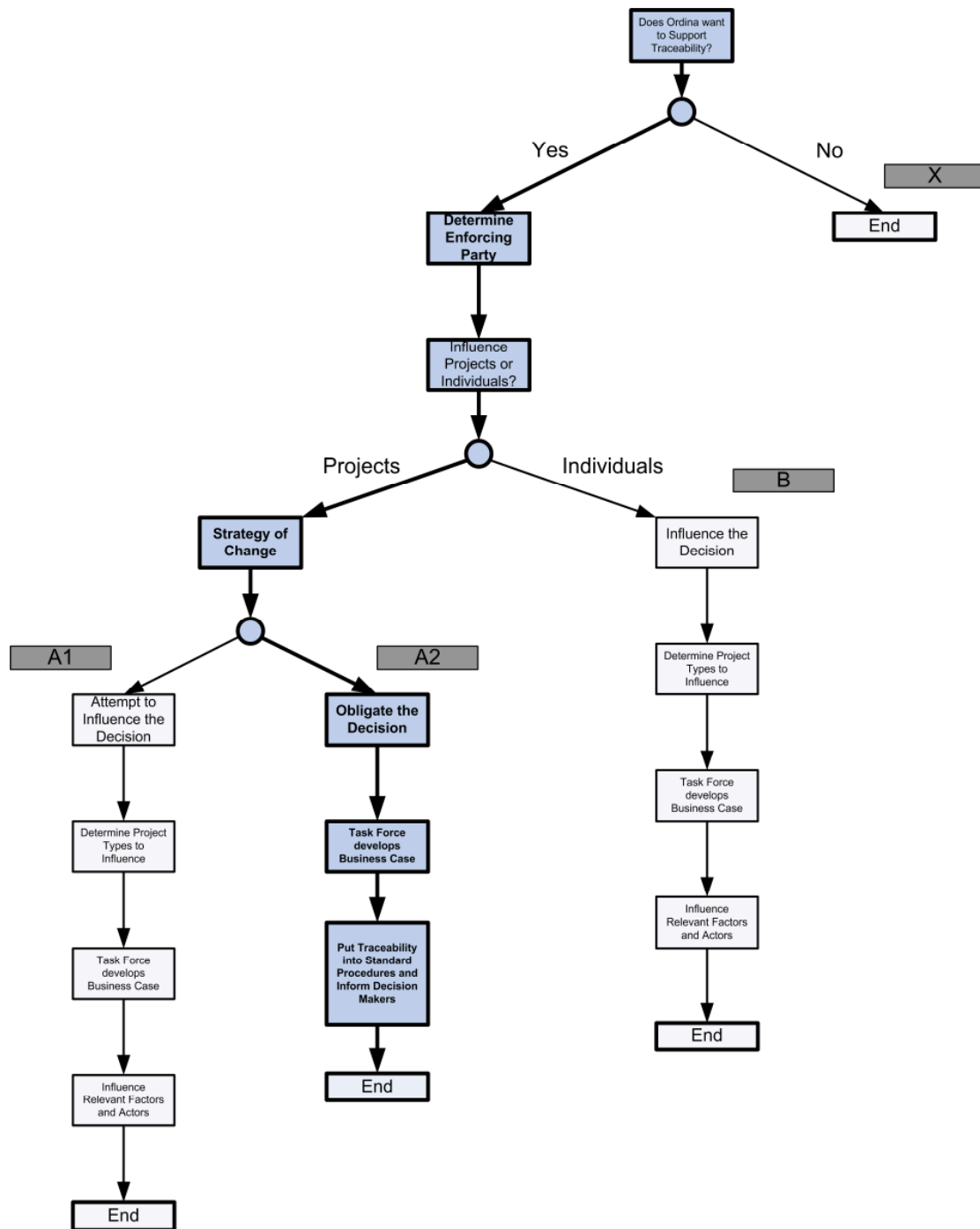**Figure 19 – Alternative Actions towards Improving the Adoption of Traceability**

Figure 20 – Recommended Actions towards Improving the Adoption of Traceability