Lappeenranta University of Technology
Faculty of Technology
Degree Programme of Mechanical Engineering

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EFFICIENT INSTALLED BASE INFORMATION MANAGEMENT AND UTILIZATION IN GLOBAL AFTER SALES SERVICE BUSINESS

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ABSTRACT

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Efficient installed base information management and utilization in global after sales service business

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Keywords: Installed base, information management, product lifecycle, after sales service, installed base information, product data

This Master´s thesis explores how the a global industrial corporation's after sales service department should arrange its installed base management practices in order to maintain and utilize the installed base information effectively. Case company has product-related records, such as product's lifecycle information, service history information and information about product's performance. Information is collected and organized often case by case, therefore the systematic and effective use of installed base information is difficult also the overview of installed base is missing. The goal of the thesis study was to find out how the case company can improve the installed base maintenance and management practices and improve the installed base information availability and reliability.

Installed base information management practices were first examined through the literature. The empirical research was conducted by the interviews and questionnaire survey, targeted to the case company's service department. The research purpose was to find out the challenges related to case company´s service department's information management practices. The study also identified the installed base information needs and improvement potential in the availability of information.

Based on the empirical research findings, recommendations for improve installed base management practices and information availability were created. Grounding of the recommendations, the case company is suggested the following proposals for action: Service report development, improving the change management process, ensuring the quality of the product documentation in early stages of product life cycle and decision to improve installed base management practices.

TIIVISTELMÄ

Lappeenrannan teknillinen yliopisto
Teknillinen tiedekunta
Konetekniikan koulutusohjelma
Juha Viitakangas

Asennettuun laitekantaan liittyvän tiedon tehokas hallinta ja hyödyntäminen globaalissa jälkimarkkinaliiketoiminnassa

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Diplomi-insinööri Jonni Jahnukainen
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Hakusanat: Asennettu laitekanta, tuotetiedon hallinta, tuotteen elinkaari, myynninjälkeiset palvelut, laitekantatieto, elinkaaritiedon hallinta

Tässä työssä käsitellään kansainvälisesti toimivan jälkimarkkinapalveluita tarjoavan yrityksen asennetun laitekantatiedon hallintaa sekä hyödyntämistä. Yrityksellä on asiakkaille toimitettuihin laitteisiin liittyvää tietoa, kuten esimerkiksi tuotteen elinkaaren aikana kertynyttä huoltohistoria tietoa, tietoa laitteen suorituskyvystä tai muihin huoltopalveluihin liittyvää tietoa. Nämä tiedot kerätään usein toimintokohtaisesti, jolloin niiden systemaattinen ja tehokas hyödyntäminen on hankalaa, tällöin myös kokonaiskuva asiakkaille toimitetuista laitteista on hajanainen. Työn tavoitteena on selvittää miten yritys voi parantaa asennetun laitekantatiedon ylläpitoa ja hallintaa sekä tiedon saatavuutta ja luotettavuutta.

Asennettuun laitekantaan liittyvän tiedon hallintaa tarkasteltiin ensin kirjallisuuden avulla. Tutkimus suoritettiin haastattelujen ja kyselytutkimuksen avulla. Tutkimuksessa kartoitettiin yrityksen Service-osaston tiedonhallintaan liittyviä toimintatapoja ja tunnistettiin niistä keskeisimpiä haasteita. Lisäksi tunnistettiin laitekantatiedon tarpeita ja tarkasteltiin millaisia etuja on mahdollista saavuttaa kehittämällä asennetun laitekantatiedon hallintaa tehokkaammaksi. Tutkimusten avulla laadittiin yritykselle suosituksia, joiden avulla voidaan tehostaa asennetun laitekantatiedon hallintaa ja hyödyntämistä.

Suosituksiin pohjautuen esitettiin seuraavia toimenpide-ehdotuksia, joiden avulla keskeisimpiä haasteita voidaan ratkaista: Huoltoraportoinnin kehittäminen, muutostenhallintaprosessin parantaminen, tuotteen dokumentaation laadun varmistaminen tuotteen elinkaaren aikaisissa vaiheissa sekä päätös parantaa laitekantatiedon hallinnan toimintatapoja.

FOREWORD

At this point when my Master´s Thesis is completed, I would like to express my gratitude to those who have contributed to the completion of this project. First, I would like to thank my Professor Juha Varis at Lappeenranta University of Technology for his time and advice. I would also like to express my gratitude to my instructor Marko Kinnunen for his valuable advice during the whole work and for providing me this opportunity.

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Warm thanks go for all my student friends which made sure that student life was not always about studying. Finally, and personally most importantly, I can’t thank my parents enough for all their constant support that they have given during my studies.

ABBREVIATIONS

CAM Computer Aided Manufacturing

CAD Computer Aided Design

ECM Enterprise Content Management

ERP Enterprise Resource Planning
- Content management software , combines the capture, search and networking of documents with digital achieving

IB Installed Base
- Set of individual pieced of equipment in currently in use.

IBI Installed Base Information
- Information about products: location, owner, user, application, operating environment, status, and service history.

OEM Original Equipment Manufacturer

PDM Product Data Management
- Software to track and control data related to a particular product

PLM Product Lifecycle Management
- A strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life.

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1 INTRODUCTION

This Master's thesis studies installed base information utilization and management practices in after sales service point of view. Master's thesis has been written for case company's after sales service department. This kind of study is necessary, because the value and role of installed base information in after-sales service business have been studied to some extend (Ala-Risku, 2009; Dekker et. al, 2010; Jalil et. al), some research in that field has been done but clear understanding on these issues does not exist. Also the literature on the opportunities of installed base information utilization to different after sales service operations and clear management practices are very limited and sparse. Thus, practical guidelines and requirements for the installed base are missing.

This Master´s thesis increases the knowledge and understanding of installed base information management. The thesis also clarifies what kind of installed base information is needed in different after sales operations. The research helps to understand of the reasons for maintaining the installed base information and how the data should be gathered. The study will be useful when the company wants to gather and utilize the installed base information in a more comprehensively and efficiently.

1.1 Background and purpose of the research

Product life cycle management (PLM) has been quite popular in the literature during recent decades. Product life cycle management systems have been introduced to increase companies' productivity and efficiency in managing product life cycle information and reducing the costs of product development. Despite the fact that PLM is designed to manage product information and processes throughout the entire life-cycle of a product, the study suggests that the adoption of PLM solutions is still focused on the early stages of the product life cycle, mainly focused on development, design, and production. The case company was interested in developing its after sales life cycle information management, i.e. installed base information management practices.

The case company did not have well defined, systematic, documented, and effective methods or practices for managing and utilizing product life cycle information, i.e. installed base information for supporting after sales services. Usually most maintenance and other service activities are planned and defined on a case by case basis, without the ability to take advantage of systematically collected service event data and maintenance history. Even though the case company has product related records on their service operations, the function-specific installed base information is scattered in many different systems and it is difficult to form an overall impression. The installed base is aging, and thus the need for services such as maintenance or spare parts grows. Consequently, the need for installed base information management is also growing because the company wanted to ensure the quality of its service. Improving installed base information management can enhance and accelerate service processes, because information reliability and availability will increase to a higher level.

Constantly moving, complex and customized products sets also many challenges for the case company to keep track of installed base. Lack of communication and information sharing between different organization functions at case company may lead to installed base errors. Also the level of control of a case company on the product composition varies. Case company can maintain installed base by offering maintenance services, but often customer or the third parties perform the maintenance and during that the equipment composition may change. Information sharing between the case company and customer/third party are not always in best possible level.

The starting point for this thesis was to examine how the case company's service unit should improve the installed base information management practices to support different service units and operations better. The value of installed base information management and the role of information management are unclear in service business. It is also difficult to define opportunities of utilization for installed base information in service business. Installed base information management is based on many different practices, which differ between business functions: different methods for filing item information, the rules for creating and modifying item data, and shortcomings with instructions and management policies between cause significant disadvantages.

1.2 Objectives and limitations

This thesis researches the possibilities of taking advantage of installed base information during the product life cycle. **The target of this Master's thesis is to research and analyze what kind of installed base information is needed in the area of after sales service and how that information should be managed more efficiently.** The secondary objective is to define problems and benefits related to installed base information management. The principal aim can be summarizes as follows: to support the development of installed base information management practices to improve the after sales business processes of the case company to ensure the quality of after sales services.

An installed base information management system can be used as a part of a product life cycle information repository. The information sharing with different services has to be studied. The transfer of needed information from the engineering department to the after sales service unit is also an important point. The scope of the thesis is framed to take into account especially product life cycle information management from the after sales point of view. The production and product engineering needs of installed base information are not included in this study. However, there is a certain feedback from service to product engineering, because product engineering has the responsibility for updating technical drawings when changes occur due to, for example, modernization.

The final conclusion is a proposal to improve methods and practices for how to manage and utilize installed base information more effectively, so that the database is sufficiently comprehensive and reliable. From the business point of view, the aim is to improve customer service quality, the product's value in use, and enhance aftermarket business planning and implementation. As a result, this thesis defines the current stage of information management in the case company's after sales service unit and offers proposed development steps to improve efficiency of installed base information management and utilization.

1.3 Research approaches and structure of the thesis

The research problem addressed in this study is the following: *How should installed base information be managed and how can it be effectively utilized in global after sales business?* The research problem is divided into three separate parts:

1) What kind of information should the case company's after sales service unit gather on the installed base?
2) What kind of installed base information management practices and guidelines are needed to support effective information management and utilization?
3) What are the benefits of the good availability of information from the after sales point of view?

The first question examines the need for different kinds of information from the after sales point of view. The second question investigates management practices and methods and how they can facilitate information sharing, use, and maintenance. The third question deals with the opportunities of installed base information and information sharing from the after sales service business perspective.

In general, this case study is divided into three separate parts, as seen in Figure 1. Part one includes a literature review, cross-functional interviews, and benchmarking. The problems, challenges, and needs are gathered from the literature review and empirical qualitative data-gathering methods, such as interviews, benchmarking, and case company system analysis. To support these interview results and benchmarking, a questionnaire has also been conducted. Literature and articles are used to focus and clarify possibilities, theory, and problems in the area of the selected topic. Part two is the analysis phase, which has been implemented by conducting interview and questionnaire summaries and collecting data together. The material is analyzed using qualitative content analysis. Part three contains the conclusions and offers solutions and consists of gathering together the observations and analyzes the preceding parts and summarizes these into a proposal of methods and activities for how to manage and utilize installed base information.

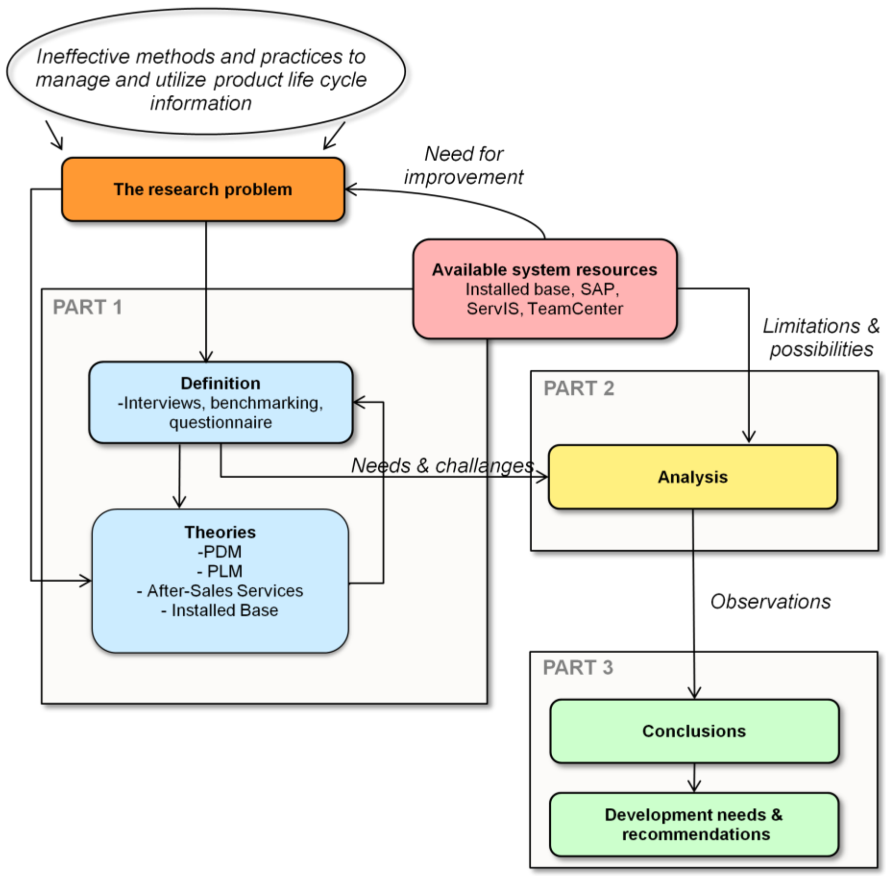

Figure 1. Research approach. Research is divided into three clearly defined parts.

