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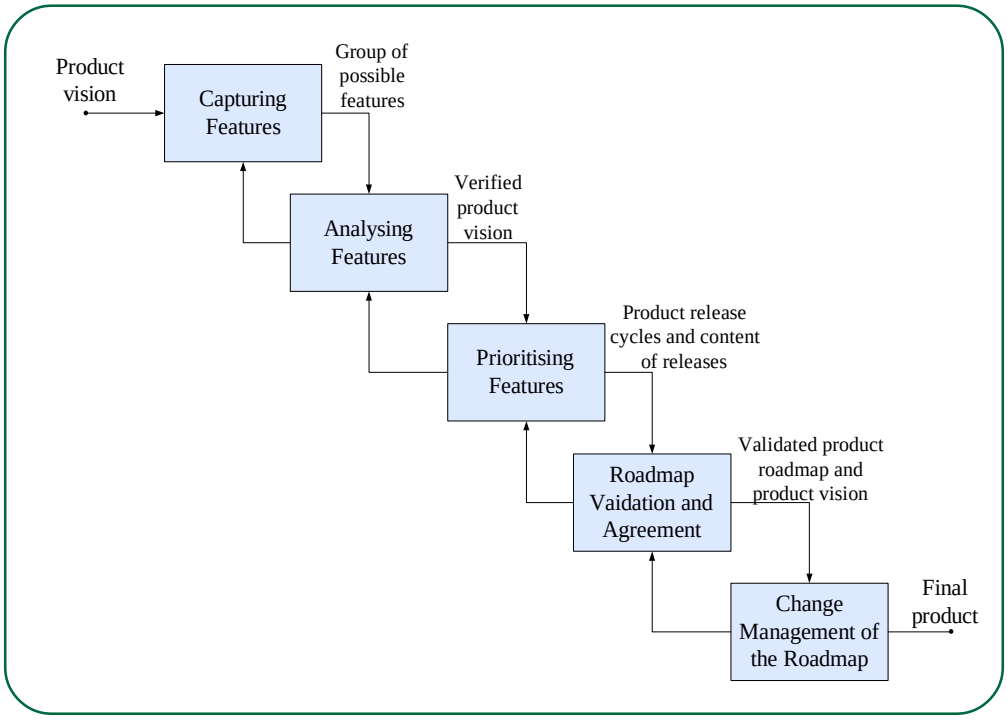

Tanja Kynkäänniemi

Product Roadmapping in Collaboration

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Keywords product roadmaps, product data, roadmapping process, requirements, priorisation, management, roadmap validation, collaboration

Abstract

Product roadmapping has not been widely examined, and particularly an inter-company collaboration perspective to product roadmapping is a fresh field of research. Therefore, the aim of this thesis is to research factors related to the product roadmapping process, and to give solutions to the problems that emerge when product roadmaps are created in collaboration. Hence, the research questions are divided into two groups. The first group of questions relates to general information about the product roadmapping process and the second group of questions relates to collaborations affecting product roadmapping.

The research questions are answered based on an extensive literature analysis and empirical studies. The empirical studies consist of multiple-case studies, in which the experiences of several companies are gathered and analysed to verify the research results. The empirical data is collected through questionnaire studies and semi-structured interviews. These data collection methods are chosen, since using questionnaire studies, the basic knowledge about product roadmapping in industry can be discovered, and by interviews, more in-depth knowledge about product roadmapping in collaboration can be revealed.

Based on the research results, the product roadmaps can be created totally, partly, or not at all together with the collaboration partners, depending on the product to be developed and the form of cooperation. Also, the results indicate that inter-company collaboration has effects on each phase of the product roadmapping process. For instance, there can be disagreements and misunderstandings between partners, and it can be more difficult to reach an agreement. Thus, continuous communication between partners is needed. The research results are applicable to companies that are involved in software product or service development. The research results are best applicable to larger companies with more than 250 employees.

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Avainsanat product roadmaps, product data, roadmapping process, requirements, priorisation, management, roadmap validation, collaboration

Tiivistelmä

Tuoteominaisuuksien julkistussuunnittelua (tuote roadmapping) ei ole kovin laajalti tutkittu, ja erityisesti yritysten välisen yhteistyön näkökulmasta se on uusi tutkimusala. Tämän opinnäytteen tarkoituksena on tutkia tekijöitä liittyen tuoteominaisuuksien julkistussuunnitteluprosessiin ja antaa ratkaisuja ongelmiin, joita ilmenee, kun tuotesuunnitelmia tehdään yhdessä yhteistyökumppaneiden kanssa. Tutkimuskysymykset on jaettu kahteen ryhmään. Ensimmäinen ryhmän kysymykset liittyvät yleiseen tietoon koskien tuoteominaisuuksien julkistussuunnittelemista ja toisen ryhmän kysymykset liittyvät yhteistyön vaikutuksiin tuotesuunnittelussa.

Tutkimuskysymyksiin vastataan laajan kirjallisuusanalyysin ja empiiristen tutkimuksien avulla. Empiiriset tutkimukset koostuvat monista tapaustutkimuksista, joissa lukuisten yrityksien kokemukset kootaan ja analysoidaan, jotta tutkimustulokset voidaan vahvistaa. Empiirinen aineisto on kerätty kyselytutkimuksien ja haastattelujen avulla. Nämä tiedonkeruumenetelmät on valittu siitä syystä, että kyselytutkimuksilla voidaan kerätä perustietämystä tuotesuunnittelemisesta teollisuudessa, ja haastattelujen avulla voidaan saada selville perusteellisempaa tietämystä tuotesuunnittelusta yritysten välisessä yhteistyössä.

Tutkimustulosten perusteella tuotesuunnitelmat voidaan tehdä kokonaan, osittain tai ei ollenkaan yhdessä yhteistyökumppaneiden kanssa, riippuen kehitettävästä tuotteesta ja yhteistyön muodosta. Lisäksi tutkimustulokset osoittavat, että yritysten välisellä yhteistyöllä on vaikutuksia jokaiseen tuoteominaisuuksien julkistussuunnitteluprosessin vaiheeseen. Esimerkiksi yhteistyökumppaneiden välillä voi olla erimielisyyksiä ja väärinkäsityksiä, ja sopimuksen tekeminen voi olla vaikeampaa. Täten jatkuvaa yhteydenpitoa tarvitaan yhteistyökumppaneiden välillä. Tutkimustulokset ovat sovellettavissa yrityksiin, jotka osallistuvat ohjelmistotuotteen tai -palvelun kehittämiseen. Parhaiten tutkimustulokset ovat sovellettavissa suurempiin yrityksiin, joissa on yli 250 työntekijää.

Preface

The research was conducted within VTT, Technical Research Center of Finland, Software Technologies Center, Product Development and Management Team. The research was a part of VTT's MERLIN project (VTT 2006). MERLIN is a three year Information Technology for European Advancement (ITEA) project (number 03010), comprising of industrial and research partners from three countries. The name stands for "Embedded Systems Engineering in Collaboration". The project aims at improving competitiveness and product quality in the European electronics industry by improving the quality of electronics products; providing technologies, and technological and methodological knowledge to establish competitive collaboration networks; and improving competitive collaboration in Europe by customizing, combining and validating state-of-the-art technologies (VTT 2006).

I would like to thank all the people who contributed to this master's thesis. First of all, I would like to thank my advisor Ms. Päivi Parviainen of VTT for her valuable guidance during the research. Similarly, I would like to thank my supervisor Professor Jouni Similä and my opponent Mr. Lasse Harjumaa from the University of Oulu for commenting this work. Also, I would like to thank my colleagues for their assistance. Furthermore, special thanks to my family and friends for their support and encouragement. Finally, I would like to thank my spouse, Lari Suomalainen, for his assistance, support, and above all his love.

In Oulu, Finland, 11th December, 2006

Tanja Kynkäänniemi

Contents

List of Abbreviations

AHP	Analytical Hierarchy Process
CCB	Change Control Board
COTS	Commercial Off-The-Shelf
CTO	Chief Technology Officer
QFD	Quality Function Deployment
RE	Requirements Engineering
ROI	Return on Investment
R&D	Research and Development
VTT	Technical Research Center of Finland

1. Introduction

Nowadays, the cost, complexity and rate of technology change are increasing, and competition and sources of technology are getting more global (Phaal et al. 2001). Therefore, companies are expected to be more responsive to technological change and to manage their technology assets more strategically (Kappel 2001). The business environment is characterized by ever-more-demanding customers, increasingly shorter product life cycles and fast developing technologies (Groenveld 1997). Additionally, the software product business is moving from custom-made solutions to ready designed and made solutions, i.e. off-the-shelf products, and consequently is facing new challenges. For instance, in market-driven requirements engineering (RE) wide markets, with a large customer base outside the company and more stakeholders within the company, are involved in product development. Thus, the future development steps of a product cannot be negotiated with just one or few customers anymore. The stakeholders need information about future product development in order to plan their activities and communicate with the customer. Hence, the demand for an overall view of the product and offerings has become important. (Lehtola et al. 2005.) Therefore, developing reliable and high quality software products on time and within a budget requires a well-coordinated and executed software process (Jiang & Coyner 2000). Product roadmapping is a promising technology to manage high-level view and to link aspects of business to RE. (Lehtola et al. 2005)

Roadmapping enables developments in technology to be mapped and linked to product evolution and market opportunities (Phaal et al. 2003a). Thus, roadmapping gives a strong awareness of how to serve important markets with the right products at the right time and to improve the cross-functional processes required for the creation of new products (Groenveld 1997). According to Phaal et al. (2004b), roadmapping is a flexible process. Hence Kappel (2001) suggests that it can be applied to different purposes, and at the same time roadmaps can address different aspects of a planning problem. From the product development point of view, product roadmapping enhances product creation process and enables early information about the products, such as which new products should be available and when (Groenveld 1997).

Several benefits can be gained when companies are using roadmapping. First, it is a simple process to present complicated issues. It focuses the discussion around specific steps of the process, enabling cross-functional understanding of complicated issues. It sensitizes those involved in the analysis to critical issues regarding alignment of technologies to meet needs, and enables faster and superior assessment of emerging technologies from the learning obtained in the roadmapping process. (McCarthy 2003.)

Additionally, product roadmapping supports the development, communication and implementation of products or product lines with a long-term view. For each product line, product roadmaps link market strategy to product plans. These roadmaps created at the product line level are the base for corporate planning, identifying needs, gaps, strengths and weaknesses, and a common language across the corporation or corporations. Roadmaps also help focus attention of the roadmapping team on future product generations, initiating longer-term planning. (Albright & Kappel 2003.) The roadmapping process improves communication and ownership of plans since it brings together people from different parts of the business, providing an opportunity for sharing information and perspectives (Albright & Kappel 2003; Phaal et al. 2001). Furthermore, the process helps to identify and focus strategy and product development on the few most important priorities at each step of the planning process. During the roadmapping, the team identifies gaps and actions to close the gaps, which may include a feature that must be included in the product to meet a high-priority customer or market need. (Albright & Kappel 2003.)

This thesis focuses on product roadmapping from the collaboration perspective. In this context roadmapping can be considered a process of creating a common view within a group about their future and what they want to achieve in that future (Probert & Radnor 2003). Therefore, from the collaboration point of view, roadmaps can be considered formal mechanisms for collecting data and sharing information in a partnering environment (McMillian 2003). A successful roadmap requires activities of learning and communication, which are also essential to co-operation (Albright 2003). During this learning and communication process, members of the roadmapping group can also discover gaps and new directions. Roadmapping also helps the group to communicate its vision and plan to customers, suppliers, partners, and other groups involved. (Probert & Radnor 2003.)

This research is important because most of the roadmapping research has been done from the perspective of the technology roadmapping. Very few surveys concentrate merely on product roadmapping, even though it is getting more general in product development organisations. Particularly, from the collaboration point of view product roadmapping has not been widely examined. However, product roadmapping in collaboration is a challenge that organisations are facing, since co-operation is a common way of developing software products. A roadmap can help to select the collaboration partners, since with a roadmap it can be better estimated, for instance, what kind of knowledge is needed from outside the organisation. Thus, organisations can concentrate on their core competencies and develop products faster and better. Through collaboration, organisations gain competitiveness in the markets, and advantages compared to competitors. Furthermore, with product roadmapping organisations can deliver the right products to the right markets at the right time.

1.1 Research Problem

The purpose of this study is to conduct research on the factors related to product roadmapping process. These factors include requirements management, validation of the product roadmap, and achieving mutual understanding between partners. Moreover, the research aims at giving solutions to the problems that emerge when creating product roadmaps in collaboration. The study is done in the form of a literature review and an empirical study. The literature relating to product roadmapping was searched from the databases presented in Appendix 1. The appendix also includes the main research terms used during the literature review. The literature review mainly consists of scientific journals and conference proceedings of the field of the study. The empirical part is carried out as multiple-case studies in software development organisations that have created product roadmaps together with collaboration partners. To achieve the goals of the research, the following research problems have been set for this study:

1. What is product roadmapping in theory and in practice?

    a. What is the product roadmapping process (participants, roles, phases, etc.)?

    b. What are the most common requirements prioritisation methods in product roadmapping?

2. How collaboration affects product roadmapping?

   a. What are the relevant modes of collaboration?
   b. What are the most important activities in roadmapping in the collaboration situation?
   c. How is a product roadmap created together with collaboration partners?
   d. How do the requirements prioritisation methods support collaboration?
   e. What are the problems of collaborative roadmapping in industry and are there solutions to these problems?

These research questions are answered based on an extensive literature analysis (in Chapters 2–4) and on empirical studies (in Chapters 5–6). The first group of questions is mainly answered based on the literature analysis, but also additional information is retrieved from the empirical studies relating to the product roadmapping process and requirements prioritisation methods. Likewise, the second group of questions is first answered based on the literature, but as noted during the literature analysis, these issues are not yet widely examined. Thus, in particular, deficiencies, gaps, and open questions found during the literature analysis are explained in the empirical part. Therefore, some of the questions can first be answered based on both literature and secondly based on empirical case studies.

1.2 Scope of the Research

This research concentrates on product roadmapping in collaboration. The focus is on product roadmapping and on product roadmaps. The main intention with this research is to give guidelines to the problems that relate to creating product roadmaps in a collaborating environment. Thus, other roadmapping domains, such as science roadmaps, industry roadmaps, and technology roadmaps, are left outside the research subject. However, these terms are defined in the thesis.

The research problems presented earlier are analysed based on the literature review and empirical studies. The data gathering method can be called empirical study, because it consists of raw data, and intermediate and final structures, and calculations, which are derived from the raw data (Järvinen 2001). The aim of

the research is to solve problems relating to product roadmapping in collaboration networks. The main problems and possible solutions relating to this specific area of research are gathered by questionnaire studies in companies that are expected to have experience from product roadmapping. Thereafter, the research is continued with interviews with persons who have particular experience from product roadmapping in inter-company collaboration. The interviews are semi-structured because then they can have the characteristics of both structured interviews and unstructured interviews (Järvinen & Järvinen 2000). Even then, the semi-structured interviews are neither free discussion nor a very structured questioning. The interviews are carried through following an interview guide, which focuses on certain themes rather than exact questions. (Järvinen 2001.) Thereafter, the collected data of the case study is analysed and conclusions are made. The conclusions are discussed last in this thesis.

1.3 Structure of the Thesis

The structure of this thesis in general is as follows: introduction, theory, empirical setting, empirical research, and conclusions. The theory is divided into three parts, which are roadmapping, collaborative development, and requirements prioritisation. Given this state of art of research in product roadmapping in a collaboration concept, Chapters 2–4 reveal what the relevant issues to be studied in an empirical setting are. Thereafter, Chapter 5 illustrates how these issues should be studied empirically. Additionally, it includes the design of an empirical research. The empirical results of the research are presented in Chapter 6. This chapter also includes discussion and summary of the main findings of the questionnaire and interview studies. Finally, the conclusion part contains answers to the research questions. Also, achievements and limitations of the study, and future research opportunities are discussed and identified in the conclusion part.

2. Roadmapping

In this chapter, the meaning of roadmapping is explained by introducing some of the main surveys on the field of research. A roadmapping taxonomy is introduced to show that roadmapping can be applied to several research areas. In addition, the roadmapping form is presented to illustrate how roadmaps are typically formed, and how information in the roadmaps can include several layers of knowledge. Thereafter, the product roadmapping process according to the literature is presented by identifying the main phases of the process, and persons involved in the process as well as their role during the process. At the end of this chapter, product roadmapping process and its participants according to this thesis are described.

2.1 Introduction to Roadmapping

In general, a roadmap is a layout of existing routes or paths. The roadmaps are used to decide among alternative routes or paths towards a desired destination. (Kostoff & Schaller 2001.) According to DeGregorio (2000) a roadmap is a visualisation of a forecast, which can be in a number of key areas, such as technology, capability, platform, system, environment, threat and business opportunity. According to Kappel (2001), roadmaps are also forecasts of what is possible or likely to happen, and plans that express a course of action. Furthermore, roadmaps are intended to be living documents, therefore they should be reviewed and updated over time, otherwise they are not useful (Albright 2003). However, modifications to the roadmaps should be done carefully and in a controlled way, not just for the sake of doing the changes.

Roadmapping describes the process of creating and revising roadmaps (Kostoff & Schaller 2001). Moreover, roadmapping is thought to be a strategic planning and forecasting process with long-lasting future activities (Kappel 2001). In addition, roadmapping can be considered a decision-making and design process (Li & Kameoka 2003).

In a roadmap, the product is represented as product releases containing several product features. Wiegers (2003) defines a product feature as a set of logically

related requirements that provide a capability to the user and enable the satisfaction of business objective. Instead, a requirement is a statement of a customer need or objective. A requirement can also be a condition, which a product must meet to satisfy such a need or objective. In other words, a requirement is a property that a product must have to provide value to a stakeholder. (Wiegers 2003.)

Roadmaps can be expressed in various forms (Kameoka et al. 2003) or with different taxonomies. Even though the roadmaps may take various forms or taxonomies, they all should answer a common set of "why-what-how-when" questions (Phaal et al. 2005) that generally relate to markets, products, and technologies. However, as Phaal et al. (2004c) emphasise, the form of the roadmap should be tailored to the specific needs of the company and its business context. This thesis focuses on the following definitions of roadmapping:

- The roadmaps are divided into a taxonomy consisting of science or technology roadmaps, industry roadmaps, product-technology roadmaps, and product roadmaps (Kappel 2001).
- Roadmaps commonly take a form of a multi-layered time based chart that includes different layers of knowledge that relate to purposes, deliveries and resources (Phaal et al. 2005).

These definitions were chosen, because they are most commonly used and referenced based on the literature analysis. Also, they give a well-defined view of the roadmapping. Furthermore, both of these definitions depict roadmaps for different purposes in an organisation.

2.2 Roadmapping Taxonomy

There are several classifications for roadmapping, which Kappel (2001) attempts to address with a roadmapping taxonomy consisting of four elements. These elements and their place in the taxonomy are illustrated in Figure 1. The roadmapping taxonomy comprises of distinct roadmaps that are science or technology roadmaps, industry roadmaps, product-technology roadmaps, and product roadmaps. The taxonomy is presented in a chart, which includes both

the horizontal and the vertical axis. The horizontal axis describes the roadmapping purpose on the industry level or on the company level, and the vertical axis describes the content emphasis of the roadmap either on specific trends or on positioning within an industry. (Kappel 2001.)

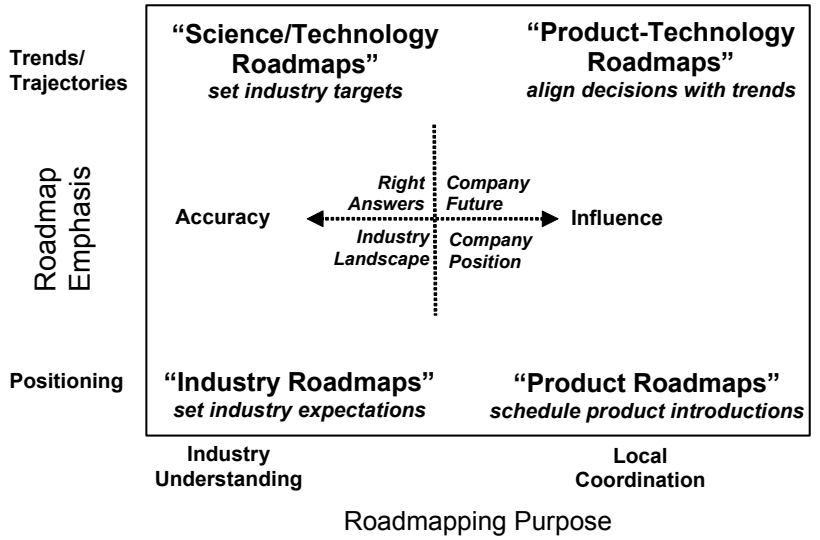

Figure 1. Roadmapping Taxonomy presented by Kappel (2001).

The purpose of the science or technology roadmaps is to set industry targets and understand the future by identifying trends and making accurate forecasts. The industry roadmap is a combination of technology forecasts and industrial matters. Thus, the purpose of the industry roadmap is to set industry expectations that express for example a technical thrust and a competitive environment. The product-technology roadmap is a combination of specific product plans with technology trends and marketplace. The purpose of the product-technology roadmaps is to align product and technology generations together. On the other hand, the product roadmaps schedule product introductions, such as a direction and schedule for product evolution, which are then communicated with customer and internal audience. (Kappel 2001.)

This thesis focuses on product roadmapping, hence the difference between product, technology, and product-technology roadmapping should be known. First, it can be noticed that the appearance of these roadmaps is different because they illustrate different matters. For instance, as Albright and Kappel (2003)

present, the product roadmap depicts the evolution of the product family over time, and a technology roadmap depicts the critical technologies that are organized by the customer and market priorities. Instead, the product-technology roadmap combines product and technology knowledge but it also depicts the market perspective. This is the plan on how to use technology to be different from the competitors, in a process of time, and with means that matter to the target markets. (Albright & Kappel 2003.)

2.3 Roadmapping Form

Phaal et al. (2000) suggest that roadmaps commonly take a form of a multi-layered time based chart that includes different layers of knowledge. Figure 2 represents the layers of knowledge and their associations to each other within a timeline. In the multi-layered time based chart, time is presented on the horizontal axis, and the several layers and sub-layers are presented on the vertical axis. The temporal dimension of the roadmap is one of the most important features of the method, because it enables mapping and linking of time-based knowledge. In addition, the different layers of the roadmap are designed to meet the needs of specific roadmapping activity. (Phaal et al. 2003a; Phaal et al. 2005.)

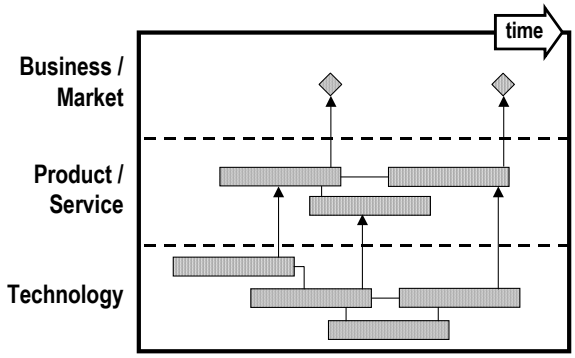

Figure 2. Multi-layered Time Based Chart suggested by Phaal et al. (2000).

In the multi-layered roadmap, the top layer presents the overall desired purpose or goals associated with the roadmapping activity. It includes both internal and external market and industry trends and drivers. In other words, it presents the

"know-why" -dimension of the roadmap. The middle layer presents mechanisms through which the purpose or the goals are achieved. This layer presents the "know-what" -dimension of the roadmap, which includes products, services and operations, etc. that are directly linked to the revenue generation. The bottom layer presents resources including technology, skills and competencies, etc. that are needed in developing the delivery mechanisms described in the middle layer. The bottom layer presents the "know-how" -dimension of the roadmap. (Phaal et al. 2003a; Phaal et al. 2005.)

According to Phaal et al. (2004b), there are also three additional dimensions to the multi-layered roadmap: "know-when" which is related to the time axis of the roadmap, and "know-who" and "know-where", which are typically included in the content of the roadmap. Moreover Phaal et al. (2004c) describe that in addition to the time based information, also other information can be stored in the roadmap. For instance, the roadmap can include linkages between objects on different layers, as well as include supplementary information, such as statement of business strategy or market drivers, or people involved in the creation of the roadmap.