This Master's thesis consists of five chapters. The structure of the thesis work is shown in Table 1 where inputs and outputs in the chapters are introduced. The first chapter includes the research problem definition, background information, methods, targets and frames. It is important to understand the research problem before starting any actions. The second chapter examines the topic from the theoretical point of view. A variety of academic literature and articles have been used to achieve some perspective on the topic and these materials constitute the theoretical part of the work. This chapter also describes the basic features and requirements for PLM, after sales service and Installed base. The PLM theory is selected because after sales business is a significant part of the product life cycle. The second chapter also illustrates how PLM and after sales business are linked together and discusses the use of PLM principles from the after sales service perspective. The last section of this chapter introduces the concept of the installed base and also gives an overview of the terms and basic systems features. The aim of this chapter is to clarify from where the need for efficient information management arises.

In the third chapter, the case study is divided into two sections. The empirical part of the thesis begins with a case company presentation in section one, where the present state and role of installed base information management in the after sales service unit are introduced. The aim is to illustrate the starting points for the study. A systems description is created and also some frames, which have to be considered when forming a solution. The second section of the chapter gives the details of executing the empirical research reported in this thesis. The section also details the installed information needs, problems, and development targets in different service subunits. These challenges and development targets are gathered through interviews and benchmarking.

The results of the third chapter are gathered in the fourth chapter where analyses and observations are made on the basis of the interviews, survey and literature. This chapter includes recommendations on how the installed base information management practices should be develop and what opportunities efficient installed base information management gives to the case company. This analysis chapter also contains a discussion on the challenges that emerged during the study and points out factors which have to be taken care of before and while proposed actions are taken.

Table 1. Structure of the thesis.

INPUT	CHAPTER AND CONTENT	OUTPUT
General information about the thesis and the challenges	1. Introduction	Research questions, objectives, frames, methods, structure of the thesis. Research problem defined
Information about the terms, concepts and systems from the literature Theory of service and after sales service business Information about the installed base system	2. Literature review of PLM, after sales service and installed base	Present state and definitions. The chapter helps to understand the basics and the central terminology of theories (PLM, PDM, after sales service business, installed base) from the service point of view
Basic Information about the case company and information management systems, i.e. PLM/ERP/PDM, interview, benchmarking, and questionnaire data	3. Case study – Installed base as part of product life cycle management	Present state, challenges, system description Installed base information needs of different service subunits
Chapters 1, 2, and 3 Requirements set in the previous chapter: Main needs and problems	4. Recommendations	A set of requirements for installed base information management and utilization. Guidelines, and development steps Overview of how well the solution succeeded. What further developments are required?
Whole thesis	5. Summary	Summary

2 LITERATURE REVIEW

Introducing the PLM concept and after sales service business offers a good starting point for this thesis. After sales services play a significant role in the second half of a product's life cycle. After a product is manufactured and delivered to the customer there is a demand to maintain installed base information to keep it up to date. Because service units usually have the best knowledge of what actions or changes have been taken or made concerning the product, it is natural that the service units also maintain product information, i.e. installed base information. On the other hand, service business as maintenance operations needs reliable information about products and service events, which have accumulated during the life cycle. The key aims of this chapter are:

- To describe the basic features and requirements of PLM as they relate to this study
- To introduce the after sales service business.
- To introduce installed base concept, terms and management practices.

Installed base information management encompasses the same issues and the functionalities as the PDM and PLM concepts, the focus is just different. Therefore, installed base information management can be considered through theories of PLM/PDM. Usually a PDM system focuses on serving product engineering, while installed base information management is a tool or method designed for different service businesses to manage all kinds of installed base information. The literature on management installed base is limited and sparse. Some research in the field has been carried out, but the true value of information from the after sales point of view is not fully understood and the discussion is limited to secondary importance in the literature on PDM and PLM.

This thesis touches on PDM in a broad sense and the starting point is the fact that PDM covers the entire life cycle of the product and the whole spectrum of product data as Sääksvuori and Immonen (2002) define it. Today, this broader frame of reference is described by the modern term PLM - Product Life cycle Management. PLM describes in a wider frame the reference of product data. It is important to understand the difference between PDM and PLM. Almost without exception, PDM and PLM are closely associated and also refer to information systems developed to manage the product life cycle and product related data. The significant difference between the two is scope and purpose. PLM is more like a holistic approach that uses a wide range of different concepts, technologies, and tools which extend to groups beyond the functions of a company or even a supply network in order to manage and control the life cycle of a product, whereas PDM is mainly a set of methods and tools aimed at efficiently managing product data. In fact, PDM can be seen subset of PLM. Installed base information management is a bit both and it can be seen as one kind of application of PLM/PDM concepts. Installed base is tool and system to maintain installed base information and in the other side it is set of guidelines and practices to manage and utilize the installed base information. (Sääksvuori and Immonen 2002)

2.1 The approach of the literature

The literature review has been divided into three groups: (1) a product life cycle management review, (2) an after sales service review, and (3) an installed base management review. The material used has been collected from various sources and used best from the writer's point of view. The sources used for this Master's thesis work are mainly scientific articles and academic literature, as well as interviews and benchmarking reports. The publications used in this thesis which have the most important weight are: Sääksvuori and Anselmi Immonen - *Product life cycle management* and Timo Ala-Risku´s doctoral dissertation (2009) "Installed base information: Ensuring customer value and profitability after the sale" is probably one of the most recent research on the subject. Ala-Risku´s thesis explores the business benefits for capital goods manufacturers in maintaining systematic records for individual products in their installed base

2.2 Product life cycle management

In the literature PLM systems have been introduced to increase companies' productivity and efficiency to manage product data and to reduce the costs of product development. Usually PLM has been a business concept for the goods manufacturing business. The growth of networking among companies and new business opportunities in after market service set up new challenges for companies. At present, the importance of PLM in intangibles business, such as services, has grown noticeably. Chapter 2.2 covers the fundamentals and concepts of product life cycle management and chapter 3.1 will focus on service products and the utilization of PLM in the service industry.

2.2.1 The concept of product life cycle management

CIMdata (2002) defines PLM as "a strategic business approach that applies a consistent set of business solutions in support of the collaborative creation, management, dissemination, and use of product definition information across the extended enterprise from concept to end of life." PLM integrates people, processes, business systems, and information together and increases an enterprise's flexibility and agility to respond swiftly to changing market pressures and competitors. Therefore, PLM is much more a strategic decision than PDM and more than just information management of the product (CIMdata 2006). According to Sääksvuori and Immonen (2002), "PLM is a systematic, controlled concept for managing and developing products and product related information."

Software providers see PLM as a software tool for managing all kinds of product information. PLM systems are distributed technological information systems whose core functions are the creation, preservation, and storage of information to the company's products and activities in required quality and in order to ensure the fast, easy, and trouble-free finding, refining, distribution, and reutilization of data. The idea of the life cycle is that the work once done should remain exploitable in the PLM information system. In other words, and according Abramovici (2009), PLM is an extension of PDM which is a comprehensive approach for product related information and knowledge management within an enterprise (Abramovici and Sieg 2009). The product life cycle management concept usually covers the following areas (Sääksvuori and Immonen 2002, p. 11):

- Product information models and product structure models.
- Definition of products and product-related information objects such as items, structures, product-related documents, metadata.
- Product life cycle management practices and guidelines used in the company.
- Product management and product information management processes.

In summary, PLM is not just about software technology but it is also a business strategy. PLM is central to the management of all product information and the technology used to access this information and knowledge. PLM can be seen as the integration of PDM, CAD, CAM, and other tools and methods, people, and processes through all stages of a product's life.

2.2.2 Life cycle

"The earliest reference to an S-shaped curve similar to a product's life cycle was detected in 1922-1923 by Prescott, who proposed an equation that fitted the growth of the automotive industry from 1900 to 1920 very well." "The product life cycle is almost certainly one of the best-known, if not most important, concepts and touches on nearly every facet of marketing and drives many elements of corporate strategy, finance, and production". These two statements are quotations from Gardner's literature review and they are widely quoted in a number of scientific publications dealing with the life cycle concept (Gardner 1987).

Product life cycle management is widely handled in the literature and there are many different interpretations concerning product life cycle, depending on the perspective. The definition may pivot, for example, on the customer view, the producer's view or the product itself. It is important to clarify by whom product life cycles are managed. The essential point is also to distinguish between product life cycles and industry life cycles. Industry life cycles can last for decades, but the life cycle of a particular product can be very short. Uusi-Rauva et al. (1994) defines life cycle as a marketing point of view and revenue planning, "the period of a product on the market". This interpretation excludes the impacts of product creation and disposal for life cycle profitability. From the producer's point of view, a possible definition of the end of a product's life cycle is the end of after sales support date. In practice, this date marks the end of a company's commitment to support the product in any form. From the information system point of view, it is quite easy to detect when the product life cycle ends – there are no relevant data to update into the system, there is no sign of life. In this thesis, we start counting the life cycle from the day when the systematic effort to create the product was started. From the system point of view – when we are able to input the product-related information into the system.

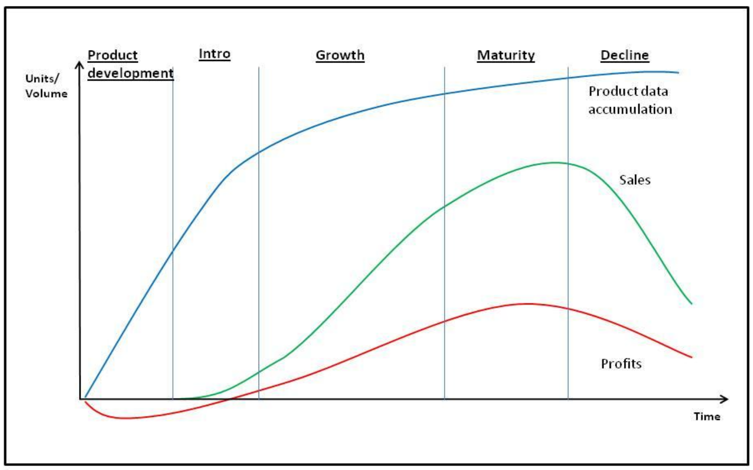

Figure 2. Sales, profit, and product data accumulation during the product's life cycle.

It is also important to notice that the definition of the moment of birth and death of a product is not self-evident. Brandao and Wynn (2008) define five stages of a product's life cycle: idea, definition, manufacturing, support/use, and disposal. The way Brandao and Wynn (2008) define life cycle stages is not the only definition. Sääksvuori and Immonen (2005) also define five stages but uses terms definition, design, sales, manufacturing, and service. Grieves (2006, pp. 41-45) defines five stages and uses the terms plan, design, build, support, and dispose. As seen by the user of the product, product life cycle can be thought to begin from the moment they acquire it and start using it, to the moment they stop using it or dispose of the product. A manufacturer of a product may think of a product having five phases in its life cycle: imagination, definition, realization, support, and retirement. A market-oriented product life cycle consists of product presentation, growth, age of maturity, and decline, as seen in Figure 2. Similarly, different life cycles can be formed, such as from the pricing, sales strategy or design points of view.

2.2.3 State of the art of product life cycle management

From the functionality point of view, PLM is typically used to work with digital files and database records including product configurations, part definitions and design data, specification, drawings, engineering analysis models, manufacturing process plans, and NC part programs. Project management functionality is supported and process and workflow management functions are implemented in most cases. All PLM functions are based on an object-oriented data model which delivers information about the status of an object, possible states in the product life cycle, the existence of multiple versions of an object and history management. Figure 3 illustrates the basic system architecture of a PLM system and how the functional core elements are related to each other. The PLM system is typically based on several servers which use the PLM application and metadata base to control other databases and file services. Modern PLM systems' common functionalities and basic features are shown in Table 2.

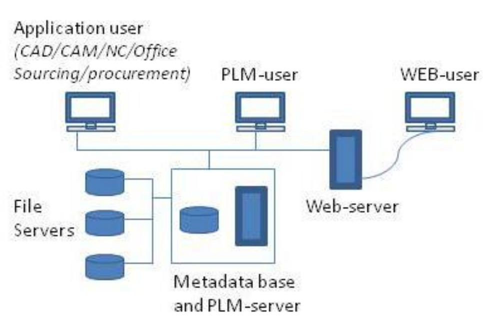

Figure 3. System architecture of the basic PLM-system. PLM-system is structured on several components. (Adapted from Sääksvuori and Immonen 2002)

Table 2. Basic functionalities of PLM-system (Sääksvuori and Immonen 2002)

Function	Description

Item management	Controls the information on the item and the status of the item as processes related to the creation and maintenance of items
Product structure management and maintenance	System identifies individual information or items and their relations to other pieces of information. Product structure consists of items hierarchically connected together.
User privilege management	Define information access and maintenance rights.
Maintenance of the state or status of documents and information	System maintains information about the state and version of each document and item and about changes made to them: what, when and by whom. Metadata management
Information retrieval	Utilizing the existing information better. All the existing information can be easily found and accessed.
Change management	The latest and most valid information about changes is recorded in documents or items. Ensures that standardized methods and procedures are used for efficient handling of all changes. Includes also history/system log – product process traceability.
Configuration management	Allows products to be customized by varying the physical properties of similar products.
Workflow management	Task management. Graphical illustration of the chain of tasks makes communication in the organization more effective.
Metadata management	Managing the information about information.
Backup management	Avoid information loss.
Data vault	Storage place for files. The place where actual data or files are located.

2.3 Product data management

Product Data Management (PDM) has different definitions depending from which perspective it is observed. Sääksvuori and Immonen (2002, p. 13) define PDM as a *strategic* approach to product information management; a systematic controlled method and wide functional wholeness to manage and develop industrially manufactured products. According to Abramovici and Sieg (2002, p. 2), PDM can be seen as an integration *tool* for connecting many different areas, which ensures that the right information in the right form is available to the right person at the right time. Philpotts (1996) describes PDM also as a tool for managing data and the product development process for keeping track of data and information for products, design, manufacture, and the support and maintenance of them.

PDM is a common term for all the systems that are used to manage product definition information. Product data management encompasses techniques commonly known as engineering data management (EDM), document management, product information management (PIM), technical data management (TDM), technical information management (TIM), image management, and others. PDM integrates and manages all the information that defines a product, from design to manufacture, and to end-user support. When properly implemented, PDM systems will result in faster work, fewer errors, less redundancy, and smoother workflow for an organization (Philpotts 1996).

The importance of PDM has been growing, especially in the manufacturing industry, since the late 1980s when engineers in the manufacturing industries become aware that the increased volume of electronic documents needed to be tracked one way or another. PDM enables people from all departments, divisions, and supply chains to participate in the design, development, and process stages of the product throughout its life cycle. Information of a common end-product must pass between the different subunits quickly, flawlessly, and automatically, in order to compete effectively in international markets.

Managing information is first and foremost a question of methods rather than technique. In some cases PDM is understood as a document management system but actually PDM is much more than that. The difference between a document management system and PDM is the way documents, items, and product structures are linked together. A document management system just manages pictures, text, drawings or other documents. PDM enables documents to be attached to a certain item as the manufacturing drawing of the part or the assembly instructions of a product. Product data management can be divided into four main categories: item, product structure, document, and change master management (Peltonen et. al. 2002, pp. 47-48).

2.3.1 The definition of product

The word “product” has many meanings and implications within PLM and PDM. When talking about products, we usually mean physical products, i.e. goods that can be touched, owned, traded, and distributed to different places at different times without changing their identity. Product does not only denote “goods” it is more like *benefit bunch* for which a customer is willing to pay (Papinniemi J. 2007). However, the word “product” tends to give rise to an image of a product that can be touched, but it can also be applied to intangibles such as services, software, knowledge or an algorithm project that can also be productized. Product can be defined in three different ways:

1. Goods meaning physical, tangible products
2. Services (specified later in chapter 2.4.1)
3. Intangible products meaning non-physical products that are not services; for example, software.

2.3.2 The product data classification

In order to better understand the challenges of managing different kinds of information, some classifications for product data are presented. These classifications help to understand how the characteristics of information affect information management practices. In this case, the terms *product data* or *product information* refer to the broad range of information related products. The first classification is from Halttunen and Hokkanen (1995). Product information is divided into three groups, as seen in Figure 4.

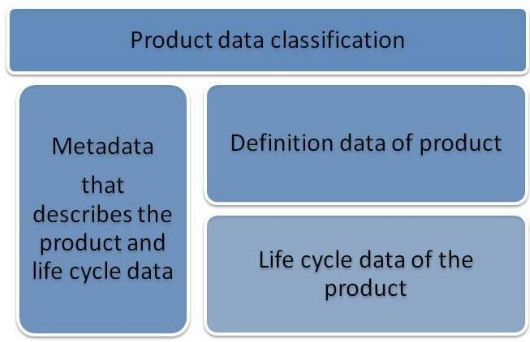

Figure 4. Product data classification is divided into three groups. (Halttunen and Hokkanen, 1995)

The first group consists of product definition data which define the product's physical and functional properties clearly and comprehensively. Product definition data may be very exact technical data as well as abstract and conceptual information about the product. Definition data of the product also describes the characteristics of the product from some parties' perspective. Intangible products, such as services, should be handled as if they were physical products. It is important to try to concretize the functions and features of intangible products to the same level as for physical products. The second group consists of the life cycle data of the product. This group is connected to the research, design, production, use, maintenance, recycling, and destruction of the product. Life cycle data describes the exact and abstract information about the product life cycle events. The third group consists of metadata and it is most relevant from the information management point of view. Metadata describes the product data: what kind of information it is, where it is located, in which data bank, who recorded it and when it can be accessed. In other words, it is information about information (Halttunen and Hokkanen 1995, p. 11).

Simon et al. (2001) state that there are two kinds of data that can be stored: static data and dynamic data. Dynamic data means the data that is collected during the product's life cycle. This includes service history, possible upgrades, and spare part replacements. Static data is generally the specification of the product. This means that data once created remains untouched throughout its life cycle. Static data is information about materials, components, configurations, and instructions (Simon et al. 2001).

2.4 After sales service business

The purpose of this chapter is to introduce the after sales service business and the theoretical definitions of service. We all have personal points of contact to services. We buy or even provide them. Service business has existed thousands of years and we are still experiencing a trend towards an increasingly service-oriented world. Today's digital and globally networked business environment service elements are added to industrial products and new service concepts are created. In the marine industry, capital equipment and products with long service lives and complex configurations are a challenge. The profitability of the industry not only comes from the sale of a product but remarkable profits may result from maintaining products for a lifespan lasting for decades.

2.4.1 The definition of service

Analyzing the term "service" on a theoretical level, it can be seen that service is something very trivial and this complicates defining a service. We all have personal experiences of service, which are based on our own personal frames and references. Service is a feeling and the experience resulting from the service rather than the actual process or the deliverables of the service. Sääksvuori and Immonen (2002) emphasize that one has to take an analytical approach to the conceptual level definition of service from numerous perspectives (Sääksvuori and Immonen 2002, p. 151).

There are many definitions of service and sometimes services are difficult to identify because they are such a complicated phenomenon. The word has many meanings, ranging from personal service to service as a product or offering. No ultimate definition has been agreed upon. According to the Oxford on-line dictionary, a service is "assistance of advice given to a customer during and after the sale of goods … [or] an act of assistance." Professor Christian Grönroos defines service as follows, and in 1990 it was reluctantly proposed: *"A service is a process consisting of a series of more or less intangible activities that normally, but not necessarily always, take place in interactions between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems."* (Grönroos 2007, p. 51)

Timo Ala-Risku defines service in his doctoral dissertation series in this way: *"Service refers to those activities that capital investment good manufacturers provide to support and improve the products they sell to their customers."* (Ala-Risku 2009, p. 11) According to Sääksvuori and Immonen (2002), definitions for service can be summarized as follows. Service is a compilation of different components, fundamentals, and objects. In most cases the core components and features of service agreed in the literature are:

1. Services are processes – consisting of a chain of tasks or activities that provide an end result for a customer
2. Services are physically intangible
3. Services are produced and consumed simultaneously
4. The customer participates as a co-producer in the service production and evaluates the outcomes and the delivery of the service against their expectations.

Statement number two is partially incorrect as services can include both tangible and intangible components (Spring and Araujo 2009). Therefore many services produce tangible outcomes or require tangibles, facilitating physical goods in the service process or contributing to products that are tangible or intangible. This means that a service cannot be entirely defined as an "intangible equivalent of an economic good" as defined by Wikipedia. However, one should remember that it is the visible part of the service process that matters in the customer's mind (Grönroos 2007, p. 54; Sääksvuori and Immonen 2002, p. 153).

2.4.2 Service products and extended products

Competitors outsourcing service businesses to markets in Asia in order to cut costs, the global trend towards service society, and the growing demand for services in the market place pressure on companies to develop, produce, and deliver new services more efficiently and at lower costs. Service quality, efficiency, and competitiveness can be increased by re-thinking services and making them more like tangible products by starting to build defined, modular, configurable, and easily repeatable service products. This means that the service industry has to create and adapt information model definitions, processes, practices, and product definition tools for their intangible products, services. When using well-defined, precise, and standard product and information models in service design and production, it makes it possible to use IT-based support systems and automation. In practice, this means the use of PLM in service management and delivery service business management is a challenge for product life cycle management (Sääksvuori and Immonen 2002).

The challenge for PLM in the service business is the lack of an exact and logical definition of what the service product is. Usually a service product information model is unavailable, service functions or features are not itemized, and it is not possible to make a BOM (Bill of Material) to describe what the service consists of in a structured way. Typically the service product definition is a mixture of the actual product definition and the service delivery.

According of Mateika (2005), the ability to provide more profitable services in addition to tangible goods is one of the most significant success factors in the manufacturing industry. This is the reason why manufacturers have to further develop their products in terms of new customer value creating concepts. Today, the key challenge for all kinds of industries is to respond to customers' requests for value-adding services because customers 'focus has moved on from ownership of physical products or systems towards guaranteed benefits based on a provided offering. Customers have demands for service benefits or even requests for guaranteed success when buying a product. Also from the after sales point of view, products are more than physical products. This is why tangible products or so-called core products need to be extended or equipped with different kinds of value-adding services, as seen in Figure 5. These intangible product assets can consist of engineering, software, maintenance, customer support services and many other things. According of Jansson and Thoben, value-adding services are often information and knowledge intensive (Jansson and Thoben 2005, p. 40).

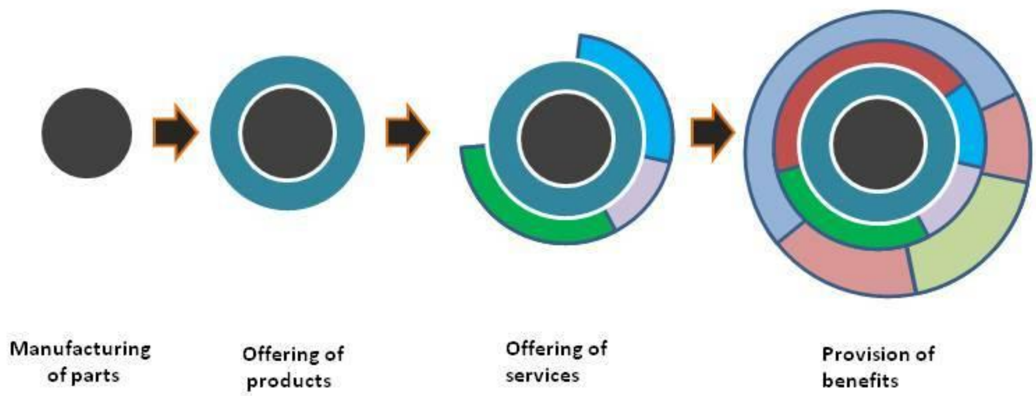

Figure 5. Changing the focus from manufacturing of parts to the provision of benefits (Adapted from Gasós and Thoben, 2003)

It is difficult to form a precise definition of the term "extended product". In the literature the concept of extended product has been defined according to various views on how to "extend" a product". However, this thesis focuses on reviewing the term extended product from a manufacturing point of view. Gasós and Thoben (2003) state that the extended product, which is related to manufacturing, includes the following elements:

- The concept makes possible the diffusion of new product ideas and services into the market.
- The customer focus is on value-added services, not the physical product.
- An information and knowledge intensive intangible extended product
- The combination of a tangible product and related services or enhancements in order to improve marketability
- An intelligent, highly customized, user-friendly tangible product containing embedded features like maintenance and product support (Gasós and Thoben 2003, p. 26)

2.5 Product life cycle management in after sales service business

To begin with, PLM was primarily used in the automotive and aerospace industries, followed by the machinery industry. Despite the fact that PLM is designed to manage product information and processes throughout the entire life cycle of a product, this study suggests that the adoption of PLM solutions are still focused on the early stages of a product's life cycle, mainly focused on development, design, and production. Figure 6 shows PLM and PDM usage throughout a product's life cycle. According to Abramovici and Sieg, the operating frequency of PLM and PDM is significantly lower in the service phase than in product design. Technological potentials have not been understood and utilized and this has led to a poor integration level of business applications and processes (Abramovici and Sieg 2009).

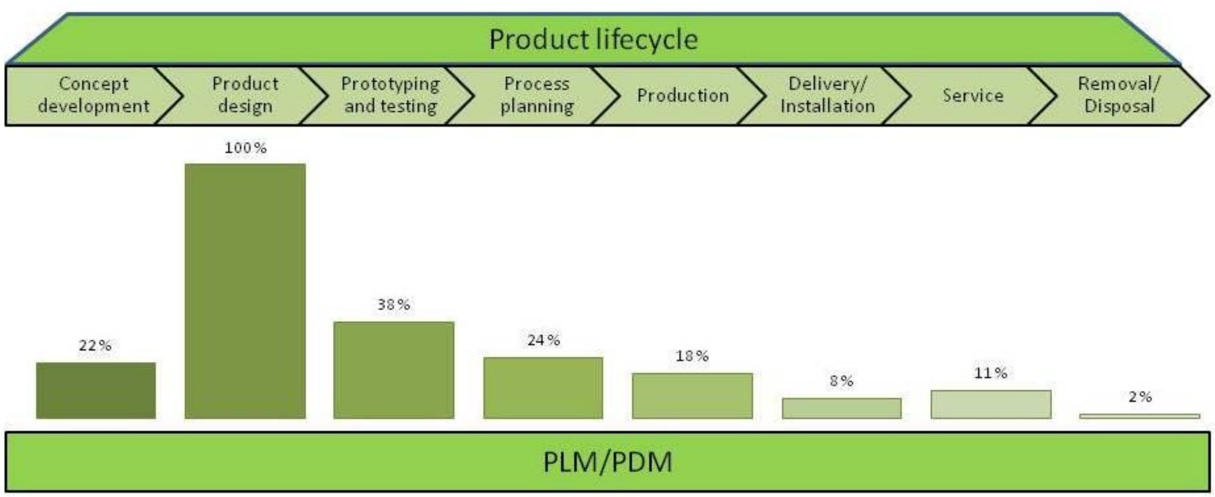

Figure 6. Current relative usage of PDM and PLM throughout a product's life cycle (Abramovici and Sieg 2009).