The multi-layered roadmap can be constructed from a market-pull or from a technology-push perspective. From the market point of view (market-pull), a roadmap should begin with defining the most important requirements of the marketplace and customers. This perspective includes defining product development in the process of time and defining the required technologies for these products. From the technology viewpoint (technology-push), a roadmap should begin with defining the key or new technologies and their market needs. This perspective describes how technology is going to affect the functionality of the product. (Albright 2003; Groenveld 1997.)

2.4 Product Roadmapping Process

In this context, a roadmap provides a forecast of product family evolution over time. The product roadmap views the whole platform or relationships between the products in a platform. (Albright & Kappel 2003) Product roadmaps are typically developed iteratively. This iterative process involves periodic review and improvement of the roadmap based on human interaction such as face-to-

face meetings and workshops. Product roadmaps can be considered knowledge management tools that can be characterised with the following elements: structural and contextual information, dynamic dimensions, and action-oriented purpose. (Phaal et al. 2005.) Typically, product roadmaps are owned by the business owner of the product, who is also responsible for gathering all relevant stakeholders to obtain the needed information for the roadmaps. Product roadmaps are generated within the scope of two to three years, during which the roadmaps are revised frequently so that the documents are always current. (Lehtola et al. 2005; Tabrizi & Walleigh 1997)

The way in which features are documented into roadmaps is an important part of the process. Accurate documentation ensures that the roadmaps can be read, analysed, redrawn, and validated. (Nuseibeh & Easterbrook 2000) The information in the product roadmaps incrementally describes how the product and its business environment changes yearly. The fields in the product roadmap define the high-level functionality of the product and target customer group. The high-level product functionality is a description of forthcoming releases with basic mandatory information. The mandatory information includes the release goal and high-level features for each release. In addition, release time, localisation, platforms, and dropped topics, e.g. features that are not supported in the subsequent versions of the product, are recorded. Additionally, the fields include information about positioning, market arguments, and geographical focus of the product for every year. The information is represented with a few bullet points for each issue. (Lehtola et al. 2005.)

The roadmapping process focuses on sharing of perspectives, involving interaction between people, leading to communication, new understanding, insights, creativity and learning (Phaal et al. 2005). However, the roadmapping process is different between companies (Groenveld 1997; Phaal et al. 2004c). According to Groenveld (1997), this is because companies serve different markets and have different cultures. Instead, according to Phaal et al. (2004c), the roadmapping process that is the most suitable for a company depends on many factors. For instance, it depends on the level of available resources such as people and time, issues to be addressed, such as purpose and scope, available information such as market and technology, and other relevant processes and management methods, such as new product development, project management and market research.

Albright and Kappel (2003) define the roadmapping process in a concise way. The process includes initiation, maintenance, and restarts, if required. The roadmapping process according to Phaal et al. (2003a) comprises three phases, which are planning, facilitated roadmapping workshops, and implementation. Additionally, Lehtola et al. (2005) suggest a roadmapping process a little bit similar to Phaal et al. (2003a), but this product roadmapping process consists of preparation, approval, and communication phases. McCarthy (2003) adds two more phases to the roadmapping process, thus the process consists of team formation, focus, analysis, implementation, and review. Moreover, Vähäniitty et al. (2002) propose a four-step model for creating and updating product roadmaps especially. The steps in the model should be performed periodically to adjust the roadmap to new information and changing market situations. Smaller updates to the roadmaps should be done to ensure that they always hold present information. (Vähäniitty et al. 2002)

If the roadmapping process is different in each company, as Phaal et al. (2004c) present, the empirical research is needed. The purpose of the empirical study is to find out how product roadmapping is conducted in the case companies, and what kind of methods and practises are used during the different phases of product roadmapping process. Since there can be several different phases, the empirical research should also reveal how the roadmapping process begins as well as what are the most important phases of product roadmapping and thereafter, what the most difficult phases are. The aim of the empirical study is also to reveal whether the company's size affects the roadmapping process. In addition, the intention is to find more information about benefits and problems relating to product roadmapping as well as how these problems are solved in the case companies.

As a synthesis, in this thesis, the product roadmapping process has these phases: capturing features, analysing features, prioritising features, roadmap validation and agreement, and change management of the roadmap. Subsequently, participants of the roadmapping process are presented, and thereafter, the phases according to this thesis are introduced in more detail based on the literature.

2.4.1 Participants of the Roadmapping Process

Tabrizi and Walleigh (1997) suggest that product roadmaps are created by senior management who are also responsible for updating the roadmaps. However, this is not the commonly used approach. Instead, generally the roadmapping process gathers together the stakeholders from different functions of the organisation or from different organisations, as for example Lehtola et al. (2005), and Li and Kameoka (2003) suggest. Thereafter, a roadmapping team is formed of the gathered stakeholders. The team shares information and perspectives to make decisions that are then presented in a roadmap (Lehtola et al. 2005). Although Lehtola et al. (2005) support this approach, they do not define in detail who the participants are, and what their role in the roadmapping process is. Nevertheless, in their research they found that according to project managers in the case companies the most important stakeholder groups to which the contents of the roadmaps should be communicated and with which they should be negotiated were the product management, sales and channel partners, and customers. The product developers were not seen as an important stakeholder group in the roadmapping process, but they were considered important in estimating the costs of future requirements. (Lehtola et al. 2005.)

According to McCarthy (2003), only the roadmapping team participates in the roadmapping process, but support from management is needed regarding personnel and budget investments. The team should be formed at the beginning of the roadmapping process, including the research and development (R&D) and technology management personnel, members from the business development, representatives from the finance, and core staff members from the functions. The first task of the team is to establish a common understanding of the process and the terminology to be used. After that, the team should begin to develop a detailed analysis of the process, and to decide factors and metrics required for the process evaluation. The roadmapping team is also responsible for analysing the required technologies as well as implementing and reviewing the roadmaps. (McCarthy 2003.)

On the other hand, Groenveld (1997) proposes that the roadmapping process should be started with a small roadmapping team in which the marketing, product management, research, development, and engineering participate. Later, the team looks for a leader who should become the owner when the roadmaps

have been drafted. The owner is then responsible for the maintenance of the roadmaps. The owner also initiates appropriate updating actions and provides additional information when needed. Afterwards, the roadmapping team guides the process. Workshops are organised to ensure integral involvement of the organisation and input by the organization. (Groenveld 1997.)

According Phaal et al. (2003a), a multifunctional team is needed in the roadmapping process to create the roadmaps. This team should have both commercial and technical perspectives, such as research, development, manufacturing, marketing, and finance (Phaal et al. 2000). In addition, Phaal et al. (2003a) believe that both the business owner and the process owner should participate in the roadmapping process. The owners should be involved in the planning phase and, thereafter, throughout the roadmapping process. The business owner is responsible for the business outcome of the process, and the process owner is responsible for the implementation of the roadmapping. (Phaal et al. 2003a; Wells et al. 2004) The owner is also responsible for selecting the persons to the roadmapping team, solving issues regarding the application, and having knowledge about the roadmapping domain (Phaal et al. 2003a). In addition, a facilitator might be needed in managing and facilitating the roadmapping process. (Phaal et al. 2003a; Wells et al. 2004) During the different phases of the roadmapping, a facilitator supports and guides the roadmapping team (Albright 2002). Moreover, according to Albright and Kappel (2003), facilitators have active roles in appropriately scoping the roadmap, forming the team, setting up a work plan, and assessing individuals with their tasks in the larger effort. The facilitator should also challenge assumptions and force rigour into the roadmap (Albright & Kappel 2003).

Instead, Albright (2002) suggests that the roadmapping process is best performed as a cross-functional team led by an experienced facilitator. Through the whole process, the facilitator steers the team towards a realistic plan. The cross-functional team includes many functions that contribute to the success of a product line or business: central and regional marketing, product management, R&D, manufacturing, services, etc. The purpose of the roadmapping team is to lay out a possible future or multiple futures, set objectives, and define a plan to achieve the objectives, as well as make sure that the required capabilities and technologies are available at the right times. (Albright 2002.) Moreover, according to Rautiainen et al. (2003), the roadmapping should be done by the

management team of the company and the team of the most important stakeholders of the product, called the sprint board. The sprint board includes the head of the product team, the product manager, the R&D team leader and the head of the professional services. The sprint board is responsible for preparing the issues for the management team, which then makes the final decisions. Additionally, customers and partners should participate by providing and evaluating ideas for future product releases. (Rautiainen et al. 2003.)

Table 1 provides a summary of the participants of the product roadmapping process presented by different authors.

Table 1. Summary of the Roadmapping Process Participants.

	Tabrizi and Walleigh	**Lehtola et al.**	**McCarthy**	**Groenveld**	**Phaal et al.**	**Albright**	**Rautiainen et al.**
Senior Management	X						X
Product Management		X		X		X	X
Sales and Channel Partners		X					
Customers		X					X
Representatives of R&D			X	X	X	X	X
Technology Management			X				
Representatives of Business Development			X				
Representatives of Finance			X		X		
Representatives of Marketing				X	X	X	
Representatives of Engineering				X			
Representatives of Manufacturing					X	X	
Representatives of Services						X	X

Since there are several theories about product roadmapping participants, the empirical research is needed. The purpose of the empirical research is to clarify these different viewpoints. Thus, the intention is to find the main roles in the roadmapping process, and to reveal who should participate in the roadmapping process. Additionally, it should be disclosed how many persons should participate in roadmapping process and discovered whether the company's size affects the number of participants in the process.

2.4.2 Capturing Features into Roadmaps

According to Vähäniitty et al. (2002), product roadmapping process starts with defining or revising, and then analysing the strategic mission and vision of the company. The purpose is to clarify and communicate the company's area of business. This is because all companies should have an idea of their purpose and desired future sufficiently clear to be written down before their operations are planned in more detail. The company's mission and vision acts as a guideline for shaping the product vision and choosing between strategic alternatives. Thereafter, major trends in the business environment, such as potential customers, competitors, the industry and developments in relevant technology, are observed and identified. The purpose is to create understanding of the desired focus and position of the company and its products, as well as examine and guide the selection of technology. (Vähäniitty et al. 2002.)

According to Nuseibeh and Easterbrook (2000), capturing or eliciting of product features is regarded as the first step in the roadmapping process. When capturing features, gathered information often needs to be interpreted, analysed, modelled and validated to be sure that a sufficiently complete set of features of a product have been collected. Thus, capturing features closely relates to other roadmapping activities. (Nuseibeh & Easterbrook 2000.)

One of the most important activities in the capturing features phase is to find the problems that need to be solved, and hence identifying the product boundaries. The boundaries define, on a high level, where the final delivered product will fit into, e.g. target markets and potential customers. Identifying and agreeing on the product's boundaries affect all following feature-capturing activities. Therefore, the identification of stakeholders, user classes, goals, tasks, scenarios, etc. all

depend on how boundaries are chosen. The identified stakeholders are persons or companies who stand to gain or lose from the success or failure of the product. Usually, the stakeholders include customers or clients, developers, and users, for instance. (Nuseibeh & Easterbrook 2000.) In addition, goals should be captured early in the product roadmapping process. The goals should denote the objectives a product must meet, and focus on the needs of the stakeholders. (Nuseibeh & Easterbrook 2000) Thereafter, the product features can be identified and gathered by communicating with all stakeholders (Parviainen et al. 2003).

There are several methods, which can be used during the feature capturing process. These methods include contextual inquiry, observation, prototyping, and scenarios. (Parviainen et al. 2003) However, based on the literature, features are captured into product roadmaps by using, for example, group elicitation techniques. For instance Nuseibeh and Easterbrook (2000) suggest that these techniques aim at improving the stakeholder agreement and buy-in, while exploiting the roadmapping team dynamics to elicit a richer understanding of needs. According to Phaal et al. (2003a), the group elicitation technique includes a workshop or series of workshops which bring together a range of expertise, supporting the rapid capture, structuring and sharing of knowledge, together with simulating and brainstorming participation. During the workshop, all ideas for features in a product are collected in a roadmap template, which is also called product backlog or product feature document. The document provides a systematic way to collect feature suggestions continuously from all participants and stakeholders. (Phaal et al. 2003a; Rautiainen et al. 2003) There are also other techniques used in capturing features into roadmaps, such as market research, interviews, surveys and analysis (Phaal et al. 2003a). This is because product roadmaps require a good understanding of the markets and application in order to define the products in terms of customer needs (Groenveld 1997).

In the capturing features phase, the companies can collect features from several sources that are preferred for the product. Parviainen et al. (2003) propose the following sources that can be used as inputs for this phase: business requirements, customer requirements, user requirements, constraints, in-house ideas and standards. In addition to these perspectives, according to Albright & Kappel (2003), the roadmapping team can define a market section which includes an analysis of competitors, a market research, and a product evaluation.

In some companies, user requirements are preferred. Thus, the product features are collected with end user and customer inquiries to find out what the target customers really want and need. Then, the user requirements are analysed within the context of business requirements, such as cost-effectiveness, organisational and political requirements (Parviainen et al. 2003). On the other hand, for some companies standards are important. Thus, the standards have to be taken into account from the beginning of the product planning so that the product can be developed accordingly.

Instead, as Albright and Kappel (2003) explain, in the competitor analysis, competitive intelligence, meaning both today's and tomorrow's competitors, is examined. Typically, the few selected competitors address the same market space. The analysis presents the key competitors' products, market share, strengths and weaknesses, competitive strategy for this market, and competitive response. Most of all, the purpose of the analysis is to understand each competitor's strategy, because their competitive strategy suggests future competitive targets. The purpose of the market research is to define growth opportunities and growth targets. These market trends can be revealed with careful market segmentation. The segments are grouped according to customers who have similar needs and benefits. The segments must be meaningfully different to their buying priorities and product features that a clean set of product priorities can ensue. Other views of the market trends to be examined are the competitors' share of the market over time and the product share of the market over time. The product evaluation includes approaches, such as analysing the buying priorities and using an experience curve to offer a long-term forecast of industry pricing and cost targets. The buying priorities imply a set of key product metrics that customers value in their purchase decisions and which are the basis of the product competition. Through these product drivers, the competitors' relative products can be evaluated in the marketplace. By identifying and plotting the product drivers, the roadmapping team can set internal development targets that R&D requires and customers are often unable to see. (Albright & Kappel 2003.)

2.4.3 Analysing Features

When the product features have been collected, the roadmapping team should begin to analyse the collected features. There are several methods that can be used during the feature analysis, for example knowledge-based critiquing (Fickas & Nagarajan 1988), and feature-oriented approach to model requirement dependencies (Zhang et al. 2005). The purpose of the analysis is to remove uncertainty, identify and resolve conflicts as well as to analyse the feasibility of the gathered features, and make resource and cost estimation (Soffer et al. 2005). Also, the purpose is to reveal dependencies between the requirements. Thus, the team should decide the methods required to evaluate the features.

Other issues to be considered in analysing the features are predictability of outcome, internal competencies in the organisation, and opportunities for technology improvement. (McCarthy 2003) Also, according to Vähäniitty et al. (2002), the company's internal factors, such as human and financial resources, competencies and infrastructure, should be taken into account when analysing the features. Furthermore, there might be some factors restricting or improving the product features. For example, in the development of the mobile phone, the amount of the memory affects the features that are going to be included in the phone. This is because the memory might not be sufficient to implement all the presented features. Therefore, in the analysing phase, it should be analysed which features can be included in the phone and which have to be excluded. On the other hand, new technologies and development methods, unavailable earlier, can improve the product development; thus, also these possibilities should be analysed.

Thereafter, the gathered features and capabilities should be mapped into groups (Phaal et al. 2003a). According to Albright (2002), the features should be grouped by the product drivers that the features most strongly affect. Instead, according to Phaal et al. (2003b), the features should be first grouped, and then the groups should be arranged in terms of impact on the market and business drives defined in the earlier phase.

The feature grouping is followed by feedback and discussion to identify synergies and gaps. The purpose of this practice is to ensure that all layers of the roadmap have been considered. (Phaal et al. 2003a.) If gaps are found, the team

should take actions to close the gaps, e.g. by filling them with new product features. The gaps may also include a key technology that must be included in the product to meet a high-priority customer and market need. Hence, it should be estimated whether to develop or acquire the needed key technology. (Albright & Kappel 2003.) Also, in this phase, the impact on market and the business drivers of the gathered product features are assessed (Holmes et al. 2004), and alternative product strategies are considered (Phaal et al. 2003b). Based on the feature analysis, the product vision is revised and captured as product roadmaps (Vähäniitty et al. 2002).

2.4.4 Prioritising Features

Prioritising features is difficult and time-consuming, since features are related to each other. Therefore, it is complicated to schedule features based on priority only. Hence, at this point interdependencies between features should be explored, identified, and managed. (Carlshamre et al. 2001.) In product roadmapping, the product features should be prioritised so that the most important features are implemented first and the less important features are left until later, and the least important features are most likely to be omitted if the schedule or budget is not sufficient (Greer & Ruhe 2004).

According to Albright and Kappel (2003), the most important goal of roadmapping is to identify and focus strategy and product development on the few most important elements for success. Therefore, the roadmapping team should try to define two or three most important drivers, elements or issues. That is, identifying the highest priorities. (Albright & Kappel 2003.) To achieve the main objectives, the team can define an action plan of a roadmap. The action plan identifies the highest priority features, and leads the team to schedule, budget, and staff them to accomplish the goals. With the action plan, the team can make sure that all feature gaps are closed. (Albright 2002.)

There are different tools to be used during prioritisation, e.g. Release Planner® (Release Planner 2004) that facilitates prioritisation. To be exact, Release Planner® is a web-based system solution that enables planning, priority and roadmapping decisions. In addition, features can be prioritised by using informal and formal prioritisation methods.

From the informal prioritisation method viewpoint, for example, Blotner (2004) suggests that initial feature prioritisation is done by the roadmapping team only using the identity information. This means that each feature is presented and input from all team members is expressed. Then the team attempts to agree on a spot for the product feature in the feature priority list. If consensus cannot be reached, the project manager either makes the final decision concerning the prioritisation or gathers enough information for the team to come to a consensus. (Blotner 2004.) Also, according to Phaal et al. (2003a), the roadmapping team conducts the prioritisation of the product features. The prioritisation of features is based on preparing an outline communication roadmap so that the priorities can be identified through feedback and discussion in a workshop session (Phaal et al. 2003a).

There are also theories that support the fact that formal feature prioritisation methods are used during product roadmapping. For instance, Phaal et al. (2003b) refer to Quality Function Deployment (QFD) (Griffin & Hauser 1993) as an often used method for supporting product design in product roadmapping. Also, according to Groenveld (1997), the roadmapping process is quite frequently supported by methods such as QFD, because it is a customer-oriented approach that guides the roadmapping team at the beginning of product roadmapping process. Typically, QFD is used because it is similar to roadmapping; they both require multidisciplinary communication and decision-making. QFD also helps to focus on the market requirements and translate these requirements into appropriate product characteristics, which facilitates feature prioritisation and, in consequence, product roadmapping. (Groenveld 1997.) According to McCarthy (2003), the simplest way to use QFD is to develop a matrix in which the product needs are listed on the left side of the matrix and along the top are listed the features used to address these needs. The degree of alignment is rated pertaining to how well the feature meets the needs. (McCarthy 2003.) QFD is described in more detail in Chapter 4.

After prioritising the features, when the relative priority of each feature is established, the product roadmap construction should start from defining the major and minor release cycles (Wiegers 2003; Vähäniitty et al. 2002). The construction should be continued with defining the business features and expectations for the upcoming releases. When business features and their objectives are included in the feature repository and their history is traced, the

rationale behind the roadmap evolution will become visible. (Vähäniitty et al. 2002.) With feature prioritisation, the construction of the product can be planned to provide the highest value at the lowest cost. However, even the low priority features should be documented, because their priority might change later and knowing them will help developers to plan future enhancements. (Wiegers 2003.) The prioritisation is also important if features are dropped in case they cannot be finished in time for the release (Rautiainen et al. 2002).

2.4.5 Roadmap Validation and Agreement

In the roadmap validation and agreement phase the planned product life cycle is estimated and the mix of development efforts is evaluated. The purpose is to check the financial rationale and assess whether the planned development is compliant with the product and company vision. (Vähäniitty et al. 2002.) Also, missing features and inconsistencies are discovered (Grynberg & Goldin 2003). At the same time, the content of the roadmap and its key messages are considered, and the gathered data is validated with internal expert information (Wells et al. 2004). Thus, the roadmapping team should review the product roadmaps to determine whether the goals of the roadmapping effort have been met. If modifications to the roadmaps are required, the roadmapping team should define a revised action plan. (McCarthy 2003.)

There are different variations how product roadmaps can be validated. For instance, according to Phaal et al. (2003a), the roadmap validation happens by ensuring that all layers of the roadmap are considered and all needed information is included. Instead, according to Nuseibeh & Easterbrook (2000), the roadmap validation is conducted by identifying the most important goals of each participant and then ensuring that these goals are met in the roadmap.

Finally, all product releases within the scope of two to three years and their content, i.e. features, are agreed and possible disagreements among stakeholders are resolved. This phase calls for effective communication on the product releases and features between different stakeholders, especially if the stakeholders have different goals. (Grynberg & Goldin 2003; Nuseibeh & Easterbrook 2000) Thereafter, when the strategic issues are identified, discussed, and actions agreed the product roadmapping process can be taken forward (Phaal et al. 2003a).

2.4.6 Change Management of the Roadmap

Change management is part of product development but it also affects roadmapping, since product roadmaps should evolve as the environment in which the product operates changes and stakeholder needs change. Thus, managing the changes is a fundamental activity in the product roadmapping process. In the product roadmapping, changes are managed by using tools for configuration management and version control, and exploiting traceability links to monitor and control the impact of changes in different parts of the roadmap documentation. (Nuseibeh & Easterbrook 2000.) Furthermore, Richey and Grinnell (2004) have suggested that maintaining the roadmaps could be supported with building a composite roadmap digitally. According to them, it is a fast and simple technique and it allows the owners of each portion of the roadmap to maintain control of edits and changes.

Typically, changes to product roadmaps include adding or deleting product features, and fixing errors. Features are added because stakeholder needs change or because they were missed in the initial analysis. (Nuseibeh & Easterbrook 2000) When new features are added to the roadmap, it means that some of the other features must be excluded (Rautiainen et al. 2003). Usually, features are deleted during development to prevent cost and schedule overruns (Nuseibeh & Easterbrook 2000). Fixing errors and improvement suggestions are included in the product roadmap and planned into future product releases. These reprioritisations of the product features are the responsibility of the product roadmapping team. Further, the priorities are reformed in different sessions with internal experts and selected customers and partners. (Rautiainen et al. 2003.)

Change management process in product roadmapping constitutes of the following phases: feature change identification, analysis of the change, definition of the change impact, definition of the change actions, decisions, and implementation of feature change. The roadmapping team members are responsible for continuously tracking and supervising features in order to discover features' changes. When the indications for feature change occur, the features should be carefully analysed and the feature change identified. After the change identification, all consequences of the change must be analysed. (Pozgaj et al. 2003.) Each proposed change should be evaluated in terms of the existing features and architecture so that the trade-off between the cost and benefit of

making a change can be assessed (Nuseibeh & Easterbrook 2000). The feature change analysis should focus on feature change impact to other features and to definition of features change actions (Pozgaj et al. 2003). The purpose of the feature impact analysis is to identify what to modify to accomplish a change, or to identify the potential consequence of a change (Arnold & Bohner 1993). Traceability links help to scope a possible impact of change and to define which parts are related to which other parts according to specific relationships (Arnold & Bohner 1993; Nuseibeh & Easterbrook 2000). The impact analysis is important, since product features are frequently interdependent. Thus, a small change could create a major impact because of the many ripple effects (Ebert & Smouts 2003). The feature change actions should be defined for all development areas that are under the impact of feature change to enable immediate response to the feature change. The purpose is to provide sufficient information for the decision about the realisation of feature change. (Pozgaj et al. 2003.)

Finally, a Change Control Board (CCB) makes all the decisions concerning the change. The CCB can be the same as the roadmapping team or the company can have separate group of people forming the CCB. On the other hand, the CCB can be also a part of the roadmapping team. In that case, only the most important representatives, e.g. the owner, participate in the decision-making. The CCB decides on each feature change request according to the information provided by the feature change analysis to implement or to refuse the feature change (Pozgaj et al. 2003). Thereafter, the final phase of the feature change process is the implementation, if the feature change is to be carried out.

Impact analysis is one of the core activities in the change management, because product features include several requirements which are linked and dependent on other requirements and changing one requirement definitely affects the interlinked requirements. Thus, the intention of the impact analysis is to understand the change of requirements, so that the scope of that change can be identified. (Ramzan & Ikram 2005.) For this reason, the impact analysis should be examined in more detail. Arthur (1988) defines that maintainers of the product would do the following when analysing the impact of a change: review change request, translate the change description into system terminology, obtain user sign-off on the translated specifications, trace impacts, for example, to other systems, develop resource estimates, and update the change request. Lock (1998) uses Arthur's definition as a basis for defining the impact analysis process that

consists of six sequential stages: review change request, determine impact or scope of the change, develop cost and resource estimates, perform cost-benefit analysis, discuss implications with customers, and document impact, cost and decisions.

Impact analysis process begins with reviewing the change request so that all roadmapping team members and developers understand the change proposed and the relevant system components, which are affected. Next, the analysis techniques are used to identify the impact on artefacts on all stages of the development life cycle. One of these techniques is used to develop cost and resource estimates. For example, potential cost of the change can be calculated by using estimation methods, such as algorithmic cost modeling, e.g. COCOMO costing model (Boehm 1981) or static analysis (e.g. Bajaj et al. 1999). After that, the cost-benefit analysis is performed. It involves balancing estimated costs of the change against the expected benefits. The purpose is to determine if the change will be cost effective. Once the relative cost and benefits involved have been identified, the decision to reject or proceed with the change can be made. This should be done after discussing with the customers and collaboration partners. Last, the roadmapping team together with developers should report the potential effect and probable cost of the change on all development artefacts as calculated in the previous stages. Such documentation should be done even if the decision is to reject the change, since the information may be useful for evaluating future changes. (Lock 1998.)

2.4.7 Summary of the Roadmapping Process

This summary of the roadmapping process is based on the literature review. The product roadmapping process is conducted by a roadmapping team, which is formed by an owner and assisted by a facilitator. These various persons in different roles are present during the whole product roadmapping process. Therefore, the roadmapping process has the following roles: owner, facilitator, and member of the roadmapping team.

In fact, the roadmapping process can have two owners, business and process owners, but one owner can also be enough if the person has experience on both areas. The owner is responsible for selecting the persons to the roadmapping team and guiding the team through the workshops. Instead, the facilitator is

responsible for arranging practical matters, e.g. materials and facilities for the roadmapping workshops, in order to enable the roadmapping process. However, in case of a small roadmapping team, the facilitator might not be needed, and hence the owner, for instance, can conduct the facilitator's tasks.

The roadmapping team has several members from different parts of the organisation or organisations such as product management, engineering, and manufacturing. In more detail, for instance the product team manager, the product manager, the product developers, and the R&D team leader, should be part of the roadmapping team. Persons from business development, finance, marketing, and services as well as customer and partner representatives should also be involved. That is to say, technical and commercial persons and particularly the core staff members from different functions should take part into the roadmapping process. The roadmapping team is responsible for planning, creating, maintaining, and possibly redrawing the roadmaps.

In this thesis, the product roadmapping process consists of following phases: capturing features, analysing features, prioritising features, roadmap validation and agreement, and change management of the roadmap. Figure 3 presents these phases and their main output for the next phase. From the beginning of the roadmapping process, it should be noticed that accurate information ensures that the roadmaps can be read, analysed, redrawn, and validated.

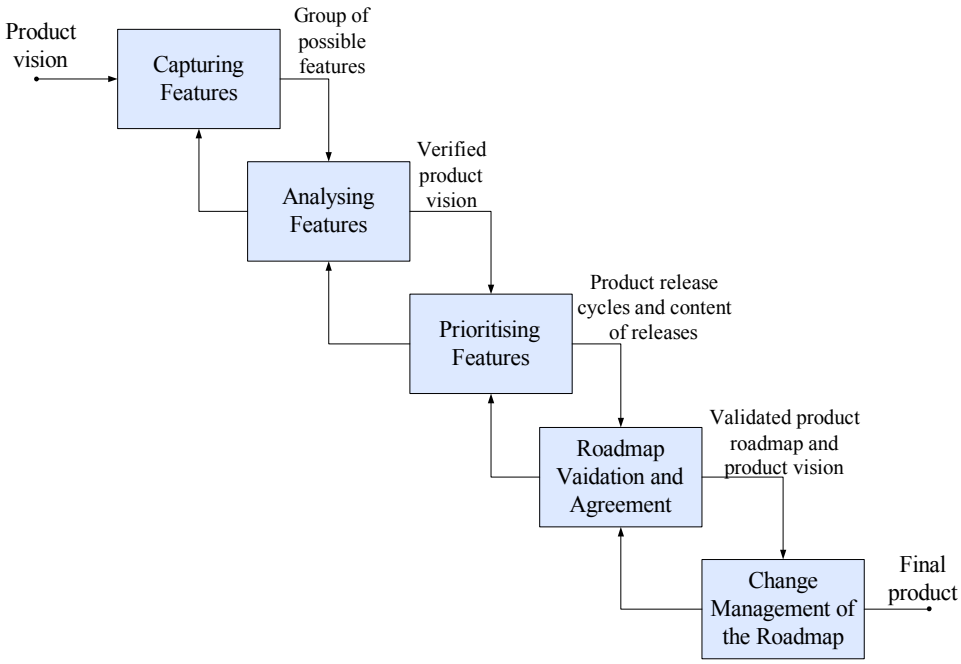

Figure 3. Product Roadmapping Process.

As it can be seen in Figure 3, the product roadmapping process begins with the identification of a product vision, which is used as an input in the first phase, capturing features. In this phase of product roadmapping, the product boundaries are set, stakeholders are defined, and product goals are determined. Additionally, based on the market, competitor and customer analysis, major business and market drivers for the product are defined. Then, the product features are identified and gathered by communicating with the participants of the roadmapping process. Also, the product features can be collected by using several sources of information, e.g. business requirements, customer requirements, user requirements, constraints, in-house ideas and standards, competitor analysis, market research, and product evaluation. Thereafter, all the suggested features in a product are collected and documented in a product roadmap template.

In the analysing phase, all the collected features are evaluated to remove uncertainty, to resolve conflicts, and to make resource and cost estimation. Thereafter, the evaluated features are grouped into themes. The purpose of the groupings is to identify synergies and gaps in the product features. If gaps are

found, they should be filled with missing product features. Hence, it is ensured that the roadmap includes all the needed information. In addition, dependencies between feature groups should be revealed. The groups are then arranged, for example, in terms of impact on the market and business drives. Finally, based on the analysis the product vision is verified.

In the prioritising phase, all the collected features are evaluated and put into order of importance based on the verified product vision. The order of priority of the features defines which features are implemented first and which features are left for the upcoming product releases. That is, planning the product release cycles and defining the content of each product release. Customers have an important role during prioritisation, since they give guidelines to the product by impressing their needs and expectations as well as what they are willing to pay for the product. Additionally, developers should attend to the prioritisation in order to present cost estimations on the product as well as to describe how much time and effort the product will require in order to be completed with certain features.

In the next phase, the roadmap is validated and thereafter approved. At this point, the roadmapping team members shall review whether the process leads to the desired outcome, and if appropriate, take further corrective actions. It has to be ensured that the roadmaps include accurate features and information from all the stakeholders, and checked that the features in the new product or version are covered. At the same time, missing features and inconsistencies should be found. Inconsistencies in the roadmap need to be checked from several viewpoints. For instance, from product development point of view: whether the product can be implemented within the planned time constrain, and from the market point of view: whether the roadmap fills the market needs and expectations or not. The purpose of the validation is to get a result that corresponds to all the features set for the roadmap. Therefore, in this phase the product vision is also validated. After validating the product vision and product roadmap, agreements are made between stakeholders, and the product roadmapping process can be taken forward.

The last phase of product roadmapping, change management, is part of the product development. However, the changes should also be noted in the product roadmaps, since roadmaps should be revised when needed. Typically, the

changes to product roadmaps arise from changes in the target markets and stakeholder needs, which relate to adding or deleting features, and fixing errors. The change management process begins with a change request, i.e. features to be changed. Thereafter, the change is analysed and impacts of the change are defined, for instance, the scope of change request is identified. This impact analysis is conducted by the product roadmapping team together with the product developers. Also, customers and collaboration partners are involved in the impact analysis after costs and benefits have been estimated to discuss whether the change request should be accepted or rejected. Finally, after defining the change actions and making decisions pertaining to the change, the changes can be implemented and documented.

3. Collaborative Development

In this chapter, collaborative development is introduced, and the reasons for the collaboration are described. The viewpoint of this thesis is the inter-company collaboration and, therefore, the modes of co-operation are divided accordingly. Then the product roadmapping is compared to the modes of collaboration. The purpose is to find how the collaboration modes affect the product roadmapping and what is different in doing the product roadmapping in different collaboration modes. Since these matters are not yet widely examined, some gaps were found in the literature, which will be revealed in the empirical study. These gaps relate to creating the product roadmaps in different collaboration modes. For example, roadmaps created together with collaborators; who makes the final decisions relating to different phases; how agreement is reached between partners, and how mutual understanding is gained.

3.1 Introduction to Collaboration

Collaboration means that two or more parties work together to create mutual value and to achieve a common goal. In other words, collaboration is a process in which cooperation parties align their activities and processes to create mutual benefit. Collaboration involves two or more companies, departments, customers, agencies or whomever that combine their competencies to create new-shared value while the parties manage their respective costs and risks. The parties can combine in any one of several different business relationships and for different periods of time which can range from short-term exploitation of a particular innovation or business opportunity, to a much longer-term ongoing relationship. To be precise, collaboration can be described as a process of creating value and relationships that allow people to work together to create that value. (Welborn & Kasten 2003.)

Collaboration can take numerous forms and it can be designed for different purposes. This thesis focuses on company or inter-company collaboration. By inter-company collaboration, it is meant that two or more companies share some of their activities (Hagedoorn 2002). A more constricted definition describes inter-company collaboration as a cooperative relationship among organizations

that relies on neither market nor hierarchical mechanisms of control (Phillips et al. 2000). Furthermore, this thesis reviews inter-company collaboration from the technology cooperation point of view. In the technology collaboration, a combined innovative activity or an exchange of technology is at least a part of the companies' collaboration agreement (Hagedoorn 1993).

3.2 Motivation for Collaboration

Generally, companies cooperate because of cost efficiency, to acquire competencies and to have a long-term strategic perspective but there are also other incentives behind collaboration. For example Herbsleb and Moitra (2001) present, that companies collaborate because of gaining business advantages including knowledge of customers and local conditions. Also the collaboration can be motivated by improving time-to-market by using time zone differences in product development enabling 24-hour development (Gortona & Motwanib 1996; Herbsleb & Moitra 2001). According to Hagedoorn (1993), there are three groups of motives that lead companies to collaboration.

The first group of motives relates to the sharing of basic and applied research and some general characteristics of technological development. Some motives in this group are related to the increased complexity of new technologies and growing interrelationship between different fields of science and technology. Therefore, to fill the competency gaps that companies might be facing, close collaboration between companies is needed. Additionally, through combining of competencies, the companies can gain economies of scale and scope. Collaboration can also be motivated by reduction, minimizing and sharing of uncertainty which is inherent to performing R&D. (Hagedoorn 1993.)

The second group relates to the concrete innovation process. Some motives in this group relate to a possibility of capturing some of the capabilities, knowledge or technologies of the partners. There might be an attempt to quickly, and at the same time secretly, to adopt some innovative capabilities from the others. On the other hand, the inter-company collaboration can be an agreed technology transfer. Additionally, the cooperation can be motivated by the reduction of the total period of the productlife cycle and the contraction of the period between invention and introduction to market. (Hagedoorn 1993.)

The third group of motives relates to the access to market and research for opportunities. Some motives in this group include opportunities for market entry through joint development that combines some activities of two geographically separated companies. The inter-company collaboration also motivates because of the ability to create new markets and products, which provide market-entry and expand the product range of both partners. (Hagedoorn 1993.)

3.3 Modes of Collaboration

The classification of collaboration modes can differ significantly. This thesis divides collaboration modes into the following three categories: joint R&D partnerships, customer-supplier relationships, and technology exchange agreements and licensing. Based on the literature review, these are the most commonly used modes of collaboration. The classification is modified from Hagedoorn's (1993) modes of cooperation. According to Hagedoorn (1993), modes of cooperation can be divided into two groups: inter-organisational governance and contractual arrangements. The inter-organisational governance modes include joint ventures, research corporations and minority investments, and on the other hand, the contractual arrangements include joint R&D agreements, technology exchange agreements, customer-supplier relationships, and one-directional technology flows (Hagedoorn 1993).

Joint R&D partnerships are formed by two or more companies that share some of their activities but still remain independent companies (Hagedoorn 2002). Joint R&D partnerships include both joint ventures and joint development agreements. Joint ventures are created by partners who agree to combine their skills and resources in a separate company characterised by joint ownership. In the joint development agreements, companies pool resources with an aim to organise joint R&D activities of two or more companies. Therefore, joint development agreements are dependent on strong commitment of the partners. These agreements are generally performed as joint development projects that have a limited time-horizon. (Duysters & Hagedoorn 2000.)

Customer-supplier relationships are close contacts between customers and suppliers (Duysters & Hagedoorn 2000). Generally, the customer is the buying organisation of the software product and the supplier is the provider of the

software to the customer. The software product may be based on defined requirements or modification of off-the-shelf products or open source code. But usually the purpose of the customer-supplier relationships is to combine knowledge and technology from the customer and the supplier in order to create a product that meets the standards of the customer (Duysters & Hagedoorn 2000). These relationships can be divided into various forms of partnership, such as market cooperation, co-production contracts, and research contracts. Usually, the relationships are formed to establish either production or research cooperation. For instance, a large company may subcontract a small company to perform particular research projects. (Hagedoorn 1993.)

Technology exchange means exchange of knowledge, technology or information between two or more companies. The technology exchange agreements cover technology sharing agreements, cross-licensing and mutual second-sourcing of existing technologies (Hagedoorn 1993). With technology sharing agreements, such as leasing or licensing ready-made Commercial Off-The-Shelf (COTS) products, for example, companies acquire access to new technologies. This allows companies to explore new fields of technologies with lower cost and without internal development (Duysters & Hagedoorn 2000). Licensing is a distinct cooperation mode but it can also be a part of a technology exchange agreement. Thus, in this classification licensing is considered together with technology exchange. The licensing agreement means that a company is granted the right to use a specific patented technology in return for a payment. Furthermore, licensing is a relatively cheap and fast way to acquire a technology. Cross-licensing and mutual second sourcing are bilateral forms of general licensing. (Duysters & Hagedoorn 2000) In cross-licensing, companies licence their patented technologies to each other (Eswaran 1994). In mutual second-sourcing, companies trade the rights to make an exact copy of the other company's products (Duysters & Hagedoorn 2000).

3.4 Product Roadmapping versus Collaboration Modes

It is said by Phaal et al. (2003a), that the roadmapping process is at least as valuable as the roadmap itself. Partially this is due to the fact that benefits associated with discussion and learning can be gained during the roadmapping process (Phaal et al. 2003a). Further, in reviews of roadmaps, the common needs

and opportunities for reuse between partners can be identified (Albright & Kappel 2003). Therefore, part of the communication between collaboration partners is arranged through the roadmapping process, in which all carefully selected representatives from partner companies are present. In addition, as Richey and Grinnell (2004) argue, an important aspect of roadmapping is gathering and sharing information with respect to customers, suppliers and competitive intelligence. For this purpose, a common roadmap library or database should be created. When roadmaps are documented in a common format and stored in one place, they enable corporate planning across product lines. These shared product roadmaps enable specific dialogue between collaboration partners, and thus help to align the corporation with them. (Albright & Kappel 2003)

From the collaboration point of view, planning particularly is a crucial activity in the roadmapping process, since at that point, customisation issues need to be considered, and the business and process objectives need to be clearly articulated. In the planning phase, issues such as scope, organisation goals, available information and resources, and different cultures between companies, should be taken into account. (Phaal et al. 2003a; Phaal et al. 2001) In addition, differences in background, thinking and ways of working among different departments and companies need to be reconciled. Thus, a degree of trust needs to be built up and nurtured between partners by management to ensure a successful start and completion. (Groenveld 1997) With careful thought and discussion, risks can be reduced and unnecessary changes can be minimized in the forthcoming phases, especially, if the roadmap architecture and roadmapping process are to be adapted to fit the particular situation and context. (Phaal et al. 2003b; Phaal et al. 2001)

From the beginning of the planning phase, co-ordination is a key activity in roadmapping, with the need to ensure that the process is continually aligned with the collaboration companies' needs (Phaal et al. 2000). Additionally, ownership of the roadmap is critical; firstly, by a single designated person or group of people, then by those that will participate in its creation and maintenance. Ideally, proficient persons from different partners should be designated into the process and its management and facilitation. (Phaal et al. 2001) Training is also an important part of planning, above all, if the roadmapping process is new to the participants. In the roadmap, training common tools and templates are

utilised to encourage a universal language for product planning throughout the companies. (Albright & Kappel 2003)

Moreover, one of the most important principles in roadmapping is that the roadmapping process must be completed. That is, even though issues identified need to be locked for future consideration, and assumptions have to be made when there are gaps in knowledge. In this manner, a first version of the roadmap can be produced, bringing direct benefits to participants of the roadmapping process. (Phaal et al. 2004a.)

Next, the product roadmapping process in each selected collaboration mode is described. The intention is to find out how the collaboration modes affect the product roadmapping process, and in what way the roadmapping process is different between the collaboration modes. Based on the literature study, very few surveys concentrate on product roadmapping in the inter-company collaboration. Some of the literature mentions the customer and supplier roadmaps, as well as how customers and suppliers can create roadmaps together. In addition, some literature can be found about how to create the product roadmap when a part of the product is acquired or licensed outside the company. Only few surveys consider the product roadmapping in joint R&D partnerships. Since there are so few surveys that focus on this specific area of research, the empirical research is needed. The purpose of the empirical part is to fill up the gaps found during the literature analysis. These gaps relate to creating product roadmaps in different collaboration modes, making the final decisions concerning priorities and changes, reaching an agreement between partners, and gaining mutual understanding, for example.

3.4.1 Customer-Supplier Relationship

From the three specified collaboration modes, the customer-supplier relationships do not affect so much the product roadmapping, since the purpose is to develop one's own products completely. This is different from the technology exchange agreements, where part of the product is being licensed from the partner, for instance, COTS products. Anyhow, the customer-supplier relationship has some effects, and particularly, it affects the first phases of the product roadmapping process.

The product roadmapping process in a customer-supplier relationship begins with the product vision. Based on the product vision, the customer should analyse which parts of the product can be developed internally and which parts need to be bought from outside the company. This resource analysis includes defining key personnel and other strategic assets, but also suppliers, partners or others upon whose actions the company may depend (Strauss & Radnor 2004). By means of the resource analysis, the customer can outsource the non-core competencies and focus on its own competencies. Thus, in customer-supplier relationships, the co-development brings together a set of skills and experiences that complement the strengths of the partner (Tabrizi & Walleigh 1997).

Afterwards, the customer should select the most suitable supplier for developing the product or a part of the product. That is the most difficult task to do in the customer-supplier roadmapping process, since the supplier may have major differences in style, priorities, and motivation from those of the customer, which can create costly delays and revisions (Tabrizi & Walleigh 1997). In the supplier selection, the customer should consider the supplier's present and forthcoming knowledge. Additionally, the supplier's characteristics, which are not yet known, but have effects on the product development, should be analysed. However, and most importantly, the selected supplier should be capable of producing the product.

The roadmaps permit content-rich dialogue and therefore they enable the showing to a supplier the directions for the future product and the discussion on how the supplier could help the customer, e.g. in the product development. The ultimate goal is to align the supplier roadmap with the customer's own roadmap. (Albright & Kappel 2003) By analysing the supplier roadmaps, a customer can identify an upcoming industry decline or growth. Also, the analysis may allow the customer to spot a movement in a competitor's market position. In addition, information, such as the supplier dependencies and strategic intent will identify areas of concern that should be taken into account in the customer's roadmaps. (Richey & Grinnell 2004.) With a customer, a roadmap shows where the supplier is going to with its product. This enables discussion about alignment and estimation of the supplier's forthcoming needs of knowledge. In addition, it helps the customer to define the future with the supplier's product and to prepare requirements aligned with the supplier's roadmap. (Albright & Kappel 2003.) Then again, by analysing the customer roadmaps, a supplier can determine how

certain changes in a customer's business model will influence the supplier's own vision. In the customer roadmap reviews, the supplier can identify internal problems that need fixing, the strengths, weaknesses and strategies of competitors, as well as determine the market size and shared information. (Richey & Grinnell 2004)

When the supplier has been selected and the co-operation between partners has been agreed on, the product roadmapping process can be taken forward. In the customer-supplier relationship, both the customer and the supplier participate in the product roadmapping process. The customer is primarily responsible for defining the needed features for the product, but also the supplier is present at the workshop where the features are captured, since all feature suggestions and different viewpoints are considered valuable.

In the next phase, the collected features are analysed, and missing features are added to the product roadmap. Thereafter, initial cost analysis for the product is made based on the features, which is approved by both partners. Also, internal competencies in both customer and supplier companies are analysed, and if competency gaps are found they should be filled either with the customer's or the supplier's knowledge. Thus, problems relating to dividing tasks between the partners might occur. At the end of this phase, the customer verifies the product vision defined in the first phase of roadmapping.

The availability of knowledge can change the prioritising of features in the customer-supplier relationship. Otherwise, the features are prioritised either with formal or informal methods that have been agreed on between the partners. Instead, after the features have been prioritised and the product development costs have been revised, the customer can decide whether to include all the planned features in the product or to eliminate some of the features in order to bring down the development costs. Also, in the validation and agreement phase, nothing else is changed than that the customer validates the features and the product roadmap (Soffer et al. 2005).

In the change management phase, after the change identification has been made, the change should be analysed, and the impact analysis should be conducted. Both partners should participate in this process in which the scope of the change is identified and cost-benefit analysis is made. The customer and the supplier

should define together the change actions and to decide whether they are able to perform the required modifications. If they are capable of making the changes, then it should be decided whether the change is cost-effective. Then, the customer makes the decision to reject or to proceed with the change. After the feature modifications, the features need to be rearranged. These rearranged features should then be approved between the customer and the supplier.

3.4.2 Joint R&D Partnership

Joint R&D partnerships affect the most the product roadmapping, and particularly, the first phase of the roadmapping. This is because then all the participants are selected and agreements are made concerning the roadmapping process. At this point, also the partner organisations' responsibilities and authorities should be clearly defined, which in this case are more unclear compared to the other collaboration modes. Hence, it should be decided, for example, who makes the decisions eventually when consensus cannot be reached between partners, and in what kind of affairs partners can make the changes by themselves, and in what kind of affairs it is not allowed.

The joint R&D partnership includes different viewpoints from the collaboration partners. Thus, problems in product roadmapping relate to gaining mutual understanding and combining ways of thinking in order to implement the planned co-operation. Additionally, joint R&D co-operation may have side effects to the partner companies. Therefore, before the collaboration it should be found where and how it will affect. Additionally, before creating product roadmaps, the partners should determine the persons who are involved in the roadmapping process. This is important, since joint R&D partnerships can include several stakeholders; hence, one partner cannot make a decision by himself or herself. Therefore, it should be decided which partner's opinion is the most valuable in the decision-making and how changes are to be made. Thus, the owner of the roadmap should be chosen. Despite of these difficulties, Wells et al. (2004) suggest that from the joint R&D partnerships' perspective, roadmaps help to identify the correct focus of the research activity, areas of research which are the highest priority for the business, and possible gaps in the plan, i.e. new areas of research.

After the contract with partners to co-operate has been made and the major participants in the roadmapping process have been chosen, the roadmapping process can be launched. The product roadmapping process in joint R&D partnerships begins with identifying the product vision and, thereby, capturing product features into the roadmap. The product vision can be difficult to form, if the partners have different visions in mind. Thus, it is important that all partners involved in the product development are present and that consensus can be created from the beginning of the process. As the mutual understanding has been gained and the features have been collected, the feature analysing phase can begin.

The purpose of analysing the features is to check whether the collected features satisfy the partnership companies' needs. In addition, during the analysis process, gaps in product features should be filled, and gaps in competencies should be patched with one or the other partner company's knowledge. At this point, the product development process should be planned in more detail, and therefore, disagreements about what strategies are going to be used during the product development may occur. According to the analysed features, both partners should verify the earlier defined product vision.