The subject described above is one reason why these theories have been collected together in this thesis. The purpose of this chapter is to introduce the benefits of PLM from the after sales point of view, how PLM and after sales business are linked together, and discuss the use of PLM principles in the after sales service business. It is hoped this will increase knowledge and skills in the field because product life cycle management thinking is a very valuable method in the service business. This chapter also serves as background information for specifying what challenges are in the PLM of the after sales services area.

PDM usage in after sales business has greatly increased during recent decades. Engineering companies who manufacture investment equipment have established after sales service as a separate business unit. The role of after sales service in business has grown quite substantially in recent times. It is important to be able to manage and control customer's service documents, spare part items, maintenance instructions, information about retrofits and other upgrades effectively, and in this way produce quality services for the customer. Rapid product development sets up requirements for efficiency and maintenance and spare part services. Document management, product structures, and material management play a significant role in after sales business (Sääksvuori and Immonen 2002, p. 44).

To understand why PLM serves an important role in the after sales business, one must identify the three fundamental concepts of PLM. These three fundamentals are also the foundation for after sales service. According to Lee et al., the three fundamental concepts of PLM are:

- The universal, secure, managed access, and utilization of product information and product related data

  Product definitions and product-related information and continuous integration throughout the product life cycle
- The management and maintenance of business processes that create, manage, distribute, and use product information (Lee, et al., 2008, pp. 296-303)

Companies have always had to deal with the dynamics of markets and technologies, and in recent years the speed of change has increased tremendously. Therefore, companies have begun indentifying and exploiting new business opportunities, especially in the after sales business area. This trend appears in traditional manufacturing companies as an increased interest in offering customers a variety of value-added services. The aim is to cover the whole life cycle of the product, which may even last decades. In this context, Sääksvuori and Immonen talk about Life

Time Service and Product life cycle management, which are prerequisites for offering life cycle services (Sääksvuori and Immonen 2002, p. 115).

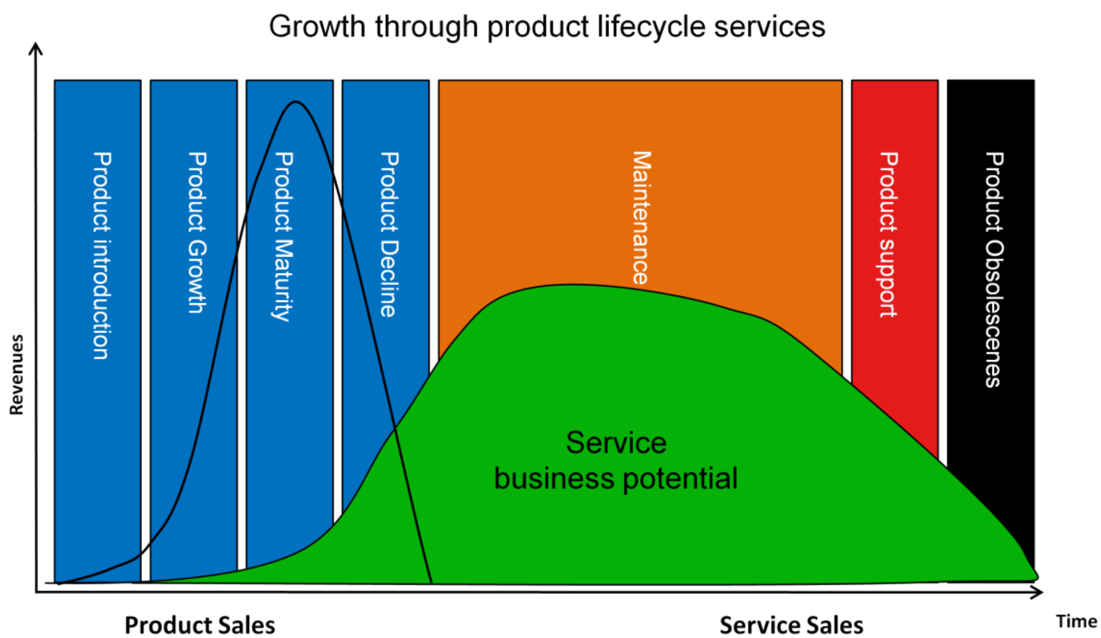

Figure 7. By identifying the service business potential it is possible to increase revenue.

Product life cycle management and product-related services are becoming a key factor in business success in certain sectors of industry. Companies create new business, additional sales, and growth by providing their customers with better productized and more customer-specific services also the amount of information increase, as seen in Figure 2. That's why the better information management practices are needed. The service business potential to increase revenue is shown in Figure 7. In addition to PLM and Life Time Service, this concept is in broader contexts also known as Extended Product (Sääksvuori and Immonen 2002, p. 115).

The ideal PLM system should be able to record, check, and manage inspection and maintenance records, such as the replacement of certain parts after repair. This reduces the time personnel spend searching paper files, filling out paper forms, and searching through maintenance manuals. A PLM system can also search historic data on similar maintenance issues and their resolution. PLM also plays an important role in the optimization of an inventory. Carrying costs can be minimized; turn-around time can be reduced by having the right part in the right place and at the right time. There is no need for expensive back-orders and the shorter turn-around time increases revenue for the company (Lee, et al. 2008, pp. 298-299).

The PLM collaborative information management function is helpful for service quality assurance and it can reduce overall maintenance costs and time. Exchanging and sharing information, such as bid price, part numbers, references to standard service bulletins, the repair schedule, inspection results, and the final agreed repair plan between Original Equipment Manufacturer (OEM) and MRO, can potentially lower maintenance to a level that meets safety and reliability standards. By using feedback the maintenance schedule can be revised and optimized. Following the research of Proud and Wetzer (2003), for example, a European airline achieved a 15% drop in unscheduled downtime and an Asian airline reached a 40% decrease in unplanned maintenance. The research found that 40% of the replacements of engine-driven air compressors on the Navy P-3 Maritime Patrol aircraft were unnecessary (Proud and Wetzer 2003).

PLM offers the opportunity to organize and manage all product-related information throughout the whole life cycle of a product. Without a concrete method on how to manage information there is a huge mass of data with little meaning and efficient utilization is almost impossible. The high quality of product data is a key factor for improving daily service operations. If product data is not stored in a quality way, data entry is poorly managed, product configuration data is not up-to-date or design history is not maintained and service quality and efficiency suffer. PLM application objectives and goals are: (Stark 2006, p.51).

- Reducing maintenance time
- Limiting actual maintenance costs
- Lengthening the time between service
- Ensuring and restoring the safety and reliability of equipment
- Obtaining the product and process information necessary to optimize maintenance when these inherent safety and reliability levels are not met
- Obtaining the information necessary for component repair and tooling design for those items to be fully repaired or replaced during the overhaul process

- Accomplishing these objectives within the required time limits and at a minimum total cost, including the cost of maintenance and cost of residual failures

In service business, the problems of product life cycle management typically become several different areas as seen in below. Challenges are adapted from Sääksvuori and Immonen (2002):

- It is not clear how to utilize the product-related information. The concept, terms within the area of product life cycle management, are not clear and not defined in companies.
- The use of the information and the formats in which it is saved and recorded vary. Information has usually been produced for different purposes or in some other connection but it should still be possible to utilize it in contexts other than the task for which it was produced.
- The reliability and wholeness of information produced in different units, departments or companies cannot be guaranteed. The parties have different approaches to protecting and managing information and product data is produced or stored in a different file format.
- Clarifying the location of the latest document version of a certain document. For example, when employees begin to update the same information on their own workstations and sharing information from there. Soon, nobody knows for sure where the latest document version is located.
- Lack of logical and semantic definitions of what a service product is and how product should be defined.

2.6 The Definition of Installed base

In service business is the need for a way to track the customer's installed base of the business product. It is also important to know what else is installed so it is possible predict the behavior of products in that environment. Because this thesis aims to develop and improve installed base information management and its utilization in after sales service business it is necessary to provide a definition of the term *installed base*. Longman Business English Dictionary (2007) defines installed base as "all the pieces of equipment of a particular kind that have been sold and are being used." When compared to *market share*, which reflects sales over a particular period, installed base can be seen as a more reliable indicator for evaluating market size. Because installed base is not the same as the total number of units sold, as some of those products will typically be out of use and they have gone missing, are broken or have become obsolete. The literature research revealed that the common definition for the term is the total number of units of a particular type of system currently in use. Oliva and Kallenberg (2003) use the following definition: "A product's installed base is the total number of products currently in use". The original equipment manufacturer (OEM) need not to be the organization which provides the after sales services. Because of that there is also the definition where the installed base is defined as the whole set of systems/products for which an organization provides after sales services.. (Dekker, et al. 2010)

In the context of this thesis, the most valuable definition is presented by Borchers and Karandikar (2006, p. 53): "An installed base system is an attempt to track down exactly where the sold products are located, who owns and operates them, what they are used for, under which conditions they are applied, their life cycle status, which service actions and technical changes have been performed, which parts have been serviced or replaced, and their current technical state." Timo Ala-Risku (2009) states that installed base do not indicate the number of installations but it is regarded as formed by individual products. (Ala-Risku 2009).

From the system point of view, installed base is a multi-level structure of products and their components for managing and representing products at the customer site and products that are used internally (SAP help 2011). Installed base services encompass all product- and process-related services required by a customer over the product life cycle to obtain a desired functionality (Oliva and Kallenberg 2003, p.163).

There are several possible business goals and objectives which can be achieved through the successful implementation of an installed base (SAP help 2011).

1) Faster resolution of customer problems when the exact environment of a problem is known, which improves customer satisfaction.
2) Increased potential for revenue, because the potential up sell and cross-sell potential of products and services due to improved knowledge of the environment at the customer site.
3) Better quality and accuracy of customer service.
4) Faster access to relevant information.
5) Reduced error rates.

2.7 Installed base information

The aim is to provide an overview of the installed base information and define the different installed base information types. "*Installed base information* is used to refer to information on individual products". (Ala-Risku 2009). In practice, this means information about products: location, owner, user, application, operating environment, status, and service history. The set of installed objects at the customer's can be used. For example: (SAP help 2011)

1) To determine the exact object for which a problem has been reported.
2) To determine in detail what the transaction refers to. For example, repair by a field service.
3) By the service employee as information about which object is affected and the parts it consists of.
4) For documenting changes made to objects.
5) Direct use of installed base information in the context of individual service processes with the customer.
6) Statistics

According to Ala-Risku (2009) and interviews, the installed base information is divided into three main categories. The relationships among the three data categories are illustrated in Figure 8. (Ala-Risku 2009).

- Item data, which consists of information about products' interest
- Location data, which consists of information about the customer site or process phase that is the target of product deliveries and service operations
- Event data, which consists of information about service operations

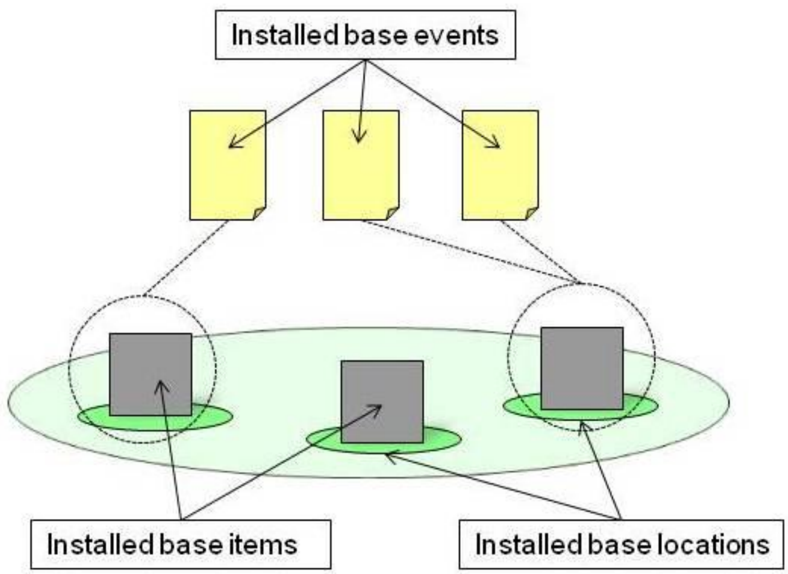

Figure 8. Illustration of Installed base items, locations and events. Data categories has the relationship between each other.(Adapted from Ala-Risku, 2009, p. 114).

<u>Item data</u>

Item data, which is also known as Equipment data includes specific data which are needed to define each equipment item uniquely in the installed base management system. General equipment data included manufacturer, model number and serial number. Additional helpful item data includes warranty period and operational data. One should capture this basic item information for equipments. Item data, which describes an item in the installed base, can be divided into two subcategories: item properties and item status. Item properties describe the item as an artifact. Item status describes the performance of its intended function. Table 3 presents the main types of item data (Ala-Risku 2009, p.177).