The feature prioritising phase is affected by the partnership. The feature prioritisation practices may be different between the partner companies. Thus, disagreements may occur when prioritisation methods are chosen, and either one or both companies may have to learn new ways of prioritising features. Disagreements between partners may also result, when the partners have different opinions about the order of priority of the features. After features have been prioritised, the partners may face problems in placing the product on the timeline, e.g. defining when the product is going to be ready, and defining the content of the product releases.

In the roadmap validation and agreement, the partners should validate the gathered data in roadmaps with both companies' internal expertise. The roadmap is validated in a way that both companies are satisfied with the content of the roadmap. If faults are still found in roadmaps and disagreements occur between partners, corrective actions should be made before the roadmap agreement can be made. Thereafter, when the agreement has been made, the product development can begin.

During the product development, partners may notice that their needs have changed. In addition, errors in the product features may be perceived. Thus, additional features have to be included or extra features have to be excluded from the product roadmaps. Hence, change management is needed for the created product roadmaps. All the selected participants from the joint R&D partnership should participate in the change management of the roadmap and in the impact analysis. First, the partners should analyse the change and define the change impact in terms of resource and cost-benefit analysis. Then the partners should identify the change actions and divide the change tasks. Thereafter, collaborators should make decisions, and in case of positive decision, implement the change. The change process also encounters the same problems as the earlier roadmapping phases, such as obtaining consensus about the features to be changed.

3.4.3 Technology Exchange and Licensing Agreement

The technology exchange and licensing agreements also affect product roadmapping, particularly, in case of COTS products. Thus, it should be noticed that there are two perspectives on COTS, which are end-users' or component integrators' perspective, and COTS vendors' perspective, i.e. organisations which are developing COTS software components (Beus-Dukic 2000). The component integrator integrates one or more COTS products into one product, in which part of the product can be developed in-house. The COTS-based product development is contrary to the merely in-house development, and thus involves some challenges and risks that are different from those of traditional software development (Alves & Finkelstein 2002). For example, vendors try to protect intellectual property and so they usually sell components as binaries, without source code or design documentation. Hence, software integrators are faced with the risk of constructing products using unknown components. (Devanbu & Stubblebine 2000)

In this context, the product roadmap is created by the component integrator and the COTS vendor. Thus, it would be useful for both of these collaboration partners to participate in the roadmapping process, because then the integrator may have possibility affect the COTS product's forthcoming features, and the vendor can gain knowledge about customer directions. Thus, the vendor should

participate, although they commonly try to meet the needs of a marketplace instead of satisfying the requirements of a particular company (Alves & Finkelstein 2002).

The product roadmapping process begins with defining a product vision, which is done by the integrator. Then based on the product vision and estimation of what product features cannot be developed in-house, the most appropriate component vendor should be selected. This is not as easy as it seems, since a perfectly suitable COTS product is rarely available, and so compromises have to be made. Also, the integrator may have very limited access to the product's internal design and the description of the commercial packages may be an incomplete and confused textual description (Alves & Finkelstein 2002). Especially, if the COTS product is sold as binaries, without source code or design documentation (Devanbu & Stubblebine 2000). In fact, the integrator has limited chance to verify in advance whether the desired product features are met (Alves & Finkelstein 2002). Therefore, the candidate COTS components need to be evaluated at an extremely early stage in the roadmapping process, and the component selection should be based on careful consideration (Dean & Vidger 2000).

After selecting the component vendor, the general strategic context of the product should be considered (Holmes et al. 2004). Then, all the feature proposals relating to the product vision are collected into the product roadmap template. At this point, vendors face problems relating to the lack of knowledge on how to specify requirements that strike the optimum balance between describing the desired user functionality and the available COTS products (Chung et al. 2001). These problems can be reduced when both the integrator, i.e. end-user, and vendor participate in capturing the product features.

In the analysing features phase, all the collected features are analysed and grouped. The key knowledge gaps are identified (Holmes et al. 2004) and information about the source of technology or product components, e.g. developed in-house, sourced from vendor, etc., are captured into the roadmap (Albright 2002). Thereafter, both partners should provide feedback on the roadmap, and discuss the synergies and gaps in the product features. The synergies should be minimized and feature gaps should be filled. Based on the analysis, the product vision should be verified by both partners.

In the feature prioritising phase, all the collected features should be prioritised. This can be difficult, since the COTS product may already be under development while it is being roadmapped. Hence, the integrator should try to affect the COTS vendor's roadmapping process in order to get features that they want into the next product release. At least, the integrator should track down information about the forthcoming features of the COTS product in question. In addition, the acquired or licensed technology can have additional features that are not taken into account in the earlier phases of product roadmapping. These additional features should first be analysed and grouped, and then prioritised together with the other features. Then again, all the additional features should be known, and their interdependencies revealed which, depending on the COTS product's design documentation, may not be so simple. On the other hand, vendors face problems in prioritising features that concern placing the product on the timeline, e.g. defining when the product is going to ready, and what strategies are going to be used in the component development. Additionally, the vendor can face challenges relating to the volume of the market of software components and the speed with which different components or their new versions emerge (Beus-Dukic 2000). At the end of this phase, it should be ensured that all feature and knowledge gaps are closed as well as forthcoming product releases defined.

In the roadmap validation and agreement phase, it should be ensured that the roadmap includes all the needed knowledge and that the process has led to the desired outcome. If faults are found in the roadmap, they should be corrected. Both partners should validate the roadmap and the product vision. After validation, the agreements concerning the product development should be made.

Typically, changes to product features are noticed during product development. The change management phase is affected by the technology or licensing agreement if adding or deleting some product features pertain to the acquired or licensed technology. Thus, integrators may face problems relating to the product's future development and risks involving it, since as Beus-Dukic (2000) suggests, vendors might not give any information about the development process used to produce and maintain the component. In addition, there might be legal contracts that restrict changing the component characteristics and further development. Especially in these cases, long-term vendor support is critical. Otherwise, without vendor support, the integrator cannot make changes to the

COTS product features. In that case, the integrator conducts the change management process and impact analysis alone, and the changes to the product roadmaps relate to the features that the integrator is developing by him/herself. Then the change management to the product roadmap is performed as usual, but taking into account the COTS product features that must necessarily be changed. Instead, if vendor support is available, the change management of the roadmap is conducted together with the vendor.

4. Requirements Prioritisation

Requirements engineering and management are often said to be the most problematic practices in software development and, furthermore, requirements prioritisation is specially complicated for distributed development projects (Juristo et al. 2002; Komi-Sirviö & Tihinen 2005; Lawrence et al. 2001). Therefore, in this chapter, the basis for requirements prioritisation is introduced in more detail, and some general prioritisation methods are presented. These prioritisation methods are also reviewed from the collaboration point of view.

4.1 Introduction to Requirements Prioritisation

Software product requirements arise from various stakeholders, which may be users, developers, project managers, business managers, or other categories of people affected by the product (Greer 2005). The requirements are habitually divided into two groups: functional requirements and non-functional requirements (Karlsson 1997). Functional requirements express the behaviour of the software system and describe the functions of the system (Karlsson 1997; Leffingwell & Widrig 2000). Non-functional requirements, also known as quality requirements, describe how the functionality should be provided (Kuusela & Savolainen 2000; Nuseibeh & Easterbrook 2000). Non-functional requirements cover wide ranges of characteristics, such as usability, reliability, performance, and supportability, which are generally more difficult to describe in a measurable way, making them more difficult to analyse and prioritise (Karlsson 1997; Leffingwell & Widrig 2000; Nuseibeh & Easterbrook 2000).

Usually, new software applications have a large number of requirements that vary in importance and in existing applications for them; there is a backlog of new requirements, potential fixes, and enhancements. In any case, it is impractical to implement all requirements simultaneously because of the cost involved, staff limitations, and market and user pressures to have the software product implemented. Therefore, prioritisation is necessary. (Greer 2005.)

Wiegers (2003) defines prioritisation to be a way to deal with competing demands for limited resources. The definition is conducted from ensuring that

the product delivers the most valuable functionality as early as possible although the customer expectations are high and timelines are short. Additionally, selecting prioritised requirements is important because it helps to resolve conflicts, for instance, in stated functional and non-functional requirements (Sivzattian & Nuseibeh 2001). Also prioritisation helps to plan for staged deliveries and to make the necessary trade-offs (Wiegers 2003). Requirements prioritisation is especially critical in incremental development which is characterised by tight and fixed release schedules (Wiegers 2003).

In general, the requirements are collected in so-called product requirement backlogs or product-priority documents. Instead, in roadmapping, the product requirements are collected as product features into the product roadmaps. The purpose of the product requirement documents is to link the product introduction to the company's overall business strategy and to keep product developers focused on the features that the customers want in the order in which they want them (Tabrizi & Walleigh 1997). Therefore, customers should point out which requirements are needed initially and which can wait. To succeed, the requirement priorities should be established early and revised periodically with the customers (Wiegers 2003). However, one of the biggest problems in the prioritisation of requirements is that the customer does not really know what he or she wants or cannot express it correctly. The problem can also be that the end customer is not heard directly, and the developers must rely on market research data, for instance. (Rautiainen et al. 2002) For example, discussing priorities can help to clarify the customers' wants, needs, and expectations. Furthermore, both customers and developers should provide contribution to the prioritisation of requirements. (Wiegers 2003)

Requirements are commonly prioritised into three categories, which are "high", "medium", and "low" priority. This kind of prioritisation scale can be thought as subjective and imprecise. Therefore, the stakeholders must agree on what each level of the scale means. (Wiegers 2003.) Further, customers might not consider requirements to be low priority because it minimises the value of the requirement. Instead, according to them all requirements are important and hence should be implemented. The required features can also be organised into categories from the customer's point of view. Then the three categories are "must have", "should have", and "nice to have". (Tabrizi & Walleigh 1997.)

This category gives more precise information on the customers' expectations and what features should be implemented foremost.

4.2 Methods for the Prioritisation of Requirements

In a small software product development project, the stakeholders can agree on requirement priorities informally, but in large or continuous projects more formal and structured approach is needed (Wiegers 2003). When developing a large software product, the number of requirements begins to rise rapidly as the size of the project increases (Kuusela & Savolainen 2000). Even then, most of the software organisations perform requirements selection and prioritisation informally, and therefore quite often produce software products that developers, customers and users view as secondary. This is because managers are still missing a simple, effective, and industrially proven method for prioritising requirements. (Karlsson & Ryan 1997) However, there are several methods for that specific purpose of which some are more analytical, mathematical, quality based methods, and the others are more market- and customer-driven methods. Anyhow, all requirements, both functional and non-functional, should be prioritised at the same time according to the chosen method.

This thesis presents the following requirements prioritisation methods: Analytic Hierarchy Process (AHP) (Saaty 1980), Quality Function Deployment (QFD) (e.g. Griffin & Hauser 1993), EVOLVE (Greer & Ruhe 2004), and Distributed Prioritisation (Regnell et al. 2001). AHP and QFD methods were chosen because they are widely known prioritisation approaches. AHP is commonly used as a part of many other prioritisation techniques, e.g. in cost-value approach (Karlsson & Ryan 1997), and QFD has been adapted for the software development, which has been termed Software Quality Function Deployment (SQFD) (Haag et al. 1996). Additionally, QFD can be used for prioritising both functional and non-functional requirements, because it does not make any distinction between them (Karlsson 1997). EVOLVE and Distributed Prioritisation were chosen because they both take into account various stakeholder perspectives (Greer & Ruhe 2004; Regnell et al. 2001). Since in this thesis the context is on collaboration, it is important to elicit, specify and prioritise requirements from the viewpoint of different stakeholders, for instance from marketing, customer services and users (Rautiainen et al. 2002).

Afterwards, a weighting factor can be assigned to each stakeholder: giving higher weights to favoured user classes than to groups who have less influence on the project decisions (Wiegers 2003). Further, EVOLVE offers decision support for software release planning, i.e. incremental product development (Greer & Ruhe 2004).

The purpose of the empirical research is to find whether these prioritisation methods presented are used in the case companies and how requirements are typically prioritised. In addition, the intention is to find out how collaboration affects the prioritising of features.

4.2.1 Analytical Hierarchy Process

AHP is a systematic procedure for representing the elements of a problem (Saaty 1986). It organises comparable alternatives in a stepwise fashion and then calls for pairwise comparisons to develop priorities (Karlsson & Ryan 1997; Saaty 1986). There are four steps in AHP decision-making process, but before that the decision-making process criterion for the evaluation of candidate requirements should be chosen. The criterion can relate to value, cost, benefit, quality, and risk reduction, for instance. The first step is to set up the requirements in the rows and columns of a matrix. The second step is to perform pairwise comparison of all the requirements according to the selected criterion. The third step is to use averaging over normalized columns to estimate the eigenvalues of the matrix. The final step is to assign each requirement its relative value based on the estimated eigenvalues. (Karlsson & Ryan 1997.)

AHP method has been criticised for being impractical in case of more than a couple of dozen requirements (Wiegers 2003). In addition, AHP has not been specifically applied to incremental software development because it does not take dependencies between requirements into account (Greer 2005).

From the collaboration point of view, the pairwise comparison of candidate requirements is simple to conduct, since the relative importance of the requirements is based on two options only. Even then, consensus about the most important requirements should be reached between the partners, since the method does not take into account different stakeholder perspectives.

Additionally, all the partner representatives have to be present during the prioritisation, to get their voice heard, since the method does not take into consideration the stakeholder's goals or give any weighting factor to the different stakeholder groups, for example. In addition, since there might be several features from different partners to be prioritised, AHP can be troublesome in collaboration. Thus, it is considered time-consuming and ineffective.

4.2.2 Quality Function Deployment

QFD is a Japanese product design and development methodology that provides a structured framework for concurrent engineering (Cristiano et al. 2001). The method is based on cross-functional teams, such as marketing, manufacturing engineering, and R&D, who have shared their responsibility for developing a new product, service, or process, or refining an existing one. The teams use series of matrices, known as "The House of Quality", to deploy a complete set of customer needs throughout design, manufacturing and service delivery. Thereby it is said that QFD improves communication among these functions. (Griffin & Hauser 1993; Katz 2001.)

There are four houses to present data. The first house links the customer needs to design attributes that are engineering measures of product performance. The second house links the design attributes to actions the company can take. The third house links actions to implementation decisions, e.g. to manufacturing process operations. The last house links the implementation to the production planning. (Griffin & Hauser 1993.)

Benefits of the of QFD are that it increases creative thinking among team members to solve various system problems, thoroughly rated requirements that are assessed against competing products, qualified relationships between the product characteristics and the customer needs, and more explicit trade-off analysis. However, the process is time-consuming and weak at handling interdependencies between requirements. Additionally, it is said that "The House of Quality" is not efficient in dealing with large number of requirements. (Katz 2001; Sivzattian & Nuseibeh 2001.)

According to Karlsson (1997) with QFD, both functional and non-functional requirements can be prioritised since it does not make any distinction between them. Rather, it forces the cross-functional team to state all requirements in a measurable and verifiable manner. Furthermore, the fulfilment of non-functional requirements is essential, because software system always processes characteristics such as usability and reliability, but to different extents. In using QFD, the cross-functional team can be forced to quantify the demanded fulfilment of the non-functional requirements, which might be otherwise neglected. For example, the team should develop exact targets for factors such as usability that must be met by the final software system. (Karlsson 1997.)

QFD does not explicitly support inter-company collaboration. However, it is considered to support roadmapping, since both of them need cross-functional teams to be conducted. Anyway, QFD can be used during co-operation. In case of large companies as partners, with a multitude of product requirements, the QFD is thought to be ineffective. In addition, QFD matrices are constructed to compare requirements with one another and rate their importance, but without explicitly identifying stakeholder goals (Nuseibeh & Easterbrook 2000). Thus, the aims of the partners are left unnoticed during the prioritisation process.

4.2.3 EVOLVE

EVOLVE is an evolutionary and iterative approach for requirements prioritisation. It combines the computational strength of generic algorithms with the flexibility of an iterative method. In EVOLVE, software releases are planned as increments, but the planning process is repeated at each iteration. The inputs to the iterations include the current set of requirements, the constraints, and the stakeholder priorities. At each iteration, a generic algorithm is applied to determine the best or the most optimal release plan or assignment of requirements. Typically, EVOLVE generates a small set of most promising candidate solutions among which the actual decision maker can chose. The emphasis of this method is on support, not on actual making of the solution. Since the method is evolutionary and iterative, it allows making late changes in requirements, prioritisation of requirements by stakeholders, effort estimation for all requirements, effort and risk constraints, precedence and coupling

constrains as well as changes in the weight assigned to stakeholders. (Greer 2005; Greer & Ruhe 2004.)

EVOLVE method has been developed in recent years so it has not been estimated and criticised quite extensively. Even so, it has already been modified. A new and extended version of EVOLVE has been created, named EVOLVEext (Ruhe & Momoh 2005).

EVOLVE takes collaboration into account, since different stakeholder priorities are noticed. For example, in case of joint R&D partnerships, it might be hard to choose from the candidate solutions, if mutual understanding is not reached between the partners. Instead, in case of customer-supplier relationship, EVOLVE is considered a valuable prioritisation method. Since each new increment is a complete new system, it is of value to the client, and thus, can also be evaluated by the client (Greer & Ruhe 2004).

4.2.4 Distributed Prioritisation

Distributed Prioritisation is developed for market-driven requirements engineering in the case of packaged software sold to mass markets. The objective of the method is to gather and highlight the differences and similarities in the requirements priorities of the different market segments. Distributed Prioritisation process is needed when potential market segments are spread worldwide. For that purpose, a distributed marketing organisation with close relations to target customers is created. The organisation consists of a product strategy team and market operations of several stakeholders. The product strategy team makes strategic decisions and communicates with the market operations that promote strategies and gather valuable information about market opportunities, user expectations and technology trends. (Regnell et al. 2001.)

Distributed Prioritisation process for gathering information from different stakeholders consists of five steps. In the first step, the product strategy team makes a candidate list of strategic high-level requirements. After that, the candidate list is distributed to the stakeholders who in parallel make the prioritisation of the requirements. It is also possible that the stakeholders can add new features or feature groups to the list. In the third step, the product strategy

team combines all priorities and decides on one resulting list of priorities. When aggregating the priorities, the influence of each stakeholder can be adjusted according to weighting criteria such as revenue or profit of last release, size of total market segment, and number of contracts lost to competitors. In the fourth step, the decision is communicated to all stakeholders. Finally, all stakeholders give feedback on the results to the product strategy team. The team then decides, whether it is necessary to start another iteration. Otherwise, the process results in high-level requirements priorities for the next release. The Distributed Prioritisation process has some challenges that relate to, for example, difficulties in absolute assessment, and assessment of prioritisation quality. The method is also sensitive to shrewd tactics by some of the stakeholders, who might give an extra-low priority to requirements in order to influence the total result to fit their aims. (Regnell et al. 2001.)

Distributed Prioritisation supports collaboration and, particularly, technology exchange and licensing agreements. For example, Regnell et al. (2001) suggest that one solution for developing COTS products is to use Distributed Prioritisation method in prioritising requirements. Accordingly, the next software release is based on collected needs and opportunities from different market segments. This information is then used as a basis for the prioritisation. (Regnell et al. 2001) Even then, the process is multi-phased and thus takes time to be conducted.

5. Empirical Design

As Yin (1994) describes, the empirical research is characterised by implicit or explicit research design, hence this chapter introduces the research design of the study. The research design specifies the logical sequence that connects the empirical data to the research questions of the study and, eventually, to its conclusions. Thus, the purpose of the research design is to avoid a situation in which the evidence does not address the initial research questions. (Yin 1994) Therefore, the empirical research was carefully planned and implemented. First in this chapter, the research methods of the study are defined and after that, the data collection methods are presented. The selections of these methods are also reasoned in each section. For instance, the empirical research method was chosen to find general practices about product roadmapping in the case companies, and to compare the empirical findings to the literature analysis. Last, at the end of this chapter, the progress of the research, i.e. the research context, is described, and the used method for analysing qualitative data is presented.

5.1 Research Methods

In this thesis, the research was carried out as a case study research. The case studies can be based on both quantitative and qualitative evidence (Yin 1994). That is because, in a case study research, data is collected through such methods as inquiries, interviews, observation, and use of documents and artefacts (Järvinen & Järvinen 2000). The qualitative data is descriptive, and captures and communicates experiences of the field of study. In other words, qualitative data tells a story about the researched phenomenon. In addition, qualitative research relies on logical conclusions on the gathered data. (Patton 2002; Yin 1994) In contrast, the quantitative data seeks numerical responses, and thus relies on quantitative measurement and mathematical models (Patton 2002; Yin 1994).

A case study is, according to Yin (1994), “an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident”. Furthermore, a case study is preferred when the researcher has little control over the events, and when “how”, “why”, and explanatory “what” questions are posed

(Yin 1994). A case study research is used to achieve various research aims, for instance to provide descriptions of the phenomena, to test a theory, and to develop a theory (Darke et al. 1998).

The case study research method was chosen for this thesis, because the aim of the study was to develop a theory and to find general practices in companies using product roadmapping. In addition, the aim of the study was to test the theory found in the literature and to compare it to practical experiences that were revealed through case studies. Therefore, constructing a preliminary theory related to the study was essential. (Yin 1994) The preliminary theory is presented in Chapters 2–4. As Yin (1994) advises, the development of the theory also helped to define the appropriate research design and data collection as well as generalising the results of the case study.

A case study research can contain both single- and multiple-case studies. A single-case study is used when a well-formulated theory is tested, or when there is possibility to have access to an extreme or unique case that is commonly difficult to approach. Multiple-case studies are used either when the results from the earlier case study are verified, i.e. similar results are predicted, or when contrasting results are obtained, but for predictable reasons. (Yin 1994) In this thesis, multiple-case studies approach was used, since the theory on the product roadmapping was not yet well formulated. Therefore, the purpose was to fill in the gaps found in the literature, and thereafter, to create a theory relating to product roadmapping process. To verify the theory, the experiences of several companies were gathered and analysed.

5.2 Data Collection Methods

In this thesis, data collection was carried out in form of questionnaires and interviews, which pertain to the chosen case study research approach (Järvinen & Järvinen 2000). These data collection methods were selected, because with questionnaire studies, the basic knowledge among companies using product roadmapping could be revealed, and with interviews, more in-depth knowledge about product roadmapping in collaboration could be discovered. In addition, like Järvinen & Järvinen (2000) suggest, the questionnaire studies are considered the most appropriate method when the number of matters to be inquired into is

relatively small and the number of respondents is relatively large, as in this case. On the other hand, the questionnaire studies were extended with interviews in order to specify the received information from the respondent. Additionally, interviews were conducted, since they were expected to bring forth new aspects that would not be otherwise revealed. (Järvinen & Järvinen 2000)

In questionnaire studies, the data is collected with an inquiry form. This inquiry in a paper or electronic format contains a set of structured or unstructured, i.e. open, questions intended to be answered by the selected people. Structured questions are used when the subject of the questions holds a generally accepted classification, which is extensive. Hence, structured questions are used in theory-testing studies. Instead, unstructured questions are used when the subject of the question is not yet structured. In that case, the questions are expected to reveal some experiences from the practice. Thus, these questions are used in theory-creating studies. (Järvinen 2001; Järvinen & Järvinen 2000) These phrasings of questions also apply to interview studies. Hence, the type of interview depends on the research approach used.

In this research, the inquiry form was divided into three parts: general information, company profile, and product roadmapping process. The questions were formed based on the literature presented in Chapters 2–4. In more detail, the questions related to the product roadmapping, collaborative development, and requirements prioritisation. All the questions in the questionnaire studies were asked in a structured form so that the respondent could select from the several alternatives. However, in order to get more information about the research areas each question could also be replied with an open answer. Thus, the questionnaire studies included both structured and unstructured questions. The structured questions were selected to attain brief response time and therefore to receive more replies. The questions for the inquiry were planned and arranged carefully in advance to attain the right form of questions and to avoid misunderstandings. Appendix 2 contains the inquiry form send to the respondents.

In an interview, data is collected in a discussion between interviewer and interviewee, in which the purpose is to gather certain information from the interviewee (Järvinen 2001). According to Järvinen and Järvinen (2000), there are three types of interviews: structured, semi-structured, and unstructured. The interview type depends on the advance planning of the interviews. In the

structured interview, questions are carefully planned and formulated before the interview, based on the research framework and hypotheses. In an unstructured interview, the themes for research guide the interview. (Järvinen 2001; Järvinen & Järvinen 2000) These interviews are not planned in detail beforehand and thus the interviewees are asked open ended questions (Hirsjärvi & Hurme 2000). Additionally, the interviewees can be asked for the facts of a matter as well as for the interviewee's opinions about events (Yin 1994). The semi-structured interview includes both structured questions and open themes of discussion (Järvinen & Järvinen 2000).

In this study, the interviews were semi-structured, since the interviews included structured questions, and proceeded along certain vital themes of the research. The vital themes of research were created based on the literature analysis, and findings of the questionnaire studies. Based on the literature, the themes related to roadmapping, collaborative development, and requirements prioritisation. Additionally, based on the findings of the questionnaire studies, the themes related to collaborative viewpoints to product roadmapping and different phases of product roadmapping. Therefore, especially the company experiences of creating product roadmaps in inter-company collaboration were emphasised during the interviews. Additionally, questions relating to the benefits and problems of the product roadmapping were asked. The interview themes were the same for all the interviewees, but the questions varied between the different interview sessions. Additionally, the interview questions were partly planned in advance, but not in detail formed or arranged. Moreover, the intention in the interviews was to emphasise the interviewee's experiences and their own opinions on the field of study. The framework for the interviews is presented in Appendix 3.

5.3 Research Context

At the beginning of the empirical research, a survey questionnaire was sent to potentially interested contacts, i.e. companies assumed to have experience on product roadmapping, through VTT's electronic mailing lists. Also, the questionnaire was send to Merlin partner companies. The survey was e-mailed to over 600 respondents in summer 2006. The respondents were given two weeks time to answer the questionnaire. The respondents were reminded once about the

questionnaire during the two weeks' response time. After the questionnaire studies, the research was continued with interviews. The purpose of the interviews was to find more and in detail, how different collaboration modes affect the product roadmapping. In the questionnaire studies, the respondents were asked whether they would be interested in participating in further research in the form of an interview. Seventeen of the respondents replied that they would be willing to participate in an interview, which would be organized either as a phone or a face-to-face interview. Because of the time limit, not all the respondents could be interviewed. Therefore, the interviewees were selected based on the company's experience in product roadmapping in collaboration.

The conducted interviews were both phone and face-to-face interviews. The interviews could be considered focused interviews, since the respondents were interviewed personally for a short period of time, i.e. not more than an hour (Yin 1994). All the interviews were tape recorded with a digital dictating machine so that the responses could be verified after the interview in order to get the correct information. After the interviews, the tape recordings were transcribed. Thereafter, as Hirsjärvi and Hurme (2000) suggest, the material of the interviews was read through several times to form a clear idea of the data for further analysis.

As said by Hirsjärvi and Hurme (2000), mainly qualitative data should be examined through analysis and synthesis. In the analysis, data should be itemized and classified, and in the synthesis, the purpose should be to create a general view of the data and to present the phenomenon from a new perspective (Hirsjärvi & Hurme 2000).

In this study, the qualitative data was analysed with classifying by type (Eskola & Suoranta 1998). First, the data was classified according to the research themes. Then, the analysis was continued with constructing generalised types from the interview answers, which were created based on the most common type of answers, that is, a combined type of answers. The types were then used as basis for creating a typical situation. In the analysis, attention was also paid to diverging types of answers, since they were seen as resource and not a threat. (Eskola & Suoranta 1998) After creating the types, the case material was rewritten based on the major findings of the analysis, in which the opinions of the researcher and classified types were combined. Afterwards, the analysis and

interpretations were continued with coupling earlier theories and research together with them. (Eskola 2001) More specific information about this data analysing method can be found in (Eskola 2001). Reporting of the questionnaire and interview research results are introduced in Chapter 6.

6. Results

In this chapter, results of the questionnaire and interview studies are presented. First, the case companies that decided to take part in the studies are introduced. Thereafter, the roadmapping process in the case companies is illustrated which includes the participants and different phases of the roadmapping process, as well as the most important and the most difficult phases of the product roadmapping process. Then, results relating to product roadmapping in collaboration are introduced, and challenges of the product roadmapping are defined. At the end of this chapter, research findings are discussed, and the main research results are summarised.

6.1 Case Companies

The return rate of the e-mail questionnaire survey was good, because the respondents of the e-mail lists were not in advance targeted to those persons only who would be expected to have experience on product roadmapping. In addition, due to the briefness of the questionnaire (three pages) many replies were received. On the other hand, the number of the responses was adequate for the analysis, since the more responses, the more reliable the results. Overall, 59 answers were received, of which seven replied that they did not have experience on the product roadmapping. Therefore, the total number of 52 replies from 34 different companies formed a good basis for further analysis. The replies that did not have experience on product roadmapping were not taken into account in the analysis, so that there were altogether 52 completed questionnaires. The companies who decided to take part in this survey came from Finland, Sweden and the Netherlands.

In the questionnaire studies, the respondents were asked whether they would be interested in participating in further research in the form of an interview. Seventeen of the respondents replied that they would be willing to participate in an interview. Because of the time limit, not all the respondents could be interviewed. Thus, the interviewees were selected based on the company's experience in product roadmapping in collaboration. After the questionnaire studies, nine persons altogether were interviewed. Two of the interviews were

conducted as face-to-face interviews, and the seven other interviews were phone interviews. Majority of the interviews were phone interviews, since phone interviews were easier to arrange and through phone interviews, the interviewees were easier to reach.

The interviewees were from eight different companies. Five of the companies were large with more than 250 employees. Two of the companies were medium sized with 50–250 employees, and one of the companies was small with less than 50 employees. The interviewees were in different roles in the companies. Two of the interviewees were general managers and two of the interviewees were group managers. Rest the interviewees were in the following roles: chief technology officer (CTO), program director, chief engineer, senior researcher, and product planner. The roles of the interviewees are not supposed to have affects on the research results.

Table 2 provides a summary of the conducted interviews indicating company nationality, company size, and role of interviewee. The duration of the interviews, varied between 30 and 60 minutes. Most of the interviews lasted approximately half an hour.

Table 2. Summary of the Interviews.

Interviewee	**Company Nationality**	**Company size**	**Role of the Interviewee**
1	Finnish	more than 250 employees	General Manager
2	Finnish	more than 250 employees	Group Manager
3	Finnish	50–250 employees	CTO
4	Finnish	more than 250 employees	Product planner
5	Finnish	fewer than 10 employees	Program Director
6	Finnish	more than 250 employees	Group Manager
7	Finnish	more than 250 employees	Chief Engineer
8	Swedish	more than 250 employees	Senior Researcher
9	Finnish	50–250 employees	General Manager

All companies surveyed were involved in software product or service development. Their scopes varied from own product development to the development of components for external partners. The size of the case companies, measured as the number of overall employees, was distributed among the given categories in the questionnaire (under 10 employees, 10–49 employees, 50–250 employees, and over 250 employees) with an emphasis on middle and large companies. One of the replies was excluded from the results, since the respondent did not select any of the alternatives, thus the total number of respondents was 51. The distribution of answers among the company's size is illustrated in Figure 4.

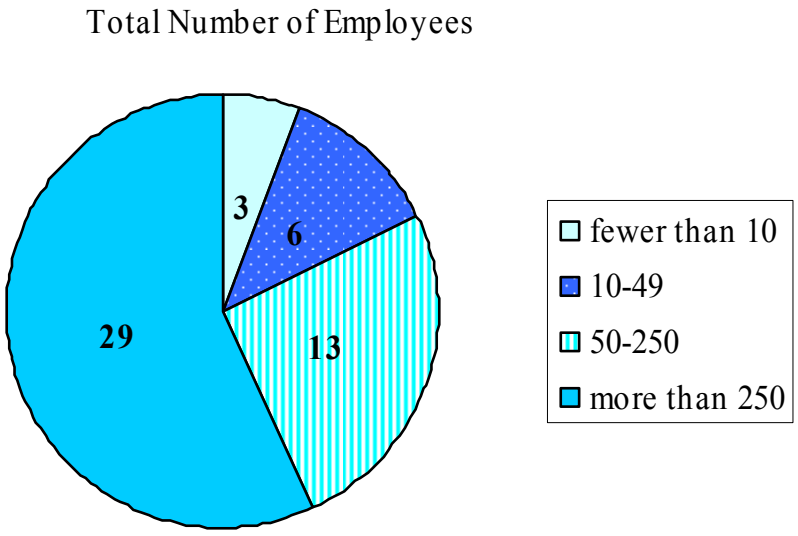

Figure 4. Sizes of the Case Companies.

In order to find out more about the case companies, the servicelife of the company's products in use by customers was distributed among the given categories (0–1 years, 1–3 years, 3–6 years, 6–10 years, more than 10 years, and other). In Figure 5 illustrates the distribution between the response alternatives, in which it can be seen that the replies divided quite evenly among the given categories.

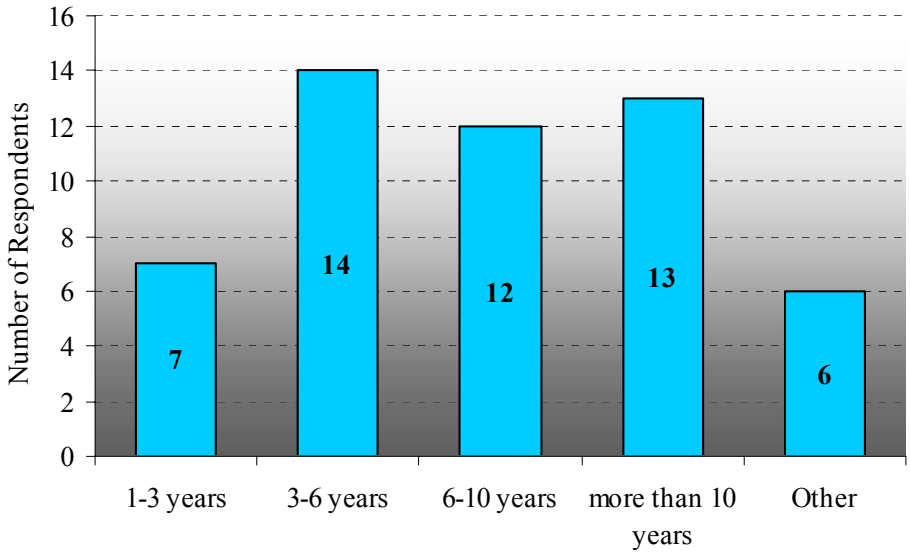

Figure 5. The Servicelife of the Case Companies Products.

Majority of the responses selected one of the following three categories: between three to six years, between six to ten years, and more than ten years. Thereafter, according to seven of the respondents the company's product cycle was between one to three years. To the category "other", the respondents described that several categories could be chosen or that the product lifecycle depended on the case or the product. Additionally, it should be noticed that none of the respondents felt that the company's product lifecycle was under one year.

6.2 Product Roadmapping Process

Among the interviewees, roadmapping was thought of as a continuous process, since the roadmapping team had meetings biweekly, quarterly, or biannually, in which roadmaps were updated and reviewed. The majority of the interviewees replied that the product roadmapping process began with the customer requirements. These requirements could be, for instance, proposals for improvement or new product features as well as the customer's goals or expectations. The requirements could also come from the company's internal research unit or through competitor analysis. Also, changes in the standards could cause the beginning of a product roadmapping, since standards are

compulsory matters to be considered in some fields of the product development. The product roadmapping process could also begin with defining what product features were emphasised on the markets. Typically, these issues were considered in the first roadmapping meeting.

The roadmapping process consisted of three to six phases according to the interviewees. Although some of the companies had fewer phases, almost all companies had the same tasks to be performed during the roadmapping process, since some of the phases were combined in some case companies. Additionally, the content of the roadmapping phases were the same, as suggested in Chapter 2. However, the names of the phases varied among the case companies.

Next, the participants of the roadmapping process according to questionnaire and interview studies are presented. Then, the common practices relating to different phases of product roadmapping according to the case companies are introduced.

6.2.1 Participants of the Product Roadmapping Process

According to the interviewees, the product roadmapping process had only two roles: a member of product roadmapping team and a product or solution owner. On the contrary, there was a third role mentioned in the literature, which was the facilitator's role. According to the interviewees, the most important role was the owner's role, because this person had the final idea of the desired roadmap, and thus each roadmap should have its owner. The owner also collected input, held the roadmap together as well, made the needed changes to the roadmaps, and took care of the information flow inside and outside the company. Instead, the roadmapping team brought input from different viewpoints to the roadmap, e.g. to schedules and to product features. The team was also responsible for evaluating and prioritising features as well as reviewing created roadmaps.

In order to clarify different definitions in the literature about the participants of the roadmapping process, the respondents were asked to select different functions of the organisation that should take part in the product roadmapping process. The participants were divided into following categories: product management, finance, engineering, marketing, manufacturing, services, development, customer and partner representatives, and other. Figure 6

illustrates the participants of the roadmapping process based on the questionnaire replies. According to the respondents, at least the following functions should participate into the product roadmapping process: product management, marketing, development, customer and partner representatives, and engineering, since these categories got more than 30 of the total number of replies. However, all the categories were considered important, because they were selected by over 11 of the respondents. Additionally, 11 of the respondents thought that other groups of representatives were needed in the process. These groups included various degrees of management, e.g. top management, senior management, and human resource management, as well as final users and sales.

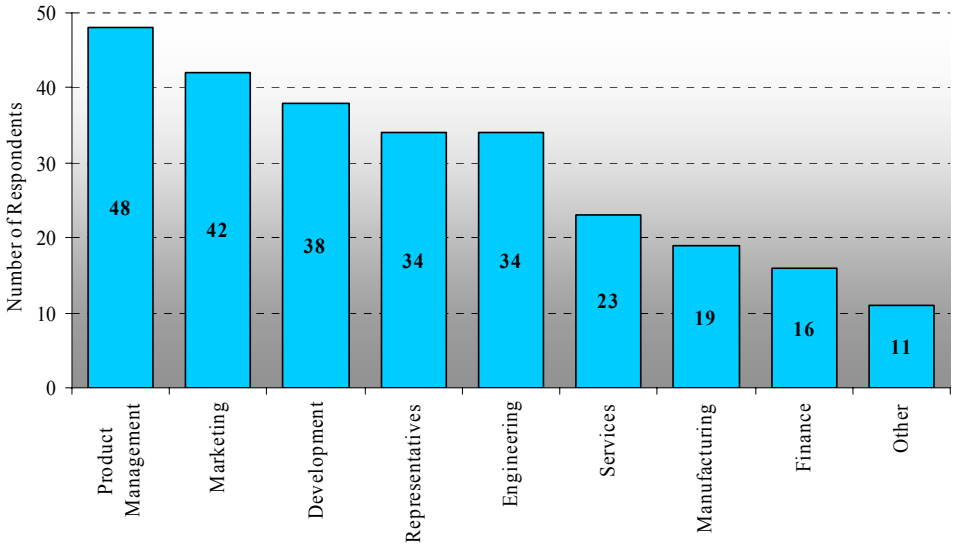

Figure 6. Participants of the Product Roadmapping Process.

When several different functions from organisation(s) participate in the roadmapping process, the number of participants can be quite large. Therefore, the respondents were asked to describe how many persons participate in the roadmapping process in their company from the given categories (1–5 persons, 6–10 persons, 11–20 persons, 21–30 persons, and other). Two of the responses were ignored, because they left this question unanswered, thus the total number of responses was 50. In Figure 7 illustrates the distribution of the number of participants.

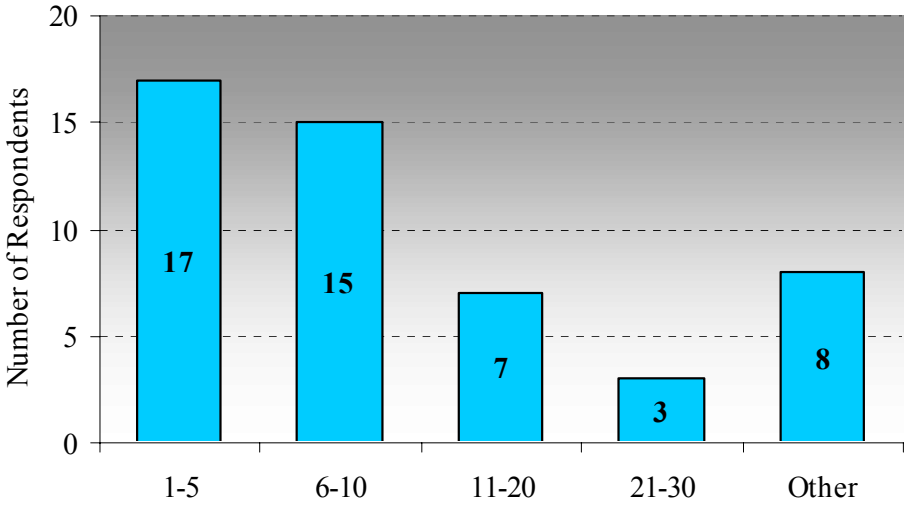

Figure 7. Number of Participants in the Product Roadmapping Process.

It was surprising to notice that the category "1–5 persons" was selected by 17 of the respondents, even though most of the companies were considered large. Thereafter, the second highest rate was given to the category "6–10 persons" with 15 of the replies. The third largest category was "Other" with eight of the replies, in which the respondents explained that more than thirty, fifty, or hundred persons should participate in the roadmapping process. Additionally, some of the respondents described that hundreds or several hundreds, or more than two hundred persons should take part in the roadmapping process. The two last categories were not such a common number of participants, since category "11–20 persons" got seven and the category "21–30 persons" got only three of the total number of replies.

Since the largest group of participants was 1–5 persons, it was interesting to find out how the company's size affects on the number of participants in the roadmapping process. In Figure 8 illustrates the distribution between the replies divided according to the size of the company. According to majority of the small companies with fewer than 50 employees, one to five persons should participate in the product roadmapping process. Instead, in medium sized companies with employees from 50 to 250, the number of participants in the roadmapping process was from six to ten. Furthermore, in case of large companies with more than 250 employees the number of participants was more than thirty, and could be even several hundreds, which made the process very complex, as one of the

respondents explained. Thus, the number of participants in the process was directly connected to the size of the company.

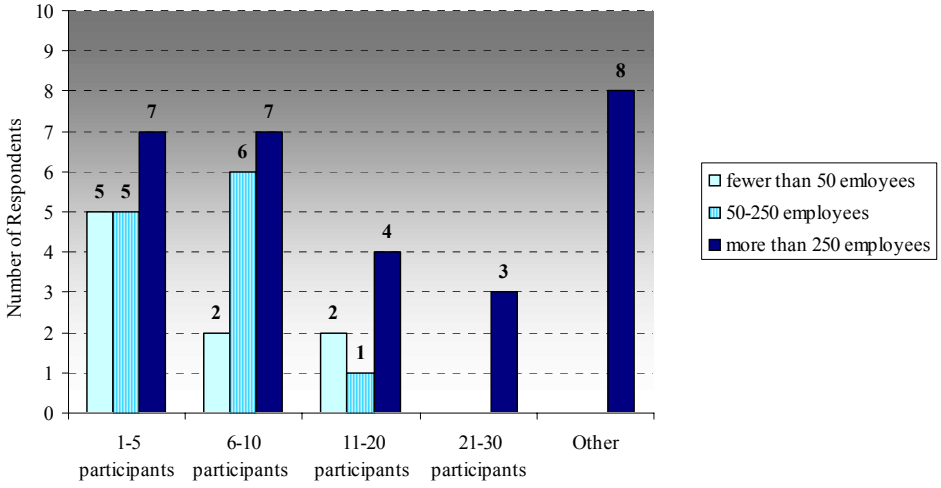

Figure 8. Number of Participants According to Three Company Sizes.

The interviewees also emphasised that not all the participants were necessarily present during each phase of the process. Instead, the participants only participated in those phases that affected their work or knowledge. Especially, when the company was large, there were different types of roles from different kinds of companies that were involved in different phases of roadmapping. Thus, there were few meetings with different groups of participants to focus on specific areas of the product. Afterwards, there could be, for instance, a separate feature prioritisation session, and a joined meeting to discuss all the issues. Instead, in smaller companies when the process included fewer participants, all the participants could be present in each phase of the process.

6.2.2 Capturing Features

As mentioned in the literature, there are several methods, which can be used during capturing features. To find out what kind of feature capturing methods were used in the case companies, the questionnaire respondents were asked to select the used method(s) from the given categories (with prototyping, with interviewing, gathering ideas over time, in some kind of workshops, and other).

All 52 responses were included in the analysis; most of the respondents selected more than one alternative. The selection of the feature capturing methods among the replies is illustrated in Figure 9.

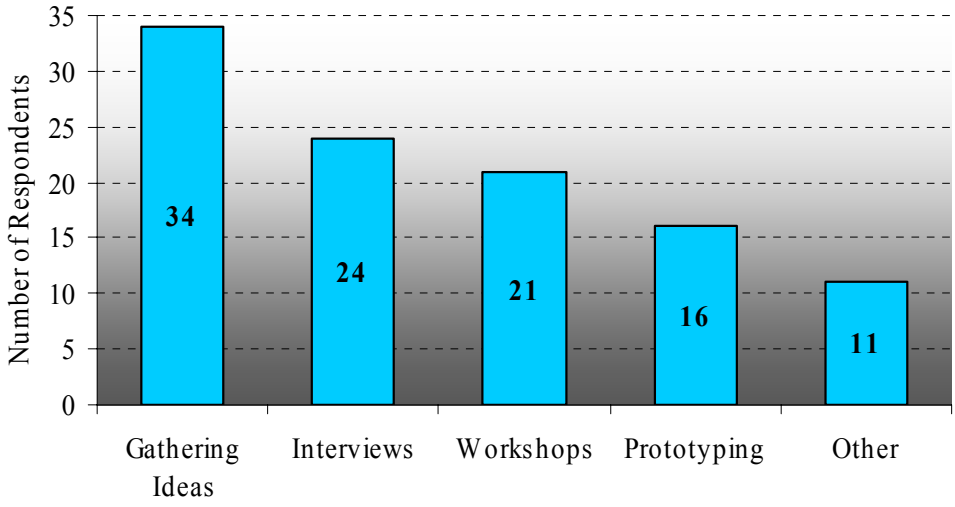

Figure 9. Methods for Capturing Features.

Although the literature on the field of the study highly suggests using workshops for capturing features, the questionnaire replies revealed that some other procedures were used more often than workshops. Accordingly, the most commonly used method was gathering ideas over time and after that, interviews. Additionally, 11 of the respondents used some other methods to capture features. These methods included, for instance, market and technical research, following market development and standards, as well as analysing the distribution channels and their requirements.

According to the interviews, during capturing features, knowledge on different participants was combined. Thus, features came from several sources, for instance the company could follow common market trends and standards. The features could also come from collaborators, sales, management, or product architects, as well as from their own research, for example, through customer and competitor analysis. Also in one case company, the features were typically captured and feedback was collected through trade shows and by distributing a free evaluation version trough Internet.

In some case companies, the idea of the product was created together with collaboration partners, e.g. through brainstorming. In the other case companies, possible participants and co-operation partners were clarified after a product idea was created inside the company. However, in order to ensure that everybody has understood the idea of the product feature correctly, the actual meaning of the suggested features had to be written down, as one of the interviewees noted.

Collaboration did not have effect on capturing the features, according to some interviewees, since it was considered an in-company process. Instead, according to other interviewees, the collaboration had effects, since the partner could give suggestions, edge conditions, and limitations for creating the roadmaps. Additionally, it was noted that when features were captured together, there was a possibility to stimulate and analyze different approaches with the partner, which enabled efficient use of resources.

6.2.3 Analysing Features

Features were analysed by using different methods among the case companies. Some of the case companies used domain-specific knowledge and experience as well as interviewed experts during analysis. Further, in one case company, the major features were analysed through a feasibility study, as suggested in the literature. The feasibility study included both technical and cost analysis. Based on the analysis estimations for the revenues, sales and implementation could be made. Minor features were not analysed, but instead they were planned and then considered whether they fit into the product content or not. If not, they were dropped or postponed as candidate for next product release. Usually, the analysing features was conducted by the experts from different roles, e.g. with sales value, with technical value, and with strategic value. However, in one case company, analysing features was a responsibility of the product manager or person in charge of the product. Typically, the most important factors in analysing features were; what does it cost, does it require some specific hardware, and what are the use cases, e.g. when it is being used, and what else should function at the same time.

In more detail, analysing features consisted of three phases. First, it was verified whether the features were understood correctly. For example, if the features

were recorded exactly, and if the feature description included information concerning the feature's functionality and limitations. Secondly, it was figured out what kind of technology would implement the features, which was typically considered by the architects and technical persons. This could also involve prototyping or drawing a sketch from the software architecture, which helped to understand the implementation of the features from the technical viewpoint. Third, after creating basic knowledge and understanding, it was estimated how much it would take in terms of time, money, and cooperation work to implement the features.