Table 3. Item data category consists of product definition information. (Adapted from Ala-Risku 2009, p.177)

Item data type	**Description**
Equipment manufacturer	Indicates manufacturer of the equipment
Model of the equipment	Indicates the equipment type or model
Life cycle status	Information about equipment's life cycle status. Reference to preventive maintenance task
Warranty	The coverage and period of the warranty
Cumulative usage	The hours in operation
Operational condition	Information about equipment's performance
Item classification	Indicates the product version

Location data

Installed base item data identifies the information which is related to the place where the equipment is located. For the customer, the key interest is the installed base location data. As long as the expected output of the location is secured and the expected costs are not exceeded, the exact item in operation and details of the service performed at the locations are irrelevant to the customer. A location's specific information is also important when comparing the performance of products across customer applications to improve the competitiveness a new product and service offers. Usually the location data reveals only the whereabouts of the item. The key location data types are provided in Table 4, (Ala-Risku 2009, p.119)

Table 4. Location data category consists of information about customer site. (Adapted from Ala-Risku, 2009, p.119)

Location data type	**Description**
Owner/user	Customer reference, identification of the owner and user of the products
Application	A description of the purpose of use at the customer
Accessibility	Information for field service access
Environment	Environmental characteristics
Installation dates	The date of installation for item
Criticality	Classification of consequences of item failure at location
Interfaces	Compatibility information
Physical location	Information on the location's whereabouts

Event data

Installed base event data consists of information about service actions. Different event data types need not be managed in a single system. Different event data can be handled in their own workflow systems. To ensure comprehensive and efficient utilization of service event information, the main point is that all types of events should be accessible with the same search keys. The key event data types are provided in Table 5 (Ala-Risku, 2009, p.121).

Table 5. Event data consists of information about service operations (Adapted from Ala-Risku, 2009, p. 121)

Event data type	**Description**
Event classification	Indicates what the event is about
Time stamps	Identifies the time of the event
Event performer	Identifies the people responsible for the event
Item changes	Identifies changes made in the installed base
Event reason	Root cause for the event's occurrence

2.8 Installed base information management

The term *installed base information management* describes systematic management, collection, and storage of installed base information (Ala-Risku 2009). Installed base information management encompasses the same issues and the functionalities as the PDM and PLM concepts, the focus is just different. Usually a PDM system focuses on serving product engineering, while installed base information management is a tool or method designed for different service businesses to manage all kinds of installed base information. In general, installed base management is the product structure, i.e. the installed base structure with its components and general data for the installed base or the components that are managed. The installed base contains only service relevant information. The installed base structure or functional location is a multi-level and hierarchical representation of a technical system which consists of components. The aim of creating a functional location is to structure a technical system or building into parts that are relevant service actions (SAP help 2011).

In literature, there was no clear guidance on how installed base should manage. In practical terms, installed base management does not differ from PLM/PDM-system management. Management consists of the same issues as PDM system management, only the data are different. The PDM system focuses on the management of technical data produced by engineering, while IB management focuses on managing the life cycle information which accumulates during the after sales phase and keeps the installed base information up to date. Based on the literature review and the researcher’s knowledge, there are no differences between installed base management and PDM management. On this basis and according to Peltonen et al. (2002), installed base management can be divided into the following main areas:

1) Item management
2) Document management
3) Product structure management
4) Change management

2.8.1 Item management

An installed base system is based on items and product structures. Item management is one of the most important processes, which must be in good condition before a company can implement the installed base system. An item is a systematic and standard way of identifying, coding, and naming a model of a physical product, part, document, component, material or service. Standardized items simplify the use and management of a product's related processes. When discussing "*items*" in this thesis, an item is a single part of the product and cannot be split into other items. An assembly of parts is a component and an assembled component creates a product. From the installed base management point of view, the "*item*" can be any independent "individual" with an identity (Peltonen et al. 20002, p.17).

Each item must have an identifier which determines the item. This identifier is usually called *a code* (such as a material number, item number, etc.). The identification code can be a classifying or non-classifying code. A classifying code includes information on the item's characteristics and status information of the company's classification system. A classifying code has one problem: if the item information changes, the code will still remain the same and then the classifying code is outdated. (Peltonen et al. 20002, p.17).

A non-classifying code is an arbitrary character string and can be based, for example, on continuous numbering. In this case, all the relevant classifying information is shown in attributes. Attributes describe what the item is like. For example, the description, item type, material information are all attributes. Because the item code (non-classifying code) does not depend on the item characteristics, all attributes can be freely changed. The item can have several attributes. Typically the item has at least a short unique identity code and a longer informal item description. The item description should be logical so as to enable different users to understand the nature of the item. It would be advisable to use standardized terminology to describe the item, making it easier to find items later more efficiently. (Peltonen et al. 2002, p.18).

When the item is modified so that the new version replaces the old version, a new *revision* of item will be created. The new revision can replace all old revisions for the same item, but the old revision cannot be used in place of the new revision. The new revision's form, functionality, and compatibility should be equal when compared to the old revision. It is necessary to check the following when considering a new revision. (Peltonen et al. 20002, p.18).

- What documents and items are affected by the change?
- What consequences are caused by the change in the sales unit (open offers, sales material, production unit, purchase unit (open orders), and after sales unit (delivered products)?
- What are the costs of the change?

2.8.2 Product structure management

Products often have hierarchical and multi-level product structures. Product structure is a decomposition of products which shows the material, component parts, subassemblies and other items in a hierarchical structure. The product structure forms the foundation of the installed base system, and the system is usually based on the use of the product structure and the items connected with it. The products and assemblies in the installed base system are created by attaching items, components, and documents to each other through the product structure. Figure 10 illustrates a simplified product structure.

The same product structure can be examined from different viewpoints. Typically a product structure is viewed from manufacturing or engineering viewpoints. Maintenance of several different product structures can become difficult in practice because the management and updating of relations between the separate product structures is such a huge task in complex products. Sääksvuori and Immonen (2002) pointed out that the importance of recording and the maintenance of individual structures will increase continuously. When the demand for after sales service and other product life cycle services increase and develop, maintenance and service companies will need to access the complete product information quickly in order to produce after sales services efficiently. According to Sääksvuori and Immonen (2002), “In this context, we often speak of the installed product base, where the information about the owner and the current location of the product is attached to the individual product information.”

The management and maintenance of product structures are among the most important functions of the whole PLM or installed base system. Properties of version management, structural management, and configuration management are typically based on product structure management. The product structure must form a suitable and sufficiently exact description of each installed product in each situation; it is not always viable to store all product-related information for individual products in the PLM or installed base system. Information on a complex product, which consists of thousands of components, should not be maintained at too exact a level. A suitable level of precision should be defined beforehand. Usually the product structure consists of functional modules, individual parts or subsections, and assemblies. An essential part of the management and functionality of the product structure is the different printable reports, such as version or change history and the order of the assemblies. The purpose of attribute information is to clarify the product structure and information in the normal data fields. There can be three kinds of attribute information: (Sääksvuori and Immonen, 2002)

- Individual product-based information – such as unique serial number
- Generic product information
- User-specific information – remarks and notes.

2.8.3 Change management

"Change management is a set of processes that are employed to ensure that significant changes are implemented in an orderly, controlled, and systematic fashion" (Tech-faq 2011). The management of changes to documents, items, and product structures is one of the key features of an installed base system. The change management feature provides controllability and visibility to change processes for products. According to Sääksvuori and Immonen (2002), a change management tool and well-defined process create advantages for a company:

- Controlled changes
- Streamline and accelerate the delivery time of changes
- Information on completed and forthcoming changes

- Changes can be triggered. Changes may be forced to happen at a certain time and an old component will be replaced with a new interchangeable component.

There are a lot of interdependencies between the installed base information. A small change in some piece of information may cause other information to change. Because changes usually cost and require work, it is often required that there are one or more people who check and confirm the changes before they are actualized. The most usual way to control the changes to an item or a document is versioning. The changes concerning a single version are observed through states. Each item or any kind of object can therefore contain a state diagram, which explains the possible states of a version and the supported transformations from one state to another. The object has a different state in different life cycle stages. (Sääksvuori and Immonen, 2002).

With a well-defined change process or tool the relations between the various pieces of installed base information, such as items and documents, are retained in change situations. When making changes, the conflicts with existing product information should be checked. It should be ensured, for example, how the design changes to a single item affect the other subassemblies to which the item is linked.

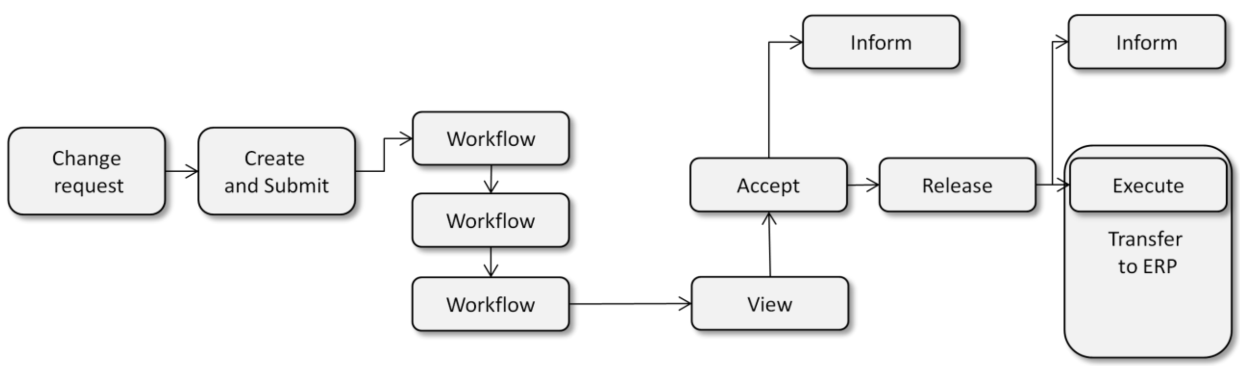

Figure 9. Workflow of change management process (Adapted from Sääkvuori and Immonen, 2002, p.35).

This section represents a simplified change process. For larger changes in items such as components and products with more complex structure than documents, a more formal change process is required. The change process workflow is shown in Figure 9. The change process begins when the change request or change order is made. The person who made the change request defines the subject of the change, the items (parts, equipment or documents) affected by the change, and the description of the reasons for change. The change request can contain valid electronic document attachments such as drawings with comments and redlining. The change request is delivered to the persons responsible for changes according to the workflow as defined in the system. At this point, the priority of change should be estimated by the person responsible for the changes. It is necessary to define clearly what kinds of changes will be made to the product. After that, the person responsible for changes makes a change order which can be based on change request. If this kind of process is possible to implement in the installed base system or PLM system, huge benefits can be achieved. A large number of change requests can be collected together quickly in a single change order, which will be put through quickly with its negotiations, inspections, and approvals. (Sääksvuori and Immonen, 2002).

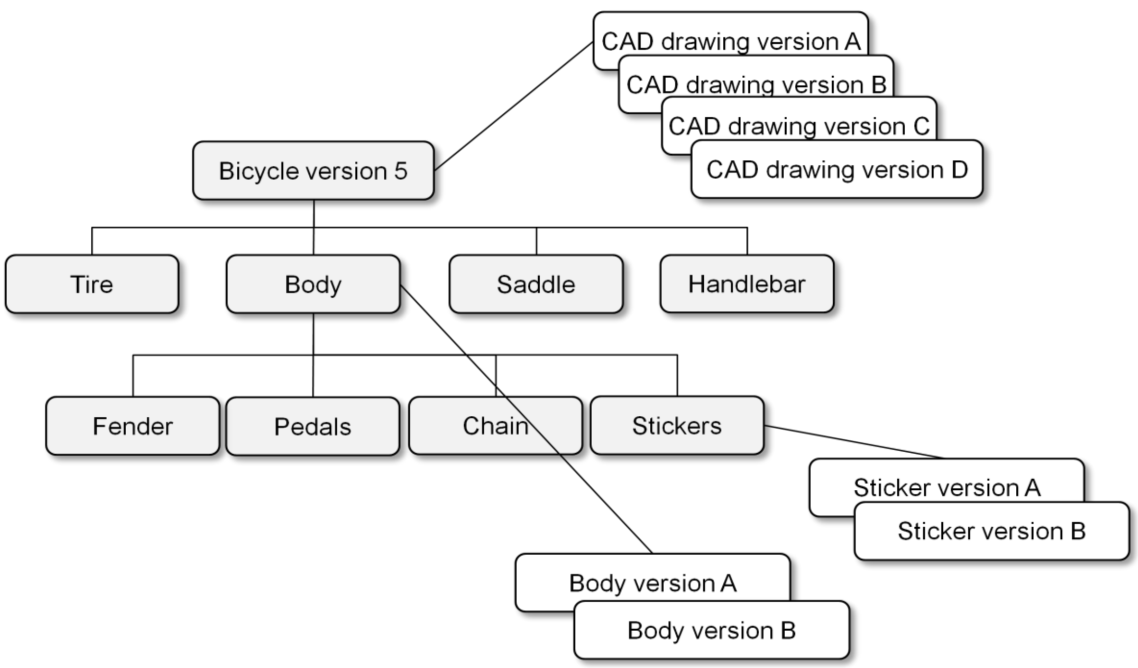

Figure 10. Example of product structure and version history. (Adapted from Sääksvuori and Immonen, 2002)

When the planned changes have been made, the persons responsible for the changes check the situations and release the documents, items or structures for distribution. When the change order is ready and changes are made, the ideal change management tool gives a new version number to different documents, components or structures. Figure 10 illustrates a simplified product structure, which contains changes made to a product and the version history. Structure updates can also be changed manually. With the component items, the release of a change usually triggers the transfer of item information to the Enterprise Resource Planning (ERP) system. Finally, the system informs interested parties of the changes made by means of a change note.

2.8.4 Document management

In past decades, traditional document management practices at an enterprise were based on paper document management. When companies started to change over from paper document management to electronic document management, it was thought that old physical binders and archives would disappear and solve the problems related to traditional document management. At first, electronic document management fell into poor condition because of the difficulties of storing electronic documents. Old document management methods designed for paper documents were not suitable for electronic documentation. This issue created the need to develop more efficient electronic document management methods and systems which can rise to the challenges of today (Anttila 2001, p.4).

Nowadays, companies have also made huge investments in their information systems to make the production of electronic documents such as e-mails, notes, Excel sheets, and drawings even more efficient. The tools which have been used to create and manage documents are easy to use. According to Anttila, increased document creation is mainly a good thing but the amount of insubstantial information will also increase: “It is better that the information is stored in some places in a form of outlined documents, than that there are no documents at all.” (Anttila, 2001, p.3).

Document management is a practical problem in many companies. Documents are also one kind of item in installed base management. Documents have specific characteristics and therefore they should be treated independently. The content of the “Document-items”, however, impose some special requirements from the management point of view. Documents and other items may be related to each other. One component may be associated with many documents, such as manufacturing drawings and maintenance instructions. Similarly, one document can be associated with many items. (Peltonen et al. 20002, p.25)

Documents are usually edited with check-out and check-in functions. When the content of a document is checked out of the system to the user’s own computer, it is possible to make changes to the document. Many systems make a new document revision automatically when the document is checked back in. The user checked out revision 1.1 and the revision was copied to the user’s computer. When the content of the file was modified, the user checked in the document and the system creates a new revision 1.2 and deletes the user’s file. Attributes can be used to search for documents, such as any other items. Documents would also be good to be able to search on the basis of their content. (Peltonen et al. 20002, p.25)

The following functions play a significant role if the aim is effective document management.

1. Life cycle of the document. Document changes are managed with a revision-mechanism.
2. Document classification. Documents must be able to form a variety of types, with attributes (drawings, notes, instructions).
3. Document status. The term is used to express the degree of preparedness and the usefulness of the document.
4. Structure of the document. Links between documents are required for multi-page drawings and the presentation of delivery-specific document folders. In general, document structures should be formed with a component structure.
5. The system should be able to manage the different version and forms of documents which relate to the same document-item.

3 CASE STUDY - INSTALLED BASE AS PART OF PRODUCT LIFE CYCLE MANAGEMENT IN SERVICE

This general information about the case company is based on the case company's internal material. Most of the handled issues have been presented as fact without any more accurate explanations. The case company is the service department of a global company, which is the leader in power and automation technologies that enable utility and industry customers to improve performance while lowering environmental impact. This business unit (case company) is the global organization, which is the manufacturer of customized industrial equipments.

3.1 Case company presentation

From the customer point of view, the long life cycle of a product gives rise to different kinds of needs and challenges. That is the reason why after sales services that meet the customer's needs are an important part of the company's business. Therefore, the case company offers a comprehensive life cycle service concept for its customers for maximizing performance and the utility value of the product, as seen in Figure 11. The case company has several ways of meeting customer needs and its life cycle service concept consists of: basic services, extended services, and value-added services. Basic services consist of training, technical support, spare and service parts, on-site service and repair, scheduled maintenance, and product warranty. An extended service consists of service contracts, retrofits, and replacements. In general, the idea of extended product/service is that it contains all the necessary spare parts as well as the installation by on-site service. It is mostly scheduled and preventive maintenance.

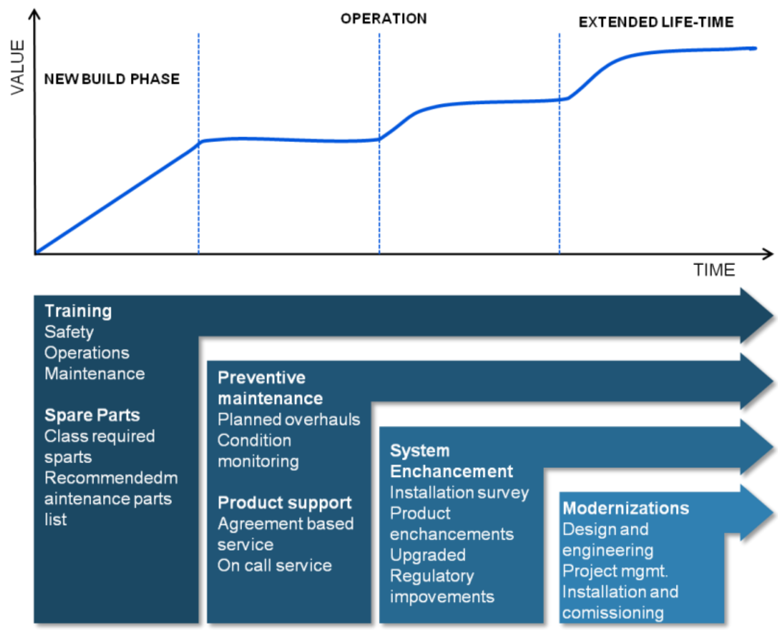

Figure 11. Life cycle service concept. The case company provides after sales services throughout the product life cycle.

Value-added services are actually product improvements which allow reducing life cycle management costs, improving product reliability and performance, and extending original installation lifetime. Value-added services reduce the customer's need to invest in the new systems. Value-added services consist of upgrades and modernizations. Extended services and value-added services usually encompass the following measures: site survey, product maintenance schedule, and service parts of actions. The case company's service department includes five different subunits, depicted in Figure 12, that provide after sales services to customers and it also has strategically positioned Service Centers throughout the world providing life cycle services and support.

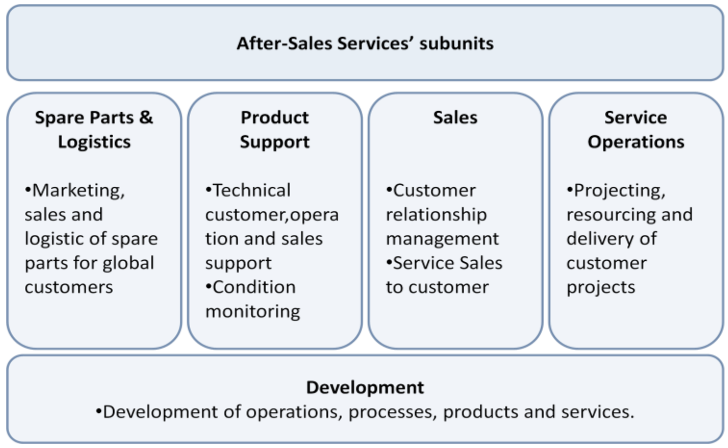

Figure 12. Structure of the After Sales Services.

Figure 13 shows the service focus in the product after sales life cycle from an installed base information collection point of view. In the start-up phase, the service focus is on securing effective utilization of systems and equipment and starting to plan and implement the maintenance strategy. From the information management point of view this phase contains data transfer from engineering to service. An installed base is created by using as-build data and continuous life cycle data collection to the installed base system begins. In phase 2, the service focuses on the spare parts services, rebuilds and replacements, and mechanical upgrades. In the third phase, the service operation focuses on modernizations and modifications which extend the product's life cycle.

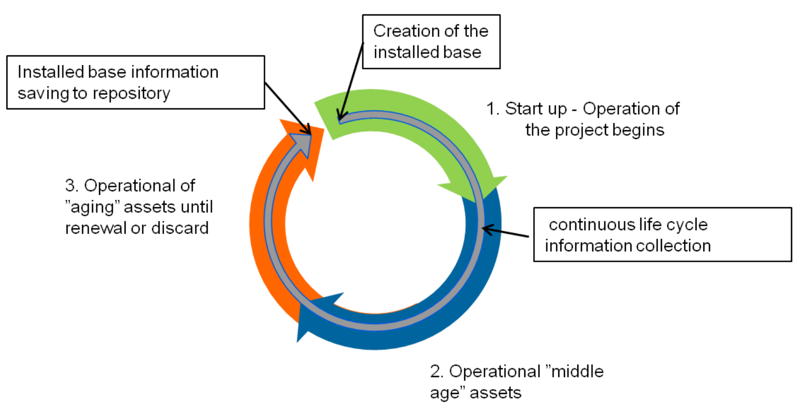

Figure 13. The product after sales life cycle from an installed information collection point of view.

3.1.1 Present state of product life cycle information management in the service department

The purpose of this chapter is to clarify the current state of information management in order to understand why development of systems and practices is necessary. About a decade ago when the manufacture of products began, the information was managed under the folder structure in the network drives. Between the years 1998 and 2003 all the information, concerning about 70 projects, was stored on the network drives. In 2003, the first ERP (ERP^1) system was introduced to facilitate technical information management, which includes tools for product information management, drawings, and product structure from the assembly and installation point of view. Approximately 110 projects were managed in ERP^1. In 2009, the company began to use new PLM-system (PLM^1) and new ERP-system (ERP^2). These new systems were designed to replace the outdated ERP^1 and improve the document management practices. During the transitional period the ERP^1-system for project management was as still being used.

When the after sales business began to grow, the case company realized that existing systems do not support the service operations. PLM^1´s purposes of use focused on the implementation of new projects and replaced ERP^1. PLM^1 was intended for design and engineering use and product structure is designed for assembly and installation. Information about the old projects was still in the network drives or in ERP^1, which were closing down. The change management of product information and maintaining service history was very challenging in these old systems. The structure of the ERP^1 projects varies and most structures were not up to date, because practices and responsibilities of who eventually maintains the information were unclear. There was a need for a new system and product structure which supports the service department's needs and where it could gather installed base information during the product's life cycle. The case company decided to start to use an installed base system for collecting life cycle information about the projects it delivered.

The engineering department, which is responsible for the maintenance of product data, does not always take into account these changes in the final stage where the product has been successfully delivered to the customer. For example, hose lengths in technical drawings do not always match reality, because during the installation some of the hoses have to be extended or shortened. This information about modification has not reached the person responsible for product data management or it has not been seen as necessary to update the drawings afterwards, since the product structure is primarily made to serve the assembly and installation stage.

3.1.2 Main stages of the life cycle process

The product life cycle from the case company's point of view contains five major phases, i.e. projecting, assembly, delivery, installation, and operation (which include the warranty time and after sales operations). This thesis will concentrate more on after sales point of view of installed base information management, but the other phases are shortly introduced to clarify the whole product life cycle in the case company. Figure 14 shows the main stages of the life cycle and which department produces or utilizes information in each stage.

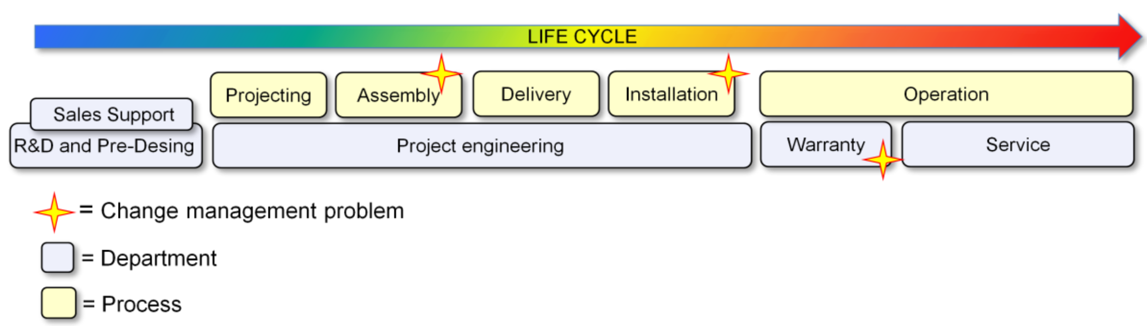

Figure 14. Main stages of the life cycle process. Change management causes problems at certain stages of life cycle.

<u>Projecting</u>

In the projecting phase, project engineering designs the project. Sales support provides the project-specific requirements. In theory, the product family consists of modular standard products, but in practice every product sold is an independent project, which is tailored to suit the customer. The project can be seen as an extended product or provision of benefits. The project usually includes services such as installation, product support or commissioning. Negotiations of a contract and the bidding process normally produce a huge number of documents, which have been handled with an Electronic Content Management (ECM) system (introduced in chapter 3.1.2). The projecting phase ends when the approval process is completed and a quotation has been accepted. This means, from the information management point of view, that all material is in the "as-proposed" phase as it has been sold to the customer.

The engineering department exploits a standard product structure in the PDM-system when they start to design the project. By modifying the standard product structure and generic equipment data the engineering department customizes the project to meet the customer's needs. The engineering department creates "as-designed" documentation which allows for manufacturing of the product. This means, from information management's point of view, that "as-designed" documentation includes, for example, detailed equipment specifications, assembly drawings, and product structure. After that the product will be transferred to the manufacturing phase and "as-designed" documentation serves as a guide to assembly.

Assembly

The "as-designed" documentation is a platform for the assembly and installation phase but there may normally occur changes to the "as-designed" version of the product when the assembling proceeds. For example, some practical changes to the equipment have to be made or some equipment has to be replaced. This sets a requirement for product data management. The assembly phase ends with the "as-build" phase, which has been comprised during the assembly. In this stage, where the product has been successfully assembled, the engineering department, which is responsible for maintenance of product data at this stage of the product life cycle, will update the product data and product structure to the "as-build" phase. The product data and product structure should reflect the reality at the moment when the assembled product leaves the factory. From a service point of view, this step does not work accurately because all of the changes are not being clearly documented in the "as-build" documentation.