Collaboration had effects on analysing the features, since it helped to verify things faster, as one of the interviewees replied. It was also thought that there could be disagreements and misunderstanding between partners during analysis. One of the interviewees explained that some features were more important to the partner, and it caused that some other features had to be left outside the product, so compromises had to be made. Therefore, partners usually participated in the analysis to suggest their own opinions about the features. It was also noticed that continuous communication with the partner was needed, since during analysis missing features, for instance, were noticed. Thus, new features required conversations with the partner to maintain mutual understanding.

6.2.4 Prioritising Features

According to the literature, the product features can be prioritised both with formal or informal methods. To find out what kind of prioritisation methods were typically used, the respondents were asked to select either formal, informal or both methods. The distribution of answers among the prioritisation methods is illustrated in Figure 10.

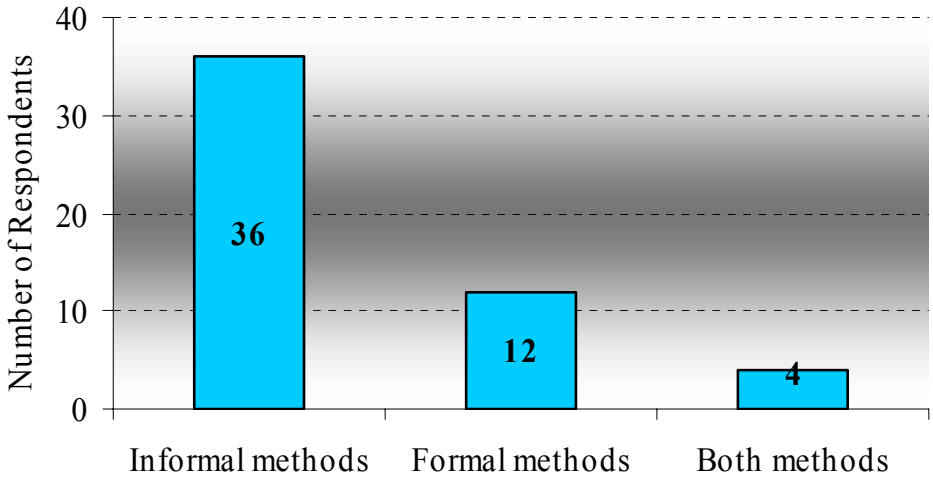

Figure 10. Prioritisation Methods.

Clear majority of the 52 respondents selected the informal methods with 36 of the total number of replies. Thereafter, 12 of the respondents used formal methods only, and four of the respondents used both methods for prioritising features. The formal prioritisation methods included AHP, Distributed Prioritisation, QFD, and EVOLVE. Additionally, in one case company, formal methods contained business cases, probability analysis (win/lose), and customer and market importance balancing.

Moreover, two of the interviewees had experience on the use of formal prioritisation methods, Distributed Prioritisation and AHP. Distributed Prioritisation was used when it was supported with tools allowing simulation of multiple approaches and weighting of answers. It was also used to support distributed knowledge, since within global company it was important to gather distributed priorities from all perspectives. Instead, AHP was used to find out focal points, etc. Accordingly, also AHP supported distribution. That was partly because the case company's user interface supported sharing and distributing information between companies.

According to the interviews, both functional and non-functional requirements were prioritised at the same time. In addition, there were no special methods for prioritising non-functional requirements. Prioritisation was informal and sometimes based on ad hoc iteration. The informal prioritising methods varied

among the case companies. For instance, the priorities could be created by using calculation system. In that case, each feature was given a point, which could also be a weighting factor, work contribution or caused costs. After giving the points, it could be seen which of the features had won. Based on the points, the order of priority was formed. Instead, in some case companies, number of customerships per feature or values related to technical importance, market value, or easiness with return on investment (ROI), guided prioritisation. On the other hand, in some cases, more information relating to the features were considered during the prioritisation. For example, customer preferences, legislatively or release specific features, and real world matters guided prioritisation.

Typically, the order of priority of the features was a result of a decision in the roadmapping team. Also in some cases, the decision could be made by the product manager, CTO, the owner, or the person in charge of the product. Usually, minor problems concerning the priorities were handled inside the team and the major problems were resolved by the management team of the company or companies. Additionally, in some case companies, the customer made the final decision concerning the priorities, especially, when intermediate versions from the product were important to the customer.

One of the interviewees said that the prioritisation was in-company process and hence collaboration did not affect the prioritisation. However, according to the other interviewees, collaboration had effects on prioritising features. Thus, it was suggested that collaboration should help prioritisation, as more information was faster and easier available for decision-making. Prioritisation was also considered more complex as more input givers were involved. However, all parties had to have mutual understanding about the features, even though good quality criteria were difficult to write down, since it was noted difficult to describe in detail the quality features and functionality.

6.2.5 Roadmap Validation and Agreement

Commonly, there were two means of performing validation according to the interviewees. According to the first group of interviewees, roadmaps were validated through negotiations, meetings, or reviews. Accordingly, reviews were the most efficient way of performing validation, especially when roadmaps were

reviewed with an adequate number of persons. During the review process, inputs as well as comments were collected, and if there was any essential new information, the necessary changes to the roadmaps were made. Hence, in order to widely spread and review the roadmaps, they were kept in either paper or electronic format. Additionally, the roadmap validation could be manifested in contracts. It could even be a legal contract, if there was going to be financial matters involved. Moreover, when roadmaps were created together with collaborators, then roadmap validation was also performed at mutual meetings with the partner. Typically, the customer confirmed that the roadmap was good.

Instead, according to the other group of interviewees, validation took place when the customers started to buy or not to buy the product. Thus, validation came through the unit's improvement and customer feedback. If bad results were obtained, then the results were analysed. For instance, why product development had gone to the wrong direction or why the newest version did not answer to the customer's needs. The roadmap validation could also come through commercial success, e.g. number of sold products.

The roadmap agreement was made in a meeting in which the roadmapping team participated. Also, the agreement could be made by the product owners, the product managers, or CTO, depending on the case company, and when needed the management participated in the meetings as well. In the meeting, the product roadmapping team made a mutual decision about the roadmap, such as "this is what we want" and based on that the work can proceed. The roadmap agreement was made to have mutual understanding about the product that was being developed. The agreement also made the roadmap official. Thus, with the agreement, it could be ensured that commitment existed and everybody knew the decided matters.

Collaboration also affected roadmap validation and agreement. As one of the interviewees described, more information was available for decision-making. Another interviewee noted that collaboration improved the business relevance of the roadmap as more perspectives were involved, but then it was also more complicated to reach an agreement. Additionally, the partners had to be committed to the roadmap and the product development. Therefore, the roadmap was typically a legal agreement, which had to be updated when changes occurred.

6.2.6 Change Management of the Roadmap

According to the interviewees, changes to the roadmaps came from delays in the product implementation as well as when new or unnecessary product features were discovered. Additionally, when partners or customers were informed about the new solutions, they typically brought out matters that might not have been taken into account earlier. These new matters had to be brought out to the ongoing releases or left at the roadmap for the forthcoming product releases. Among the case companies, there were meeting practices for change management, in which change requests were handled and decisions concerning the change were made. Especially, changes that affected schedules and money were managed in joint meetings with the partners. That was because on the meetings, notes were taken and meeting memos were written down, in case there was a need to verify the change decisions later on.

The roadmap change process typically went as follows: First, the change request was noticed by either one of the collaboration partners. Secondly, the effects of the change were analysed, i.e. impact analysis was conducted. Third, changes were approved together with the partners, or a customer was requested to approve the changes. That was because all the decisions had to be conscious and those that were mostly affected by the change had to be able to affect the change decisions. Thereafter, it was verified that everyone had understood the changes. Finally, the changes were joined in with the rest of the features, i.e. a new roadmap or updated version of a roadmap was created, which was then communicated.

The decision-maker of the change depended on the importance of the matter to be changed. The minor changes could be made by the product manager or CTO. The major changes were managed by the roadmapping team. The major changes related to schedules, deleting important or key features from the roadmap, or adding bigger features to the roadmap, etc. Thus, these changes had to be communicated and approved by the same forum that had approved the roadmap. Instead, when the customer was the payer, then the final decision was made by the customer. Moreover, in other collaboration situations, the first, preliminary decision concerning the change was made inside the case company. Thereafter, the change decision was negotiated together with the collaboration partners in meetings, and they tried to reach an agreement. When unsolvable problems

occurred during meetings, then management of the companies made the final decisions concerning the change. Therefore, in collaboration the changes could not be unilaterally decided, instead they had to be approved mutually. Usually, the rules concerning the change management were known and approved before cooperation, for example, in the cooperation agreement.

Based on the interviews, collaboration affected the change management in several ways. For instance, the company could have persons on the market area who were regularly cooperating with the partners. These persons were the ones who commonly noticed the change proposals. Additionally, there could be an upper-management, who met the most important customers regularly. Then also, the roadmaps were reviewed. During the roadmap review if something did not please the customer, different alternatives were searched and communicated. The aim was to find a new solution and make changes to the roadmaps accordingly. Also, roles between the collaborators had to be clear in order to divide the change management tasks. For example, in case when changes came from the customer, e.g. customer's technical environment or some feature's order of priority changed. Then the changes were analysed and approved by the customer. When collaborators were involved in the roadmapping, then changes to the roadmap also meant changes to the cooperation agreement. If the change request came on a part that affected the partner, then the partner had to be involved in the change management process as well. Then, the need for an impact analysis was proposed, and the partner's reply was waited. At the end, the input from the partner's change impact analysis was taken into the change management process.

6.2.7 Critical Phases in Product Roadmapping

The critical phases in product roadmapping relate to the most important and the most difficult phases of product roadmapping process. Therefore, to find this specific information about product roadmapping, the questionnaire respondents were asked to rank the roadmapping phases from the most important to the least significant with numbers, in which one meant the most significant and five meant the least significant. The phases were divided into following categories: capturing features into roadmaps, analysing features, prioritising features, roadmap validation and agreement, change management of the roadmap, and

other. Two of the replies were left outside the analysis since several ”most significant” alternatives were selected. Hence, the total number of replies was 50. It should be noticed that not all of the respondents ranked all the categories. Instead, some of the respondents only selected one to three phases that were considered the most significant, and left the other phases outside the ranking. Thus, some of the categories have fewer replies. Figure 11 illustrates the phases of the product roadmapping process and the ranking order given by the respondents.

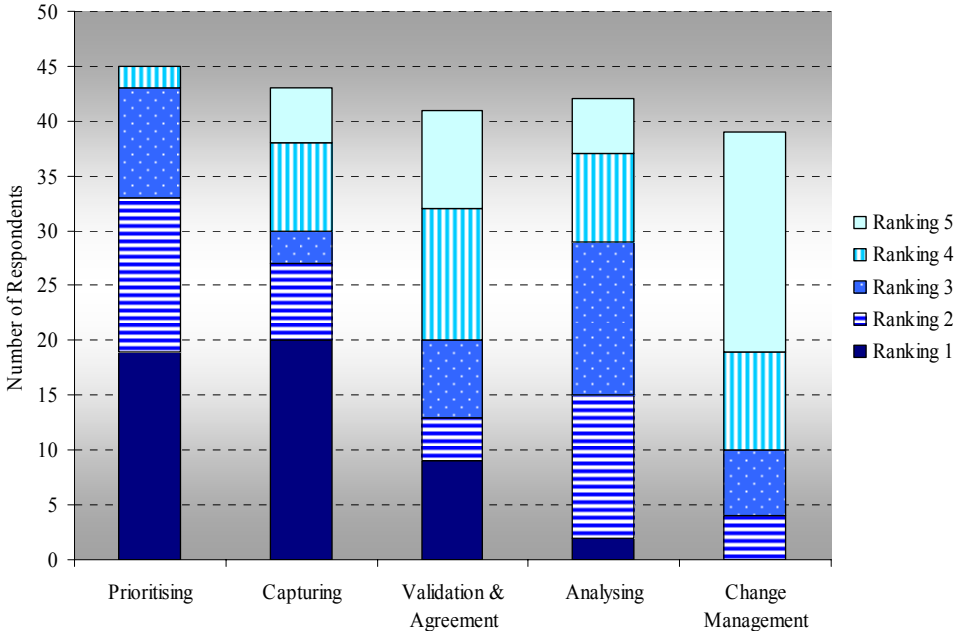

Figure 11. The Most Important Phase in Roadmapping.

The majority of the most important replies, 20 altogether, were given to the capturing features. After this came the prioritising features phase with 19 of the most important replies. Since none of the respondents thought that prioritising features was the least significant phase in roadmapping, the prioritising product features was considered the most important phase in the product roadmapping, and then the capturing features. The roadmap validation and agreement was considered the third most important, and the analysing features phase was the fourth most important. The change management of the roadmap was not considered so important, since none of the respondents ranked this phase as the

most important. Instead, the majority of replies gave this phase the rate of the least significant. This can be explained by the fact that the change management will not help, if all the other phases have gone wrong.

Thereafter, the respondents were asked to select one of the product roadmapping phases that was the most difficult. According to the clear majority of replies, the most difficult phase was prioritising features. The other phases were distributed quite equally among the replies, which is illustrated in Figure 12.

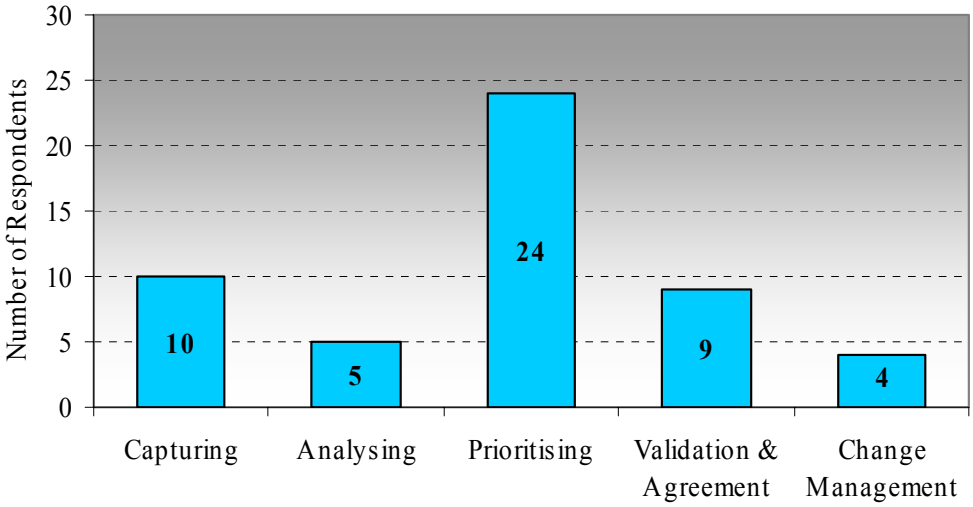

Figure 12. The Most Difficult Phase in Product Roadmapping.

In order to find whether the company's size affects the most difficult phase in roadmapping, the companies were divided into the three size groups. The total number of replies was 51, since one of the replies was ignored because the size of the company was unknown. Figure 13 illustrates the most difficult phase of the roadmapping process arranged according to the size of the company.

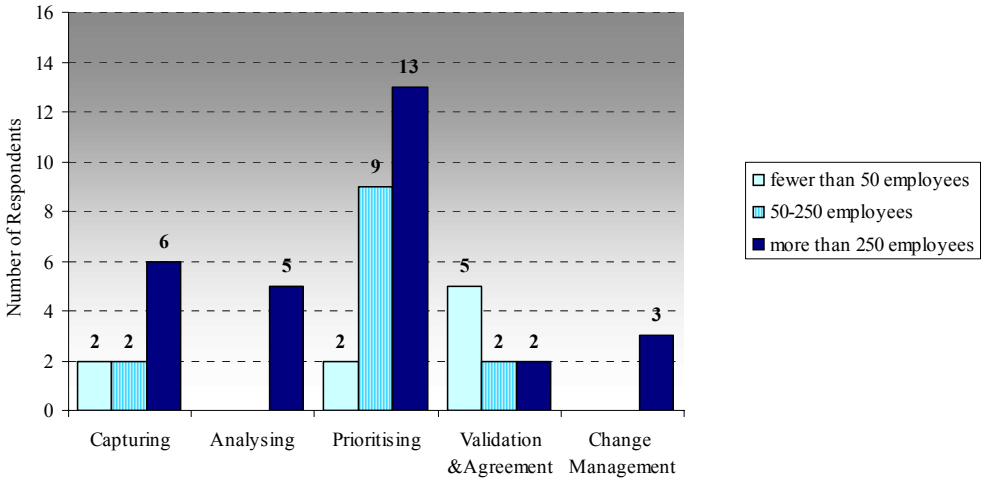

Figure 13. The Most Difficult Phase According to Company Sizes.

Based on the replies, both the medium and the large sized company groups thought, that the most difficult phase of roadmapping was the prioritising features. Instead, according to small companies, the most difficult phase in the product roadmapping was the roadmap validation and agreement phase. Additionally, large companies faced difficulties during all the phases of roadmapping unlike the small and medium sized companies that faced difficulties only during prioritising features, roadmap validation and agreement, and capturing features into product roadmaps.

Furthermore, it was analysed whether the lifetime of the company's products had effects on the most difficult phases of the roadmapping. The product servicelives in use by customers were divided into following categories: lifetime from one to six years, lifetime over six years, and other that included products with varying lifespan from one to more than ten years. Figure 14 illustrates the most difficult phase of the roadmapping process arranged according to the lifetime of the company's products.

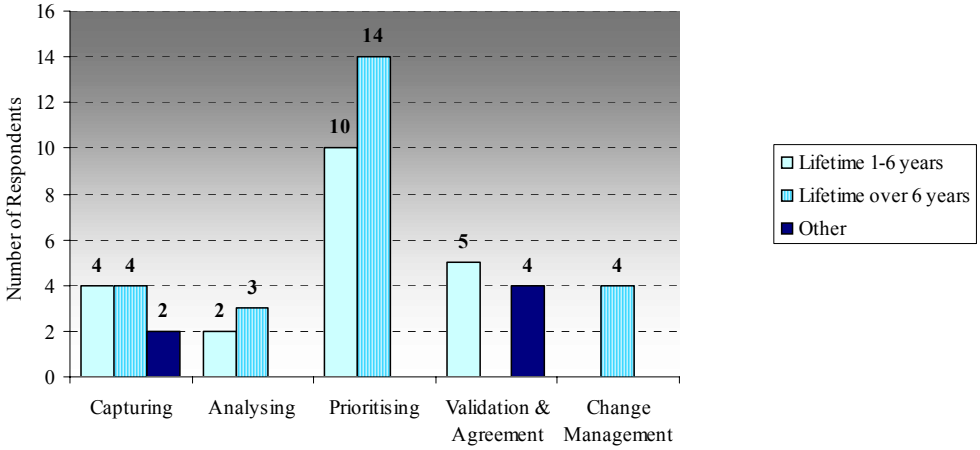

Figure 14. The Most Difficult Phase According to the Product Lifetimes.

The companies with product lifetime between one to six years had difficulties during all the phases of roadmapping except during the change management phase. Additionally, the companies with product lifetime over six years did not face difficulties during the roadmap validation and agreement. Instead, companies that selected category "Other" faced only difficulties during roadmap validation and agreement, and capturing features.

6.3 Product Roadmapping versus Collaboration Modes

Of the total of 52 questionnaire respondents, 33 respondents had experience on collaboration, of whom 29 had experience on customer-supplier relationships, 15 had experience on joint R&D partnerships, and six had experience on technology exchange and licensing agreements. Furthermore, of the nine interviewees, seven persons had experience on customer-supplier relationships, five persons had experience on joint R&D partnerships, and two persons had experience on technology exchange and licensing agreements. Hence, information relating to customer-supplier relationship mostly was gained.

Creating product roadmaps could be partly, totally or not at all manual work, according to the interviewees. The creation of the product roadmap in collaboration depended on the product to be developed and the form of cooperation as presented in Table 3. For instance, period of the product's lifespan,

closeness of the relationships, and type of the partnership, i.e. who was in control of the activities taking place, influenced product roadmap creation process.

Table 3. Creating Product Roadmaps in Collaboration.

	Close Collaboration	**Distant Collaboration**
Long Lifespan Products	Roadmaps are created together.	Collaborators create roadmaps themselves, and then show some parts of the roadmap to the partner.
Short Lifespan Products	Some parts of the roadmap are created together.	Roadmaps are not created together.

When the partnership was long and close, the product roadmaps were created together. For example, when the product was being created for the client, then the partner became part of the client company, and thus the cooperation became very close. Additionally, in case of long lifespan products, product roadmaps were created in closer co-operation and companies' roadmaps were shared more mutually. That was partly because partners wanted to correspond to each other's future challenges. Instead, when the partnership was not so long lasting and intensive, or the purpose was to create a short lifespan product, then the partners did not create the product roadmaps together. In that case, the partners created the roadmaps by themselves and then shared or showed some parts of the roadmap to the partner. Furthermore, that was the case when the customer was a competitor. Hence, as one of the interviewees replied, different situations required different types of communications, roadmaps, and alignment.

Product roadmaps were created together with collaboration partners through negotiation; information was shared between partners, and if there were any misalignments then they had to be solved, so there was always conciliation involved. Additionally, tools allowing collecting and sorting out the received feedback were used in the creation of the product roadmaps. In the case, when most of the product was created together with the collaboration partners, the product roadmapping process took the partners' practices into account early on. Therefore, before launching the actual project, the negotiations were conducted and the contracts were signed between the collaboration partners. In the contracts, contact persons from both partners were agreed and creation of the

product roadmaps was defined. In addition, the means of steering the roadmap creation process, e.g. regular project meetings, were defined in the contracts. The contracts could also include obligations to partners to inform if they acquire new technology that affects the content of the roadmap.

Moreover, when the product roadmaps were created together with collaboration partners, it was important to write down unambiguous and clear features that could be set on a timeline. The timeline presented when the features were to be ready and what their quality was. That ensured that all parties had mutual understanding about the features and the whole product. It was also important to approve the milestones together and to synchronise the processes when there were more collaborators involved in the process. Therefore, the product roadmapping process required more brainstorming and going through ideas jointly.

When product roadmaps were created together with collaboration partners, it produced results that were more accurate than when product roadmaps were created inside the company. That was because then mutual interests were aligned through communication. Collaboration also saved processing time and enabled better visibility, common understanding, as well as efficient use of resources.

In *customer-supplier relationship*, roadmapping starts with planning, sharing information, and communication to create a mutual vision about the product. Thus, a central idea in creating product roadmaps together with the customer and supplier was to create mutual understanding before the product was being implemented. However, the product roadmap was confidential and the competitors should not know it. Hence, the roadmap was considered a business secret and a competitive advantage. Therefore, confidentially and secrecy were important in the customer-supplier relationships.

There were several definitions among the interviewees, how the roadmaps were created in the customer-supplier relationship. For instance, according to one group of interviewees, the company only had specific points in time when they met in the line with the customer-supplier relationship partners, which was not on the daily basis. Therefore, the partners did not create the product roadmaps together, but the partners' viewpoints were collected as input to the roadmaps. Afterwards, the created roadmaps were shown to the partners to the appropriate extent; not all the big secrets were shown, e.g. plans for the future. Instead,

according to another interviewee group, customers and subcontractors participated in the creation of the product roadmaps. Especially, the customers were present, since they were considered dominant partners, whose opinion ruled. In addition, when the product was being developed together with a subcontractor and there was a common customer, the customer made the final decisions.

When the product roadmap was created in *joint R&D partnerships*, then the partners had to have mutual understanding of each other's roadmaps and deeper insights to them. Additionally, the partners had to be able to disclose confidential matters. In this kind of relationship, either one was the leading partner, who had the overall idea of the product to be developed. The other partner supported and gave input to the process. The leading partner created the first idea of the product, and most likely was the owner of the roadmap. However, the supporting partner was also closely related to creating the idea of the product and to other phases as well, especially to the parts that affect them. The supporting partner also helped the leading partner to create the roadmap and the final view of the product.

When the product roadmaps were created together with *technology exchange or licensing agreement* partners, then the relationship was a more matter of legal agreements and contracts that controlled the strategy. Therefore, according to one group of interviewees, it was not common to share roadmaps in the way as in the other modes of collaboration. Thus, the technology exchange and licensing agreements were more a matter of disclosure and trust. The partners had their own roadmaps, and there was an agreement on a line strategy. This meant that the partners only showed the schedule requirements to each other, but not the actual roadmaps. Instead, according to another interviewee group, when a part of the product was created by a partner, e.g. a COTS vendor, then the roadmap was partly created together. That was because then the vendor could declare whether the wanted features could be done in a certain way or within a given schedule. The vendor could also bring out matters that affected the whole roadmap, e.g. matters that the integrator did not realise or did not notice before.