Installation

In this stage the product will be installed at the customer's premises. During the installation some changes may still take place to the product structure. For example, some hoses or cables have to be shortened or mounting parts have to be replaced. These changes should also be documented properly, but challenges also occur in this updating process. After the installation process the product will be released to the customer. From the information management point of view, "as-is" means the state of the assembled product which has been delivered and installed at the customer's premises. "As-is" documentation has been updated and it includes the changes that took place during the installation.

Product life cycle from the service point of view

From the service business point of view, reliable and clear documentation is very important. It helps the service department to serve customers efficiently and faster. When the product has been delivered to the customer, the service department takes control of maintenance and other services for the product. All the relevant "as-is" data, which creates the basis of the installed base, will be exported to the installed base. Installed base information, such as service history, that accumulates during the life cycle is stored and managed in the installed base.

Service uses "as-is" material for a platform for installed base information management and when some changes occur due to service operations the "as-is" material expires and a new "as-maintained" phase is created. In practice, "as-maintained" information, also known as installed base information, is the best possible and updated information about the customer's equipment.

Information management does not work quite the way it is intended. The first three information phases in the projecting life cycle part are well managed, but the challenges begin in the "as-build" phase. The challenges are encapsulated in change management which is not working well enough in the "as-build" and "as-is" phases. If some practical changes to the equipment have to be made or some equipment has to be replaced the information about the changes is not being clearly documented and updated in the "as-build" documentation.

If the "as-is" information (basis of the installed base), which should reflect the reality at the moment when the assembled product is delivered and installed, is already outdated when the service department receives it leaves the service department with big challenges to maintain “as-maintained” information. It is difficult to rely on the information if you cannot be sure of the reliability of the information. This slows down the decision-making in service operations because the information accuracy should always be evaluated and ensured.

This study found that if there is a system for collecting installed base information, one has to remember that information about the “as-is” status doesn’t necessarily describe the current condition. The customer could have replaced equipment and used some other suppliers, information about these changes aren’t necessarily in the case company records. The customer can also order maintenance from other suppliers,

The case company also has local service centers around the world from which customers can order maintenance. In these cases, it is important to get proper information about the current condition of the equipment and the maintenance history must be collected.

3.1.3 Information management systems

The purpose of this chapter is to introduce the information management systems used by the case company. The present information management practice includes four different systems: ERP-system, PLM/PDM-system, Enterprise content management system (ECM) and global web-based tool to support installed base management. These four main information systems have been selected for this thesis because they constitute a frame of what a system could be used for in installed base information management.

PLM-System

The system enables application integrations (CAM, CAD and document management systems etc.). Nowadays, the software is primarily used for technical information management in the case company. The case company uses current PLM-System for managing product- and engineering information. With PLM-system the case company manages all product data from product development to manufacturing and installation. PLM-system is integrated with the ERP-system and the transfer of data from the PLM-system to ERP-system is enabled. The system supports material (Item), product structures, workflow, and change and document management (Siemens automation 2011).

ERP-System

The case company currently uses integrated enterprise resource planning (ERP) software and which uses the concept of modules. Modules are individual programs that can be purchased, installed, and run separately, but which all extract data from a common database. ERP-system consists of several modules, including: utilities for marketing and sales, field service, product design and development, production and inventory control, human resources, finance, and accounting, as seen in Figure 15. The key objective of ERP is to integrate internal and external information and processes from all functional divisions of an organization. Its purpose is to facilitate the flow of information between all business processes inside the boundaries of the organization and manage the connections to outside stakeholders. The integration between business processes helps develop communication and information distribution. The ideal ERP system chains all the organizational processes together with a central database repository and a fused computing platform (Tech-faq ERP 2011).

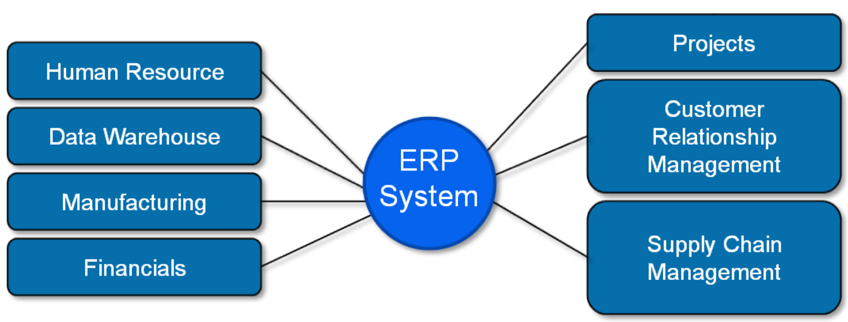

Figure 15. ERP System chains all the organizational processes together (Adapted from Tech-Fag SAP 2011)

Web-based tool to support installed base management

Tool is a global and web-based system to support installed base management. It is designed for looking for installed base information and contains the ability to keep track of all information concerning a corporate company's products and systems at a customer site. Tool has the ability to maintain customer site information, track products and systems installed at the site, and maintain the service history. The system main purpose is to support sales.

The system has not been properly implemented in the case company and currently it is not exploited in any way. Technical information about delivered projects has been transferred into the system, but this information has not been maintained, nor is it utilized in daily tasks. The system might have the potential in future to serve as a tool for collecting and maintaining installed base information.

Enterprise content management system

Case company´s ECM-system is a cross-divisional and cross-regional service and it has been selected as the document management system in the case company. The enterprise content management system is generally in strategies, methods, and tools used to capture, manage, store, preserve, and deliver content and documents related to organizational processes. The ECM tool allows the management of an organization's unstructured information, wherever that information exists. The case company uses web-based user interface, for document control and management. ECM-system includes collaboration, publishing, traceability, standard structures, document numbering, template handling and integration, and enables managing, sharing, and publishing information from one source globally – internally and externally.

3.2 Description of the research material

This chapter contains a short description of the methods that were used to collect the research material. Research has been carried out with interviews and survey. Also background information of the respondents is presented. Timetable of the interviews is available in Appendix II.

3.2.1 Interviews

The gathered case material is mainly qualitative interviews and internal documentation. Twenty one people were interviewed in 15 interviews and also three benchmarking surveys have been conducted. Each interview lasted between one and three hours and was recorded whenever possible. All the recorded interviews and interview memoranda have been transcribed and stored in a database.

Interviews have focused on the employees of the case company's service department. This is natural, since the information users are in an important role when looking to improve the organization's information system. Interviews covered three topics: analysis of current state - Information availability and reliability, determination of the challenges and the installed base information requirements in service operations. The interview data was gathered using semi-structured, open-ended interview guides, and by asking the interviewees questions on the following generic themes, but going into detail with each respondent's specific tasks (Woods 2006).

- What kind of challenges there are in obtaining reliable information on the installed base?
- What kind of installed base information is needed?
- How would you use that information in your tasks and how it effects in service quality and efficiency?
- How the information reliability and availability could be improved?

The survey methodology was used to collect qualitative research material for the research questions. Qualitative research is about exploring issues, understanding phenomena, and answering questions. Qualitative research aims to provide an understanding of how or why things are as they are. Unlike quantitative research, there are no fixed set of questions but, instead, a topic guide is used to explore various issues in depth. Qualitative and quantitative research methods can be more useful when the two methods are combined. A decision to use both methods in this thesis was based on the fact that the results can be viewed more broadly. This means the potential challenges and development needs can be defined more precisely. Table 6 below summarizes the key differences between quantitative and qualitative research (Qualitative research 2011).

Qualitative research is usually used in the analysis of unstructured information such as interview transcripts and open-ended survey responses. It is used to gain insight into people's attitudes, behaviors, motivations, and culture. It seeks to answer "why" questions. Qualitative analysis is typically inductive reasoning which seeks to make generalizations and draw conclusions emerging on the basis of the material. A statistical generalization is not intended (Ereaut 2011).

*Table 6***.** Key differences between qualitative and quantitative information (Qualitative research 2011)

Quantitative information	**Qualitative information**
Larger samples	Smaller samples
Statistically valid	Directional findings
Analyses numbers – how many think what?	Analyses thoughts and feelings
Closed questioning techniques (less opportunity to ask "why"	Open questioning techniques
Who thinks what? (Measuring)	Why do people think/behave as they do? (Explaining)
Analyzed in aggregate	Allows us to provide anecdotal type information

Hypotheses are not usually used in qualitative research and the material is intended to analyze with a minimum of presuppositions. However, research cannot be done without any prior assumptions. In this thesis is assumed that there is a need for the development of the installed base information availability and utilization.

3.2.2 Survey

The motivation to use a survey was that it made it possible to contact a large and clearly defined group of people who work in the after sales service business, and it made it possible to gather more extensive quantitative data. The questionnaire was tested with two employees whose feedback was used to revise the questions. The questionnaire included multiple choice questions and two open-ended questions.

This section contains background information on the survey and the respondents. The questionnaire was sent to 40 people and the response rate was 75 %. Ten people failed to respond for unexplained reasons. The survey was targeted at the case company's service department and the entities that are the potential installed base information users. Most of the respondents have worked for the company for over two years. This is worth noting because within two years the company's processes, methods, and systems have become well known. The questionnaire mainly focused on service department employees as seen in Figure 16. Local service centers were also included in the questionnaire in order to obtain a perspective from outside the after sales service department.

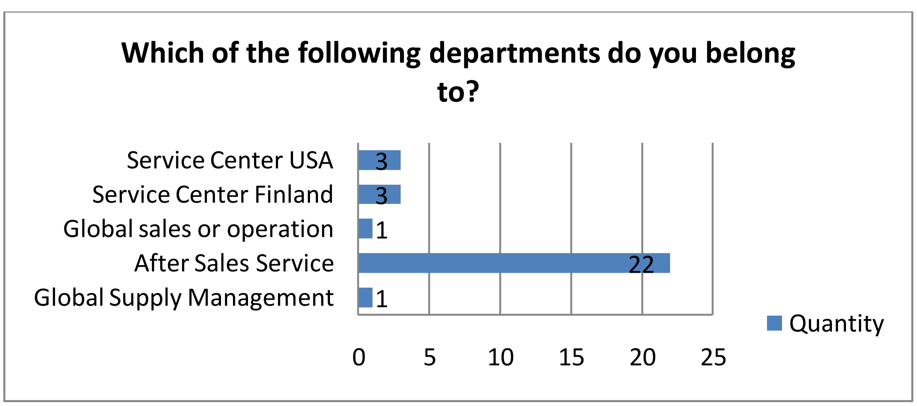

Figure 16. Distribution of respondents by department

The objective of the above background information was to help interpret the answers in the right way and to understand what perspectives the answers have come from. The questionnaire contains 19 detailed questions on multiple topics. The topics covered were:

- Background information of the respondents
- Analysis of current state - information availability and reliability
- Determination of the challenges
- The installed base information requirements in service operations

The purposes of the questionnaire's constructs are the followings. Questions related to information availability and reliability was included to provide answers to user experiences of the information systems. The purpose of these questions was to enable analysis of the current state of installed base information management in the case company. The motivation to examine challenges related to the search for information was to analyze which processes and methods need to be developed, so that information management and utilization is more efficient. The requirements of installed base information were inquired into in order to determine what kind of installed base information is needed in the after sales business.

3.3 Results

In this chapter the results of the questionnaire and the survey are presented. First part of this chapter examines the current state of installed base information availability and reliability. Objective of this part was to determine the user experiences of the current systems. Second part of the chapter summaries the challenges related to information management practices and challenges associated with information collection. The goal of this part is to find out which information management processes and methods are needed to develop. Third section describes the types of installed base information needs and clarifies the service department´s subunits specific needs for installed base information. The aim is to determine what kind of installed base information is essential in after-sales point of view.

3.3.1 Current state

In this survey the respondents were asked to estimate how much time they spend daily searching for installed base information. The distribution of time usage is illustrated in

Figure 17. About one third of respondents spent more than two hours every day searching for installed base information. It is assumed that the effective working time is approximately six hours a day (calculated as 7.5 hours a working day minus breaks and other unprofitable time). In that case, it means that employees spend on average over 30% of their working time just searching for information. This unprofitable time spent searching for information directly affects the different service operations' response times.

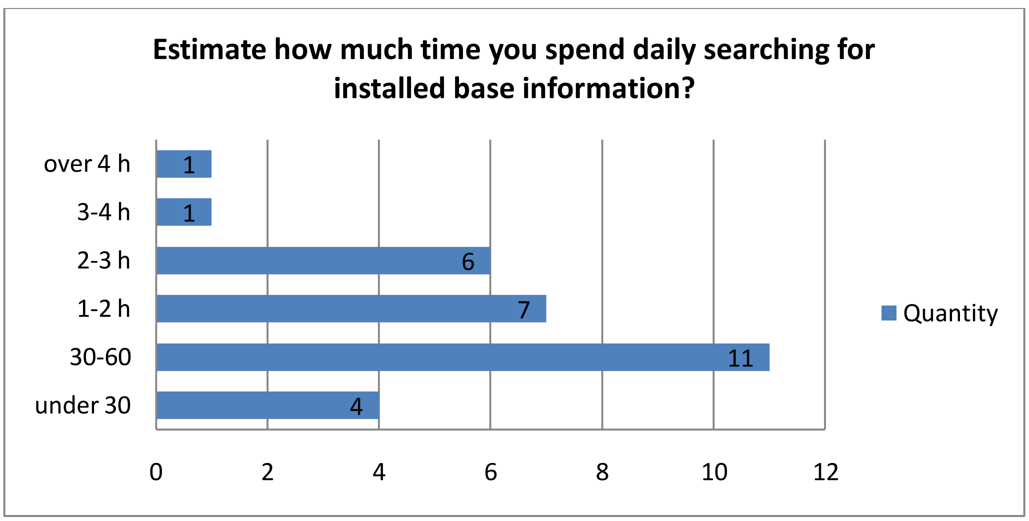

Figure 17. The distribution of time usage.