According to the interviewees, one of the most important activities in product roadmapping was to have cooperation in different layers of product development for instance with component manufacturers, regulators, standardisation organisations, and end-customers. Thus, in case of multiple actors in the

roadmapping process, also the project management was considered essential, because problems were caused when tasks were divided between partners, since nobody wanted to do more than was their part. Additionally, traditional roles between partners were vital, especially, during prioritising features, in order to know who makes the final decision about the priorities. Thus, also those persons who had the ability and powers to say that this is vital and this should be done first had to be involved in the roadmapping process.

Openness between the partners in order to share ideas and views mutually was also considered important, since it was essential to understand each other's views and reasons. Anyhow, intelligence had to be shared without loosing the critical confidentiality. Hence, creating good and confidential relationships with all customer and cooperation partners was significant. Moreover, creating long lasting customer relationships and, thereby, creating a reliable image of the case company to the customer was also considered essential. Additionally, one interviewee said that there has to be a customer need or an actual customership to confirm the roadmap's goal. Thus, the customer also acted as a controller for the product proposal that the roadmap stayed on track and that something useful was being created.

Moreover, the partners had to be tightly part of the product roadmapping process. Since if partners were preparing for the product implementation in the wrong way, then the required products might not have been created. Thus, the partner had to have components, production lines, and test arrangements with the right features in order to create the right products. Furthermore, determining the product's property rights was important, particularly when something new was being created. Hence, it had to be solved how the property rights should be divided between the collaboration partners.

Continuous *communication* with collaboration partners was vital, since there were several changes during the process. Daily communication between collaboration partners was arranged trough regular meetings, phone calls, and email. At the beginning of the roadmapping process, especially face-to-face meetings were considered important to avoid misunderstandings. Thereafter, participation in regular follow-up meetings was vital, in order to keep track of the product development. The partners could also come together ad hoc in case

of major changes in the product. Communication was also arranged through boards and forums as well as exchanging documents between partners.

The communication practices were different between small, and medium and large companies. With smaller companies, communication tools were typically email and telephone as well as telephone and net meetings. In medium and large sized companies and particularly with bigger collaboration partners, there could be connections between companies on external web pages, and tools supporting shared view and feedback collection. As one of the interviewees described, the company's intranet included web pages for the most important customers to download the new versions of the company's products. The web pages could also include the latest publication versions. Additionally, one of the interviewees said that in case of settled partnerships, the partners could have access thought extranets to project management systems and to the joint customer and product-specific data warehouses.

6.4 Product Roadmapping Challenges

Based on the interviews, a roadmap is a plan about the company's future directions, in other words, it is a leading map where the company is going with its products. Thus, it is the means of structuring and arranging the product development, in order to know how to use certain resources. A roadmap holds the product development together by guiding what is to be done and when. Hence, product development is somehow deterministic and enables steering of the product implementation. A roadmap also gives a clear focus in the product development, and provides high-level understanding of scoping the strategy. On the other hand, a clear strategy allows better planning and commitment to the set plans. Roadmapping also improves predictability, and hence reduces surprises during the development. With a roadmap, tasks to be done can be prioritised, and thus resources can be allocated to the most profitable projects. It can even be verified from the roadmap that the right things are done at the right time. Additionally, with a good roadmap the customer needs can be met with a product that they really want. Hence, the competitors can be beat. Moreover, a roadmap is a central tool for communication, and therefore it should be shown to the company's own staff and to partners. It gives a clear idea what is about to be done and enables communication about forthcoming strategic projects.

In the collaboration situation, a good roadmap is a document gathering up the cooperation parties. It is the main document about what the parties have agreed to together and what is about to be done together, so everybody knows the goals. That is to say, a roadmap is an agreement between partners, and the work proceeds according to this agreement. On a good roadmap, it can be seen what others are doing currently and in which phase they should be in. Thus, it simplifies the synchronisation between collaboration parties. It also gives vigour, backbone and predictability of product development for the partners.

Despite all the benefits that roadmapping has, it also has problems. According to the interviewees, there are problems relating to almost every phase of the product roadmapping process. Most commonly, the problems relate to prioritising the features, managing changes, and maintaining roadmaps. Also, sharing information, communication, and making the roadmap agreement were considered difficult.

Collecting input was considered difficult, and more precisely, getting the right information and accurate knowledge was problematic. Also, background research and finding out both competitors' and customers' opinions was difficult. Hence, uncertain predictions about the future were tried to be avoided by collecting feedback on the prediction accuracy. Additionally, it was highlighted that at the beginning of the product, the roadmaps could be more accurate which meant that a more precise product design could be created right from the beginning of the process.

In prioritisation, problems were caused by uncertainty about which features should be taken into which product version. It was also described that the strongest opinion may not be the best understanding of the values, and thus prioritisation should be done carefully. Further, if the prioritisation was not done with clear vision and with strategic thinking, it would lead to changes in plans and result in frustration of very ineffective product release cycles. Also, prioritising customer requirements was considered a continuous problem and a challenge in the roadmapping process. Making an agreement was also considered difficult, since combining and processing different viewpoints was complex. Especially, consolidation of different wishes, needs, and technical implementation possibilities in an economical frame was considered hard. Moreover, managing and maintaining product roadmaps was thought difficult.

The problems were caused by a large number of changing matters, and the more precise the roadmaps were the harder they were to maintain.

Communication about features across organisation borders to ensure that everyone involved understands the meaning of the features was considered difficult. Additionally, communication in large companies was considered problematic. Thus, it was suggested that sharing information and its visibility should be improved. Moreover, it was feared that information would get into wrong hands, since it was problematic to verify persons who should know about the roadmap, and that they were well aware of the content of the roadmap. Thus, it was a matter of concern, how to get the information without the danger of data leak. Hence, the purpose was to avoid the information from the roadmap from passing on to competitors or competitive companies.

6.5 Discussion and Summary

According to the empirical findings, the product roadmapping process was considered a continuous process that was a part of the product development process. Also, according to the findings, the product roadmapping process only had two different roles: owner and member of the roadmapping team, contrary to the literature where also a third role was mentioned, that is: facilitator. Further, in the literature, it was suggested that the roadmapping team was, among others, responsible for creating the roadmaps. However, based on the interviews, the roadmaps were created by the owner, and the main task of the team was to give input to the roadmap.

As several different functions were mentioned in the literature to take part in the roadmapping process, the empirical findings exposed that at least the following functions from an organisation should participate into the product roadmapping process: product management, marketing, development, customer and partner representatives, and engineering. Therefore, for example, participants from R&D, finance, and manufacturing were not seen as important as it was suggested in the literature. Additionally, based on the empirical findings, the number of participants in the roadmapping process was directly connected to the size of the company. In larger companies, more functions participate in the process. All of the participants were necessarily not present during each phase of

the process. Instead, they only participated those phases that affected their work or knowledge.

Although it was suggested in the literature that the roadmapping process is different in every company, according to the empirical results, the contents of the roadmapping processes were almost the same. The tasks to be done during the roadmapping process were the same in spite of the fact that the case companies had a different number of phases and different names for the phases. Thus, the phases could be divided into the phases suggested in this thesis.

Unlike it was suggested in the literature, the product roadmapping process begins with the customer requirements according to the interviews. In addition, the process could begin from product requirements that come from the company's internal research, or through competitor, market or standard analysis. Likewise, it was presented in the literature that workshops were most commonly used for capturing features. Instead, the questionnaire studies revealed that gathering ideas over time was the most commonly used method for capturing features and interviews after that. The methods for analysing features were almost the same in the literature and empirical results, but during the interviews, it was noted that there is a difference between analysing the major and minor features. The major features were analysed by using such methods as mentioned in the literature. Instead, the minor features were not analysed; on the contrary, they were only planned and then considered whether they fit into the product's content or not.

Features were typically prioritised by using informal prioritisation methods. However, the informal prioritising methods were different in literature and empirical findings. According to the interviewees, the priorities could be created by using calculation system, or number of customerships per feature or values related to technical importance, market value, or easiness with return on investment (ROI), guided prioritisation. Based on the interviews, more information relating to the features was considered during the prioritisation. For example, customer preferences, legislatively or release specific features, and real world matters guided prioritisation. As suggested in the literature, the roadmapping team prioritised the features, additionally based on interviews, if consensus could not be reached in the team, the management team of the company or companies made the final decision.

According to both literature and empirical findings, the roadmaps were typically validated and agreed on in meetings. However, according to some of the case companies, the validation occurred when the customers started to buy or not to buy the product. Hence, the validation could also come through the unit's improvement, customer feedback, or product's commercial success. Moreover, based on the empirical findings, the change management process of the roadmap consisted of four phases instead of six phases illustrated in the literature. Additionally, the findings revealed that in product roadmapping process there was no official CCB during the change management phase as suggested in the literature. Instead, the decisions concerning the change were made based on the importance of the matter to be changed. The minor changes were made by the product manager or COTS, and the major changes were managed by the roadmapping team.

Based on the literature, when the product roadmaps were created together with collaboration partners, for example, planning and training were considered important. Instead, based on the interviews, for example, collaboration in different layers of product development was important, and especially creating long and close relationships was vital. That was partly because openness and confidentiality were considered as bases for a good cooperation relationship. Additionally, project management and roles between collaborators were considered essential.

There were two definitions on how the roadmaps could be created in the customer-supplier relationship based on the empirical results. According to the first group, the roadmaps were created together. This perspective was also supported by the literature. Instead, according to the other group, the roadmaps were not created together, but the companies created the roadmaps by themselves then shared some parts of the roadmap with the collaboration partners. In addition, in technology exchange and licensing agreements typically, the partners did not create the roadmaps together, unlike presented in the literature analysis. However, there were also exceptions, for instance, when the product was being created together with the COST vendor.

6.5.1 Problems and Solutions

At the beginning of product roadmapping process, collecting input, and getting the right information and accurate knowledge was problematic according to the interviewees. As a solution, it was suggested that several different persons inside and outside the company should be involved in the process. Thus, it was proposed that collaborators should create the idea of the product together, and hence knowledge from different participants of the companies would be combined. Additionally, background research, and finding out both the competitors' and the customers opinions' was difficult. Thus, some of the case companies used consults to conduct the competitor or customer analysis. The customer feedback was also collected directly from the customers, e.g. through trade shows and by distributing free evaluation versions of the product through the Internet. Feedback was also collected on prediction accuracy in order to avoid uncertain predictions about the future.

According to the questionnaire respondents, the prioritisation phase was the most important phase in the roadmapping process. At the same time, the prioritisation was also the most difficult phase. According to the interviewees, problems were caused by uncertainty about which features should be included in the product and which features should be excluded from the product or left for the forthcoming product releases. As a solution, it was suggested that prioritisation should be done carefully, with a clear vision in mind and with strategic thinking. Additionally, some informal prioritisation methods were suggested to solve this problem. For instance, a calculation system, in which each feature was given a point, and based on the points the order of priority could be formed. Some of the case companies also faced difficulties during the prioritisation of the customer's requirements. To avoid this problem, some companies gave the customer the authority to prioritise the features themselves or the features were prioritised together with the customer.

Reaching an agreement was also considered difficult, since combining and processing different viewpoints was complex. Hence, meeting practices for reaching agreement were suggested, since the purpose of the meeting was to reach a joint decision. Additionally, consolidation of different wishes, needs, and technical implementation possibilities in an economical frame was considered complex. Thus, it was noted that all cost estimations should be done

early on the roadmapping process, for instance in the analysing phase. Even then, if consensus inside the team could not be reached, then the companies management also participated in to the roadmap agreement making.

Managing and maintaining product roadmaps was also thought hard. The problems were caused by a large number of changing matters. Therefore, as a solution it was suggested that more time should be used in the first phases of roadmapping to reduce changing matters at the end. For instance, more time and effort should be given to defining the features and analysing them to avoid situations were missing features were discovered. In addition, it was seen that the more precise the roadmaps were the harder they were to maintain. Thus, one of the interviewees said, that the roadmaps should only contain the needed information and nothing extra.

Communication about features between collaborators was considered difficult, since it was complicated to verify that everyone involved understands the meaning of the features. Thus, continuous communication between collaborators was regarded as essential. At the beginning, it was suggested that face-to-face meetings should be held to avoid misunderstandings about features. Thereafter, regular communication could also be arranged though phone calls and email. Additionally, communication in large companies was considered problematic. Thus, it was suggested that information sharing and information's visibility should be improved inside the company. Some of the interviewees also detected the danger of data leak that the information from the roadmap passes on to competitors or competitive companies. Thus, for example, trust between partners was emphasised, and roadmaps were shared most commonly in settled partnerships and in close collaboration modes to avoid data security problems.

6.5.2 Summary of Empirical Research Results

The most important findings of the empirical research are presented in Table 4. The table includes the most important issues relating to each phase of the roadmapping process, and the effects of the collaboration on these phases.

Table 4. Summary of Main Research Findings.

Phase	Important Issues	Effect of Collaboration
Capturing Features	• Gathering ideas over time and interviews • Combining knowledge • Features come from several sources	• Suggestions, edge conditions and limitations given by the partner • Efficient use of resources
Analysing Features	• Domain-specific knowledge and experience, and expert interviews • Analysing major features and planning minor feature • 1) Verify understanding, 2) Clarify implementing technology, and 3) Create cost, time, and work estimations	• Helps to verify features faster • Disagreements and misunderstanding between partners • Partners value different features, so compromises has to be made • Partners participate to analysis to suggest their opinions • Continuous communication needed
Prioritising Features	• Informal prioritisation methods • Functional and non-functional requirements are prioritised at the same time • Several factors guide prioritisation	• More information is available for decision-making • Prioritisation is more complex • Important to create mutual understanding
Roadmap Validation and Agreement	• Roadmaps are validated: 1) through negotiations, meetings or reviews in order to collect input and comments, or 2) through unit's improvement, customer feedback and commercial success • Meetings for making an agreement • In the meeting mutual decision about the roadmap is made	• More information is available for decision-making • Improves roadmap's business relevance • More complicated to reach agreement • Partners have to be committed • Makes the roadmap a legal agreement
Change Management of the Roadmap	• Delays in product implementation • Discovering new or unnecessary product features • Meeting practices for change management • 1) Change request, 2) Impact analysis, 3) Collaborators approve changes together, 4) Verify understanding, and 5) Revise roadmap	• Persons on market who regularly cooperate with the partners are those who notice change proposals • Regular meetings with the customers to review and make changes to the roadmaps • Clear roles between collaborators to divide change management tasks

7. Conclusions

This research aimed at describing roadmapping and factors related to product roadmapping process. The factors related to the requirements management, validation of the product roadmap and achieving mutual understanding between partners. Additionally, the research aimed at giving solutions to problems that emerged when product roadmaps were created together with collaboration partners. The research questions presented in Chapter 1 were first answered based on an extensive literature analysis and then through empirical studies. The purpose of the empirical studies was to reveal general practices of product roadmapping in industry, thus questionnaire studies were conducted. Thereafter, more information relating to product roadmapping in collaboration situation was retrieved through interviews. Next, the research questions are answered based on the research results.

A roadmap is a strategic planning and communication tool. Furthermore, it gives a description about the company's future directions and enables clear understanding about the future. Also, the roadmap gives a clear focus to the product development, and provides a high-level understanding of scoping the product strategy. Roadmapping is the process of creating the roadmaps. More precisely, product roadmapping is the process of creating understanding about company's future products or product lines. In the product roadmap, the company's products are arranged on a timeline. The timeline illustrates which product versions are going to be implemented and when. The product roadmap describes the product evolution over time and it can include more specific information relating to each product, for instance, product features and release cycles.

The roadmaps can be presented in diverse forms or with different taxonomies. In this thesis, the roadmaps are classified as follows: science or technology roadmaps, industry roadmaps, product-technology roadmaps, and product roadmaps. In addition, the roadmaps are formed as a multi-layered time based chart, in which information is presented on different layers of knowledge. The layers pertain to technology, product, and market information. The roadmap can also include additional information, such as people involved in the roadmap creation.

The product roadmapping process can have several participants, but at least the following functions should participate in the product roadmapping process: product management, marketing, development, customer and partner representatives, and engineering. The number of participants in the roadmapping process is directly attached to the size of the company. In small and medium sized companies with fewer than 250 employees, from one to ten persons participate in the roadmapping process. Instead, in larger companies, the number of participants can be several dozens or even hundreds, thus not all the participants are necessarily present during every phase of the process. Instead, the participants participate to those phases that affect their work or knowledge. Furthermore, the product roadmapping process has two roles: owner and member of the roadmapping team. The owner creates the roadmaps, and the roadmapping team gives input on the content of the roadmap.

In this thesis, the product roadmapping process consists of the following phases: capturing features, analysing features, prioritising features, roadmap validation and agreement, and change management of the roadmap. Based on the empirical findings, on these phases, the prioritising features phase is the most important and the most difficult phase in the product roadmapping. During the product roadmapping, the requirements can be prioritised both with formal and informal priorisation methods. The formal prioritisation methods help to prioritise and manage requirements in large and continuous projects in which the number of requirements rises rapidly. However, requirements are most commonly prioritised with informal prioritisation methods. Additionally, both functional and non-functional requirements are prioritised at the same time, and separate methods for prioritising non-functional requirements were not used in the case companies.

In this thesis, the collaboration modes are divided into the following three categories: joint R&D partnerships, customer-supplier relationships, and technology exchange agreements and licensing. Thus, the product roadmapping in collaboration is studied through these collaboration modes. Based on the literature analysis the most important activities in the roadmapping in the collaboration situation are planning, training and the ownership of the roadmap. Moreover, based on the empirical results, collaboration in different layers of the product development is important, and especially creating long and close relationships is vital. This is because openness and confidentiality are bases for a

good cooperation relationship. In addition, the project management and roles between collaborators are essential.

The product roadmaps can be created partly, totally, or not at all together with the collaboration partners. The creation of the product roadmap in collaboration depends on the product to be developed and on the form of cooperation. When the partnership is long and close or the product's lifespan is long, the product roadmaps are created together. Instead, when the partnership is not so long lasting and intensive, or the purpose is to create a short lifespan product, then the partners do not create the product roadmaps together. Then, the partners create the roadmaps by themselves and then share or show some parts of the roadmap to the partner.

Based on the empirical findings, informal prioritisation methods commonly support collaboration. Additionally, some formal prioritisation methods can also be used when roadmaps are created together with collaborators. Based on the literature, there are even specific methods created to support information gathering from various stakeholders, for instance Distributed prioritisation and EVOLVE, since they both take into account different stakeholder perspectives and weighting of answers. These prioritisation methods were used in the case companies.

Most commonly, the problems in product roadmapping relate to prioritising features, managing changes and maintaining roadmaps. Also, sharing information and communication are considered difficult. These problem areas relating to product roadmapping were revealed through empirical studies. The problem areas are very different from the most important activities based on the literature. The problems related to prioritisation are solved with careful consideration and strategic thinking. The priorities can also be created together with collaborators to get more perspectives involved in the process. Regular meeting practices are agreed between partners to solve problems relating to managing changes and making roadmap agreement. The problems relating to the roadmap maintenance are solved by using more time in the first phases of roadmapping to reduce changing matters at the end. Additionally, the roadmaps should only contain the required information and nothing extra. Communication problems are solved with continuous communication practices between collaborators, such as face-to-face meetings, phone calls, and email. Moreover,

information is shared more commonly in settled partnerships and in close collaboration modes to avoid data security problems.

The main goal of this thesis was to create an understanding about product roadmapping in a collaboration situation, which has been achieved by extensive literature and empirical studies. Additionally, since product roadmapping has not been widely examined in the literature, the main achievements of the study relate to creating basic understanding of the product roadmapping. Furthermore, the study has achieved to clarify the product roadmapping process as a whole. For instance, the study has revealed the main participants, roles, and phases of the product roadmapping process.

In this thesis, the research was carried out as multiple-case studies to verify the research results and to predict similar results. First, a survey questionnaire was sent to potentially interested contacts and thereafter semi-structured interviews were conducted. The selected research method was appropriate since the research questions could be answered and the research results were achieved. However, multiple-case studies took time to be conducted. The planning of the questionnaire was not so simple as first expected, since the questionnaire had to be prepared carefully in order to get the right information from the respondents. The analysis of the questionnaire results was interesting and quite fast. Thereafter the interview questions were easy to form but after the interviews, the transcription of the answers was time-consuming. Also creating the types of answers was slow since there were nine interview answers and the case material had to be rewritten several times to combine the opinions of the researcher and the classified types. Anyhow, the classifying by type was appropriate for this research since with the help of this method similarities and diverging types of answers could be found among the replies.

The scope of the research was adequate considering that altogether 52 applicable questionnaire replies were received and nine persons in total were interviewed. Furthermore, the questionnaire responses came from several companies; 34 different companies in all decided to take part in the questionnaire survey. Additionally, similarities could clearly be seen among the replies, hence the sampling was considered adequate. However, it should be noted that some of the respondents may have replied without careful consideration or the replies can have been given based on assumptions. Also, both the interviewees and the

questionnaire respondents have subjective perspectives to the issues asked, thus the answers do not reveal the whole opinion of the company, only the replier's opinions. Additionally, most of the case companies were considered large organisations with more than 250 employees, thus the results may be applied only in an appropriate extent to smaller companies. In addition, the research results apply to companies that are involved in software product or service development.

Since product roadmapping is quite a new area of research, the research could be continued by focusing more on specific parts of the roadmapping process. For instance, to find what kind of requirements prioritisation methods are used in different collaboration modes, and to find out what kind of prioritisation methods are the most appropriate for different collaboration modes. In addition, product roadmapping could be considered from some other perspective than process viewpoint, as in this thesis. For instance, product roadmapping could be studied from an administrative point of view. Also, it would be interesting to find out whether the different cultures of the collaboration companies affect product roadmapping process especially when the product roadmaps are created in globally distributed development projects.

References

Albright, R. E. 2002. The Process: How to Use Roadmapping for Global Platform Products. PDMA Visions. Vol. 26, No. 4, pp. 19–23.

Albright, R. E. 2003. A Unifying Architecture For Roadmaps Frames a Value Scorecard. Proceedings of the IEEE International Engineering Management Conference, Albany: New York. Pp. 383–386.

Albright, R. E. & Kappel, T. A. 2003. Roadmapping in the Corporation. Research Technology Management. Vol. 46, No. 2, pp. 31–40.

Alves, C. & Finkelstein, A. 2002. Challenges in COTS Decision-Making: A Goal-Driven Requirements Engineering Perspective. Proceedings of the 14th International Conference on Software Engineering and Knowledge Engineering, Ischia: Italy. Pp. 789–794.

Arnold, R. S. & Bohner, S. A. 1993. Impact Analysis – Towards a Framework for Comparison. Proceedings of the IEEE Conference on Software Maintenance (CSM), Montreal: Canada. Pp. 292–301.

Arthur, L. J. 1988. Software Evolution: The Software Maintenance Challenge. New York: John Wiley & Sons, Inc.

Bajaj, C. L., Pascucci, V., Thompson, D. & Zhang, X. Y. 1999. Parallel Accelerated Isocontouring for Out-of-Core Visualization. Proceedings of the 1999 IEEE Symposium on Parallel Visualization And Graphics, San Francisco: California. Pp. 97–104.

Beus-Dukic, L. 2000. Non-Functional Requirements for COTS Software Components. Proceedings of the International Conference on Software Engineering (ICSE), Workshop on COTS-Based Software Development, Limerick: Ireland.

Blotner, J. A. 2004. PIP: A Product Planning Strategy for the Whole Family Or... How We Became the Brady Bunch. Proceedings of the 19th Annual ACM SIGPLAN Conference on Object-Oriented Programming Systems, Languages, and Applications, Vancouver: Canada. Pp. 253–259.

Boehm, B. W. 1981. Software Engineering Economics. Englewood Cliffs, N.J.: Prentice-Hall.

Carlshamre, P., Sandakh, K., Lindvall, M., Regnell, B. & Natt och Dag, J. 2001. An Industrial Survey of Requirements Interdependencies in Software Release Planning. Proceedings of the 5th IEEE International Symposium on Requirements Engineering, Toronto: Canada. Pp. 84–91.

Chung, L., Cooper, K. & Huynh, D. T. 2001. COTS-Aware Requirements Engineering Techniques. Proceedings of the 2001 Workshop on Embedded Software Technology (WEST).

Cristiano, J. J., Liker, J. K. & White, C. C. 2001. Key Factors in the Successful Application of Quality Function Deployment (QFD). IEEE Transactions on Engineering Management. Vol. 48, No. 1, pp. 81–95.

Darke, P., Shanks, G. & Broadbent, M. 1998. Successfully Completing Case Study Research: Combining Rigour, Relevance and Pragmatism. Information Systems Journal. Vol. 8, No. 4, pp. 273–289.

Dean, J. C. & Vidger, M. R. 2000. COTS Software Evaluation Techniques. Proceedings of the NATO Information Systems Technology. Symposium on Commercial Off-the-shelf Products in Defence Applications, Brussels: Belgium.

DeGregorio, G. 2000. Technology Management via a Set of Dynamically Linked Roadmaps. Proceedings of the 2000 IEEE Conference, Albuquerque: New Mexico. Pp. 184–190.

Devanbu, P. T. & Stubblebine, S. 2000. Software Engineering for Security: A Roadmap. Proceedings of the Conference on the Future of Software Engineering, Limerick: Ireland. Pp. 227–239.

Duysters, G. & Hagedoorn, J. 2000. A Note on Organizational Modes of Strategic Technology Partnering. Journal of Scientific & Industrial Research. Vol. 58, No. August-September. Pp. 640–649.

Ebert, C. & Smouts, M. 2003. Tricks and Traps of Initiating a Product Line Concept in Existing Products. Proceedings of the 25th International Conference on Software Engineering, Portland: Oregon. Pp. 520–525.

Eskola, J. 2001. Laadullisen tutkimuksen juhannustaiat: Laadullisen aineiston analyysi vaihe vaiheelta. In: Aaltola, J. & Valli, R. (eds.) Ikkunoita tutkimus-metodeihin II – Näkökulmia aloittelevalle tutkijalle tutkimuksen teoreettisiin lähtökohtiin ja analyysimenetelmiin. PS-kustannus Gummerus Kirjapaino Oy. Pp. 133–157. (In Finnish)

Eskola, J. & Suoranta, J. 1998. Johdatus laadulliseen tutkimukseen, 3rd ed. Tampere: Osuuskunta Vastapaino. (In Finnish)

Eswaran, M. 1994. Cross-Licensing of Competing Patents as a Facilitating Device. The Canadian Journal of Economics. Vol. 27, No. 3, pp. 689–708.

Fickas, S. & Nagarajan, P. 1988. Critiquing Software Specifications. IEEE Software. Vol. 5, No. 6, pp. 37–47.

Gortona, I. & Motwanib, S. 1996. Issues in Co-Operative Software Engineering Using Globally Distributed Teams. Information and Software Technology. Vol. 38, No. 10, pp. 647–655.

Greer, D. 2005. Requirements Prioritisation for Incremental and Iterative Development. In: Maté, J. L. & Silva, A. (eds.) Requirements Engineering for Sociotechnical Systems. Idea Group Inc., Chapter 7. Pp. 100–118.

Greer, D. & Ruhe, G. 2004. Software Release Planning: An Evolutionary and Iterative Approach. Information and Software Technology. Vol. 46, No. 4, pp. 243–253.

Griffin, A. & Hauser, J. R. 1993. The Voice of the Customer. Marketing Science. Vol. 12, No. 1, pp. 1–27.

Groenveld, P. 1997. Roadmapping Integrates Business and Technology. Research Technology Management. Vol. 40, No. 5, pp. 48–55.

Grynberg, A. & Goldin, L. 2003. Product Management in Telecom Industry – Using Requirements Management Process. Proceedings of the IEEE International Conference on Software – Science, Technology & Engineering (SwSTE), Herzlia: Israel. Pp. 63–70.

Haag, S., Raja, M. K. & Schkade, L. L. 1996. Quality Function Deployment Usage in Software Development. Communications of the ACM. Vol. 39, No. 1, pp. 41–49.

Hagedoorn, J. 1993. Understanding the Rationale of Strategic Technology Partnering: Interorganizational Modes of Cooperation and Sectoral Differences. Strategic Management Journal. Vol. 14, No. 5, pp. 371–385.

Hagedoorn, J. 2002. Inter-Firm R&D Partnerships – An Overview of Major Trends and Patterns since 1960. Research Policy. Vol. 31, No. 4, pp. 477–492.

Herbsleb, J. D. & Moitra, D. 2001. Global Software Development. IEEE Software. Vol. 18, No. 2, pp. 16–20.

Hirsjärvi, S. & Hurme, H. 2000. Tutkimushaastattelu: Teemahaastattelun teoria ja käytäntö. Helsinki: Helsinki University Press. (In Finnish)

Holmes, C. J., Ferrill, M. B. A. & Phaal, R. 2004. Reasons for Roadmapping: A Study of the Singaporean SME Manufacturing Sector. Proceedings of the IEEE International Engineering Management Conference (IEMC), Singapore: Southeast Asia. Pp. 292–296.

Jiang, T.-M. & Coyner, M. 2000. Software Process Disturbances. Proceedings of the 24th Annual International Computer Software and Applications Conference (COMPSAC), Taipei: Taiwan. Pp. 167–168.

Juristo, N., Moreno, A. M. & Silva, A. 2002. Is the European Industry Moving toward Solving Requirements Engineering Problems? IEEE Software. Vol. 19, No. 6, pp. 70–77.

Järvinen, P. 2001. On Research Methods. Tampere: Opinpajan kirja. (In Finnish)

Järvinen, P. & Järvinen, A. 2000. Tutkimustyön metodeista. Tampere: Opinpajan kirja. (In Finnish)

Kameoka, A., Kuwahara, T. & Li, M. 2003. Integrated Strategy Development: An Integrated Roadmapping Approach. Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET), Portland: Oregon. Pp. 370–379.

Kappel, T. A. 2001. Perspectives on Roadmaps: How Organisations Talk about the Future. Journal of Product Innovation Management. Vol. 18, No. 1, pp. 39–50.

Karlsson, J. 1997. Managing Software Requirements Using Quality Function Deployment. Software Quality Journal. Vol. 6, No. 4, pp. 311–325.

Karlsson, J. & Ryan, K. 1997. A Cost-Value Approach for Prioritizing Requirements. IEEE Software. Vol. 14, No. 5, pp. 67–74.

Katz, G. M. 2001. After QFD – Now What? [Web-document]. Available: http://www.pdma.org/visions/apr01/after_qfd.html. [Referenced 11.04.2006].

Komi-Sirviö, S. & Tihinen, M. 2005. Lessons Learned by Participants of Distributed Software Development. Knowledge and Process Management. Vol. 12, No. 2, pp. 108–122.

Kostoff, R. N. & Schaller, R. R. 2001. Science and Technology Roadmaps. IEEE Transactions on Engineering Management. Vol. 48, No. 2, pp. 132–143.

Kuusela, J. & Savolainen, J. 2000. Requirements Engineering for Product Families. Proceedings of the 22nd International Conference on Software Engineering (ICSE), Limerick: Ireland. Pp. 61–69.

Lawrence, B., Wiegers, K. & Ebert, C. 2001. The Top Risk of Requirements Engineering. IEEE Software. Vol. 18, No. 6, pp. 62–63.

Leffingwell, D. & Widrig, D. 2000. Managing Software Requirements: A Unified Approach. Addison-Wesley.

Lehtola, L., Kauppinen, M. & Kujala, S. 2005. Linking the Business View to Requirements Engineering: Long-Term Product Planning by Roadmapping. Proceedings of the 13th IEEE International Conference on Requirements Engineering (RE'05), Paris: France. Pp. 439–446.

Li, M. & Kameoka, A. 2003. Creating Added Value from Roadmapping Process: A Knowledge-Creating Perspective. Proceedings of the International Engineering Management Conference (IEMC), Albany: New York. Pp. 387–392.

Lock, S. 1998. Requirement Level Change Management and Impact Analysis. Technical report no. CSEG/21/98, Lancaster University Computing Department.

McCarthy, R. C. 2003. Linking Technological Change to Business Needs. Research Technology Management. Vol. 46, No. 2, pp. 47–52.

McMillian, A. 2003. Roadmapping – Agent of Change. Research Technology Management. Vol. 46, No. 2, pp. 40–47.

Nuseibeh, B. & Easterbrook, S. 2000. Requirements Engineering: A Roadmap. Proceedings of the Conference on the Future of Software Engineering, Limerick: Ireland. Pp. 35–46.

Parviainen, P., Hulkko, H., Kääriäinen, J., Takalo, J. & Tihinen, M. 2003. Requirements Engineering: Inventory of Technologies. Espoo: VTT Publications 508. 107 p. http://virtual.vtt.fi/inf/pdf/publications/2003/P508.pdf.

Patton, M. Q. 2002. Qualitative Research & Evaluation Methods, 3rd. ed. Thousand Oaks, California: Sage Publications, Inc.

Phaal, R., Farrukh, C., Mills, J. & Probert, D. 2003a. Customizing the Technology Roadmapping Approach. Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET), Portland: Oregon. Pp. 361–369.

Phaal, R., Farrukh, C., Mitchell, R. & Probert, D. 2003b. Starting-Up Roadmapping Fast. Research Technology Management. Vol. 46, No. 2, pp. 52–59.

Phaal, R., Farrukh, C. & Probert, D. 2000. Fast-Start Technology Roadmapping. Proceedings of the 9th International Conference on Management of Technology (IAMOT), Miami: Florida. Pp. 1–12.

Phaal, R., Farrukh, C. & Probert, D. 2001. Technology Roadmapping: Linking Technology Resources to Business Objectives. Nov. 11, University of Cambridge, Center for Technology Management. Pp. 1–18.

Phaal, R., Farrukh, C. & Probert, D. 2004a. Collaborative Technology Roadmapping: Network Development and Research Prioritisation. International Journal of Technology Intelligence and Planning. Vol. 1, No. 1, pp. 39–55.

Phaal, R., Farrukh, C. & Probert, D. 2004b. Customizing Roadmapping. Research Technology Management. Vol. 47, No. 2, pp. 26–37.

Phaal, R., Farrukh, C. & Probert, D. 2004c. Technology Roadmapping – A Planning Framework for Evolution and Revolution. Technological Forecasting and Social Change. Vol. 71, No. 1–2, pp. 5–26.

Phaal, R., Farrukh, C. & Probert, D. 2005. Developing a Technology Roadmapping System. Proceedings of the Portland International Conference on Management of Engineering and Technology (PICMET), Portland: Oregon. Pp. 99–111.

Phillips, N., Lawrence, T. B. & Hardy, C. 2000. Inter-Organizational Collaboration and the Dynamics of Institutional Fields. Journal of Management Studies. Vol. 37, No. 1, pp. 23–43.

Pozgaj, Z., Sertic, H. & Boban, M. 2003. Effective Requirement Specification as a Precondition for Successful Software Development Project. Proceedings of the 25th International Conference on Information Technology Interfaces (ITI), Cavtat: Croatia. Pp. 669–674.

Probert, D. & Radnor, M. 2003. Frontier Experiences from Industry-Academia Consortia. Research Technology Management. Vol. 46, No. 2, pp. 27–30.

Ramzan, S. & Ikram, N. 2005. Making Decision in Requirement Change Management. Proceedings of the First International Conference on Information and Communication Technologies (ICICT), Pakistan: South Asia. Pp. 309–312.

Rautiainen, K., Lassenius, C., Vähäniitty, J., Pyhäjärvi, M. & Vanhanen, J. 2002. A Tentative Framework for Managing Software Product Development in Small Companies. Proceedings of the 35th Hawaii International Conference on System Sciences (HICSS-35). Pp. 3409–3417.

Rautiainen, K., Vuornos, L. & Lassenius, C. 2003. An Experience in Combining Flexibility and Control in a Small Company's Software Product Development Process. Proceedings of the International Symposium on Empirical Software Engineering (ISESE), Rome: Italy. Pp. 28–37.

Regnell, B., Hösta, M., Natt och Dag, J., Beremark, P. & Hjelm, T. 2001. An Industrial Case Study on Distributed Prioritisation in Market-Driven Requirements Engineering for Packaged Software. Requirements Engineering. Vol. 6, No. 1, pp. 51– 62.

Release Planner 2004. Release Planner, Intelligent Decision Support, Product Management Software [Web-document]. Available: http://www.releaseplanner.com/. [Referenced 10.7.2006].

Richey, J. M. & Grinnell, M. 2004. Evolution of Roadmapping at Motorola. Research Technology Management. Vol. 47, No. 2, pp. 37–41.

Ruhe, G. & Momoh, J. 2005. Strategic Release Planning and Evaluation of Operational Feasibility. Proceedings of the 38th Annual Hawaii International Conference on System Sciences (HICSS), 313b.

Saaty, T. L. 1980. The Analytic Hierarchy Process. New York, USA: McGraw-Hill.

Saaty, T. L. 1986. Axiomatic Foundation of the Analytic Hierarchy Process. Management Science. Vol. 32, No. 7, pp. 841–855.

Sivzattian, S. & Nuseibeh, B. 2001. Linking the Selection of requirements to Market Value: A Portfolio-Based Approach. Proceedings of the 7th International Workshop on Requirements Engineering: Foundation for Software Quality, Interlaken: Switzerland.

Soffer, P., Goldin, L. & Kuflik, T. 2005. A Unified RE Approach for Software Product Evolution: Challenges and Research Agenda. Proceedings of the Situational Requirements Engineering Processes (SREP) – Methods, Techniques and Tools to Support Situation-Specific Requirements Engineering Processes, Paris: France. Pp. 200–210.

Strauss, J. D. & Radnor, M. 2004. Roadmapping for Dynamic and Uncertain Environments. Research Technology Management. Vol. 47, No. 2, pp. 51–57.

Tabrizi, B. & Walleigh, R. 1997. Defining Next-Generation Products: An Inside Look. Nov.-Dec., Harvard Business Review. Pp. 116–124.

Welborn, R. & Kasten, V. 2003. The Jericho Principle – How Companies Use Strategic Collaboration to Find New Sources of Value. Hoboken, New Jersey: John Wiley and Sons, Inc.

Wells, R., Phaal, R., Farrukh, C. & Probert, D. 2004. Technology Roadmapping for a Service Organization. Research Technology Management. Vol. 47, No. 2, pp. 46–51.

Wiegers, K. E. 2003. Software Requirements. Practical Techniques for Gathering and Managing Requirements throughout the Product Development Cycle, 2nd ed. Redmond, Washington: Microsoft Press.

VTT 2006. MERLIN Project Homepage [Web-document]. Available: http://virtual.vtt.fi/merlin/index.html. [Referenced 4.7.2006].

Vähäniitty, J., Lassenius, C. & Rautiainen, K. 2002. An Approach to Product Roadmapping in Small Software Product Businesses. Proceedings of the 7th European Conference on Software Quality (ESCQ) – Quality Connection, Helsinki: Finland.

Yin, R. K. 1994. Case Study Research: Design and Methods, 2nd ed. Thousand Oaks, California: Sage Publications, Inc.

Zhang, W., Mei, H. & Zhao, H. 2005. A Feature-Oriented Approach to Modeling Requirements Dependencies. Proceedings of the 13th IEEE International Conference on Requirements Engineering (ICRE), La Sorbonne: France. Pp. 273–282.

Appendix A: Databases and Research Terms for Product Roadmapping

Databases from which literature relating to product roadmapping was searched:

- ABI Inform: ProQuest direct
- CSA: Materials Science and PsycInfo
- Elsevier: Scopus and ScienceDirect
- Engineering Village: Compendex, Inspec, and NTIS
- Food Science and Technology Abstracts (FSTA)
- IEEE: Xplore
- ISI Web of Knowledge.

The literature relating to product roadmapping was also searched from the databases of the Library of the University of Oulu. For instance, information from the databases belonging to the natural science category, sub-category computer science was searched:

- ACM
- IEEE/IEE Electronic library
- SpringerLink.

Research terms used during the literature review:

- roadmap
- road map
- roadmapping
- product roadmap
- product roadmapping
- technology roadmap
- technology Roadmapping.

Appendix B: Product Roadmapping Questionnaire

All information will be handled confidentially!

1. General Information

(By providing us your contact information you will receive the report from the questionnaire results)

Your name:	
Company:	
Department:	
Address:	
Title:	
Primary role:	
Phone number:	
E-mail:	

2. Company Profile

What is the size of your company, i.e. total amount of employees?

☐ <10 ☐ 10–49 ☐ 50–250 ☐ >250

☐ Other, what?

What is the life time of your company's products? In use by customers:

☐ 0–1 year ☐ 1–3 year ☐ 3–6 year ☐ 6–10 year ☐ >10 year

☐ Other, what?

3. Product Roadmapping Process

Who should participate in product roadmapping?

- ☐ Product management
- ☐ Engineering
- ☐ Manufacturing
- ☐ Development
- ☐ Other, what?
- ☐ Finance
- ☐ Marketing
- ☐ Services
- ☐ Customer and partner representatives

How many persons participate in a roadmapping process in your company?

- ☐ 1–5
- ☐ 6–10
- ☐ 11–20
- ☐ 21–30
- ☐ Other, what?

What is the most important phase in the roadmapping process? (Please rank most to least significant, 1 = most significant)

- ☐ Capturing features into roadmaps
- ☐ Analysing features
- ☐ Prioritising features
- ☐ Roadmap validation and agreement
- ☐ Change management of the roadmap
- ☐ Other, what?

What is the most difficult phase in the roadmapping process? (Please select one)

- ☐ Capturing features into roadmaps
- ☐ Analysing features
- ☐ Prioritising features
- ☐ Roadmap validation and agreement
- ☐ Change management of the roadmap
- ☐ Other, what?

How product requirements are captured into roadmaps?

- ☐ With prototyping
- ☐ With interviews
- ☐ Gathering ideas over time (e.g. to a tool)
- ☐ In some kind of workshops, what kind?
- ☐ Other, what?

How requirements are prioritised in product roadmapping?

- ☐ With formal methods
- ☐ With informal methods(Please describe the method/practice)

If formal methods are used for requirements prioritisation, what are the formal methods?

- ☐ Analytical Hierarchy Process
- ☐ Quality Function Deployment
- ☐ EVOLVE
- ☐ Distributed Prioritisation
- ☐ Other, what?

If your company has experience from product roadmapping in collaboration, please select the used collaboration mode.

- ☐ Joint research and development partnership
- ☐ Technology exchange agreement or licensing
- ☐ Customer-supplier relationship
- ☐ Other, what?

From your opinion, did the collaboration effect on roadmapping process?

- ☐ No
- ☐ Yes (Please describe more details)

Would you be willing to participate in an interview relating to product roadmapping?

- ☐ No
- ☐ Yes, select the most suitable practice
  - ☐ Phone interview (max. duration ½ hour)
  - ☐ Face-to-face interview (max. duration 1 hour)

Thank you very much for completing this questionnaire!

Appendix C: Framework for the Interviews

Product Roadmapping Process

- How does the roadmapping process begin?
- What roles does the roadmapping process include?
- Who participates into the roadmapping process and to which activities in it?
- What do they do during the roadmapping process (what are their responsibilities and what viewpoints are their concern)?
- How does the roadmapping process proceed? / What are the main phases of product roadmapping process?

Collaboration viewpoints

- What are the most important activities in roadmapping in collaboration situation?
- How communication (e.g. about requirements, and change management) is arranged between collaboration partners?
- How roadmaps are created together with collaboration partners (e.g. participants, responsibilities, tasks, decision-making, gaining mutual understanding)?
- How does the collaboration change product roadmapping process / the content of the product roadmap?

Capturing features

- How features are captured?
- How does the collaboration mode affect on capturing features?

Analysing features

- How features are analysed?
- What methods / practices are used during analysing features?
- How does the collaboration mode affect on analysing features?

Prioritising features

- How prioritisation methods are selected (between collaboration partners)?
- How does the selected prioritisation method support collaboration (especially: AHP, QFD, Distributed Prioritisation, EVOLVE)?
- How to prioritise requirements (functional and especially non-functional requirements) when there are several stakeholders?
- How does the collaboration mode affect on prioritising product features?
- Who makes the final decision about the priorities?

Roadmap validation and agreement

- How roadmaps are validated?
- How roadmap agreement is made?
- How does the collaboration affect on roadmap validation and agreement?

Change Management of the product roadmaps

- How changes to product roadmaps are managed in collaboration networks?
- Who should participate into the impact analysis?
- How is the impact analysis done in collaboration environment?
- Who makes the final decision concerning the change in collaboration?

What are the benefits of product roadmapping?

What are the problems of product roadmapping?

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Product Roadmapping in Collaboration

Abstract

Product roadmapping has not been widely examined, and particularly an inter-company collaboration perspective to product roadmapping is a fresh field of research. Therefore, the aim of this thesis is to research factors related to the product roadmapping process, and to give solutions to the problems that emerge when product roadmaps are created in collaboration. Hence, the research questions are divided into two groups. The first group of questions relates to general information about the product roadmapping process and the second group of questions relates to collaborations affecting product roadmapping.

The research questions are answered based on an extensive literature analysis and empirical studies. The empirical studies consist of multiple-case studies, in which the experiences of several companies are gathered and analysed to verify the research results. The empirical data is collected through questionnaire studies and semi-structured interviews. These data collection methods are chosen, since using questionnaire studies, the basic knowledge about product roadmapping in industry can be discovered, and by interviews, more in-depth knowledge about product roadmapping in collaboration can be revealed.

Based on the research results, the product roadmaps can be created totally, partly, or not at all together with the collaboration partners, depending on the product to be developed and the form of cooperation. Also, the results indicate that inter-company collaboration has effects on each phase of the product roadmapping process. For instance, there can be disagreements and misunderstandings between partners, and it can be more difficult to reach an agreement. Thus, continuous communication between partners is needed. The research results are applicable to companies that are involved in software product or service development. The research results are best applicable to larger companies with more than 250 employees.

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Tuoteominaisuuksien julkistussuunnittelu verkottuneessa tuotekehityksessä

Tiivistelmä

Tuoteominaisuuksien julkistussuunnittelua (tuote roadmapping) ei ole kovin laajalti tutkittu, ja erityisesti yritysten välisen yhteistyön näkökulmasta se on uusi tutkimusala. Tämän opinnäytteen tarkoituksena on tutkia tekijöitä liittyen tuoteominaisuuksien julkistussuunnitteluprosessiin ja antaa ratkaisuja ongelmiin, joita ilmenee, kun tuotesuunnitelmia tehdään yhdessä yhteistyökumppaneiden kanssa. Tutkimuskysymykset on jaettu kahteen ryhmään. Ensimmäinen ryhmän kysymykset liittyvät yleiseen tietoon koskien tuoteominaisuuksien julkistussuunnittelemista ja toisen ryhmän kysymykset liittyvät yhteistyön vaikutuksiin tuotesuunnittelussa.

Tutkimuskysymyksiin vastataan laajan kirjallisuusanalyysin ja empiiristen tutkimuksien avulla. Empiiriset tutkimukset koostuvat monista tapaustutkimuksista, joissa lukuisten yrityksien kokemukset kootaan ja analysoidaan, jotta tutkimustulokset voidaan vahvistaa. Empiirinen aineisto on kerätty kyselytutkimuksien ja haastattelujen avulla. Nämä tiedonkeruumenetelmät on valittu siitä syystä, että kyselytutkimuksilla voidaan kerätä perustietämystä tuotesuunnittelemisesta teollisuudessa, ja haastattelujen avulla voidaan saada selville perusteellisempaa tietämystä tuotesuunnittelusta yritysten välisessä yhteistyössä.

Tutkimustulosten perusteella tuotesuunnitelmat voidaan tehdä kokonaan, osittain tai ei ollenkaan yhdessä yhteistyökumppaneiden kanssa, riippuen kehitettävästä tuotteesta ja yhteistyön muodosta. Lisäksi tutkimustulokset osoittavat, että yritysten välisellä yhteistyöllä on vaikutuksia jokaiseen tuoteominaisuuksien julkistussuunnitteluprosessin vaiheeseen. Esimerkiksi yhteistyökumppaneiden välillä voi olla erimielisyyksiä ja väärinkäsityksiä, ja sopimuksen tekeminen voi olla vaikeampaa. Täten jatkuvaa yhteydenpitoa tarvitaan yhteistyökumppaneiden välillä. Tutkimustulokset ovat sovellettavissa yrityksiin, jotka osallistuvat ohjelmistotuotteen tai -palvelun kehittämiseen. Parhaiten tutkimustulokset ovat sovellettavissa suurempiin yrityksiin, joissa on yli 250 työntekijää.

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