The Figure 18 shows that approximately half of respondents estimated that over one hour would be saved when searching information during the working day if the information was more easily available. Average annual hours (Man-year) actually worked per person in Finland are about 1700 hours (OECD Employment Outlook 2009). On this basis it can be estimated following: two and half man-years per year could be used for productive work in service department, if the information is more easily available.

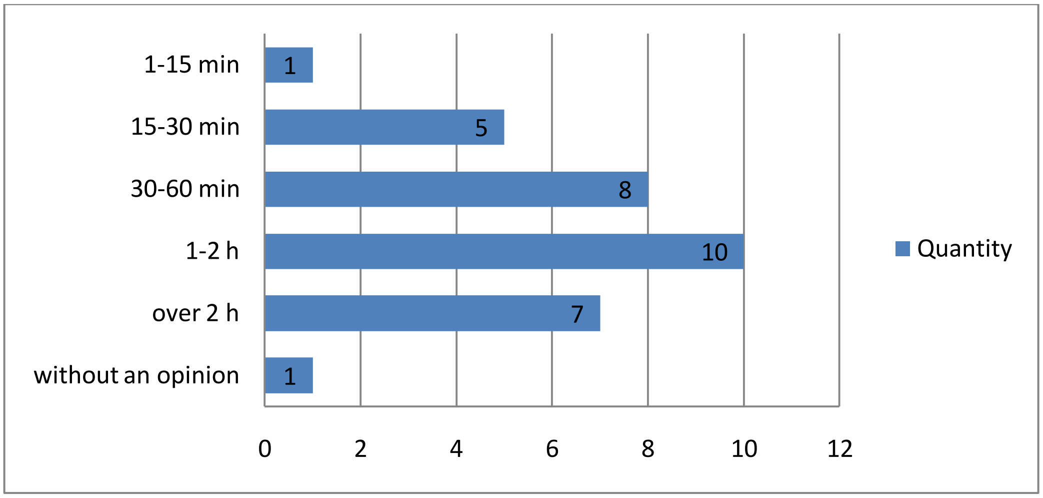

Figure 18.Respondents estimates of how much time would be saved when search for information during the working day if the information could be found more easily.

In the survey, respondents were asked to estimate the reliability of the installed base information that they used in daily working duties. Based on Figure 19 below, most of respondents estimated that the reliability was at a tolerable level and only a few estimated the reliability at a good level. When considering the current state of installed base information management and utilization from the system point of view, the fact is that most of the respondents were not satisfied with the current information systems and felt that they cannot perform their daily tasks effectively.

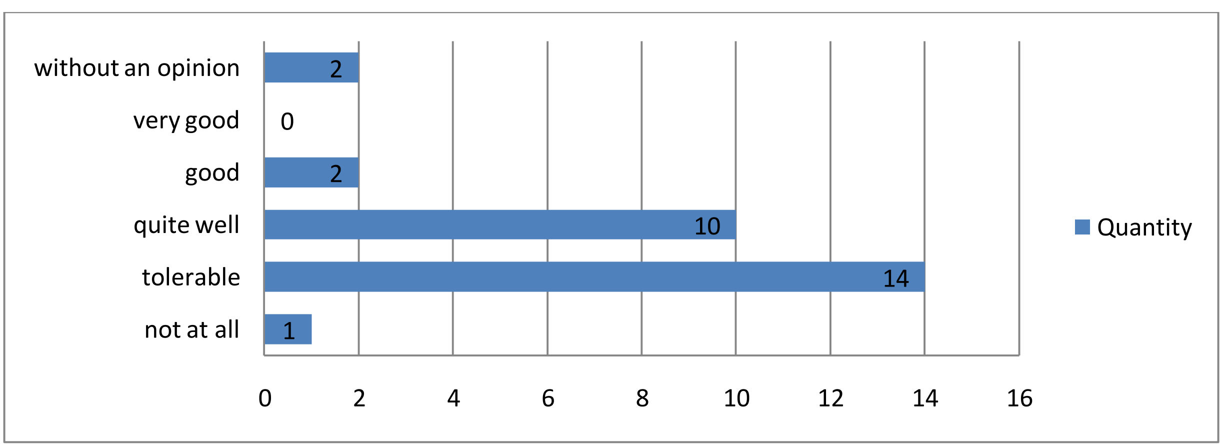

Figure 19. Respondents were asked to estimate how much they trust the installed base information that they use in their daily working duties.

As seen in Figure 20 below, more than half of respondents felt that current information systems are rarely or quite rarely sufficient to perform routine duties related to work assignment. Comparing this result to the result of the questions where the respondents were asked to estimate the overall user friendliness of information systems, it can be assumed that the dissatisfaction is at least partially due to poor user-friendliness. Therefore, most of respondents believe that user friendliness is at quite a poor or even worse level. The distribution of these answers is shown in Figure 21.

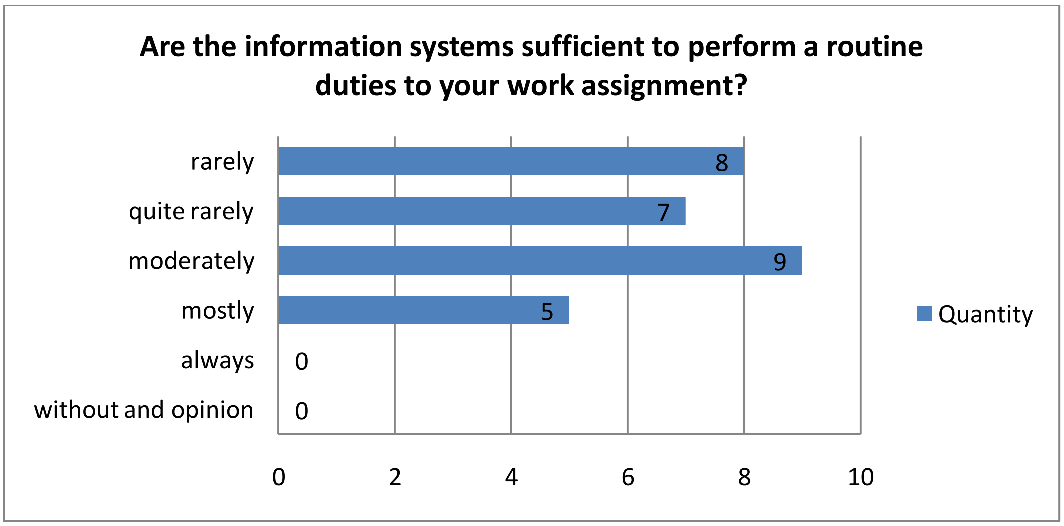

Figure 20. Adequacy of information to perform duties.

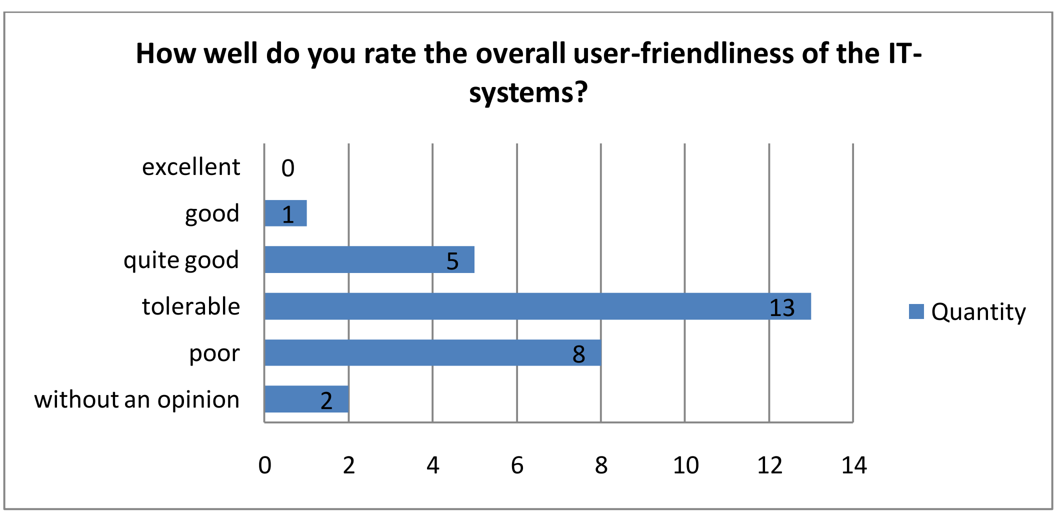

Figure 21. User-friendliness of the IT systems.

3.3.2 Determination of the challenges

In this section the challenges related to installed base information utilization and management are examined. The basic assumption was that the installed base system management and installed base information utilization is currently not at the best possible level. On this basis, two questions were added to the survey, whose aim was to help define the development needs. The purpose was to identify common problems and factors which currently are not working well. Improving these identified factors makes it possible to improve the information management and utilization practices and processes. Respondents were asked to estimate how often certain problems occur when installed base information is needed in working duties. The significances of these reasons were estimated using the following scale:

1. Almost always
2. Often
3. About every other time
4. Sometimes
5. Seldom

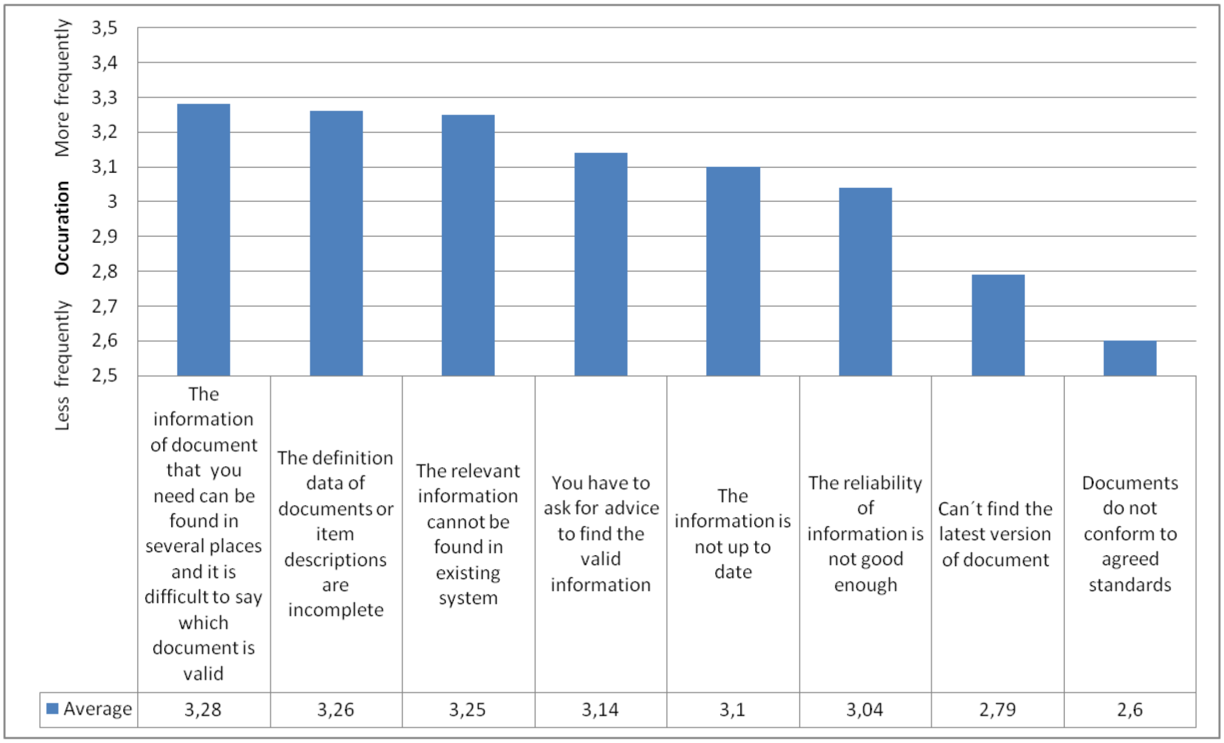

Figure 22. Main problems related to the exploration and utilization of installed base information

Figure 22 shows the occurrence ratio (in ascending order) for the different problems related to the management and utilization of installed base information. The question's purpose was to find out which problems are the most common. Distributions of responses are presented in Appendix III. There was only a little variety in the distribution as expected. This can be partly explained by the fact that all of the selected problems are collected via the interviews and the selected problems really exist. Hypothetical problems were not included in the question. The most common problem was that the same document can be found in several places and it is difficult to say which one is valid. According to the respondents, almost as common a problem is the fact that the item's and document's metadata are incomplete. In practice, this means that the item and document definition information is imperfect and because of that they are often difficult to find. Incomplete metadata also affects the level of errors because of uncertainty about the correctness of the information arise. In general terms, information search and discovery seems to cause problems frequently. The survey also highlights the fact that one has to ask for advice to find the needed information.

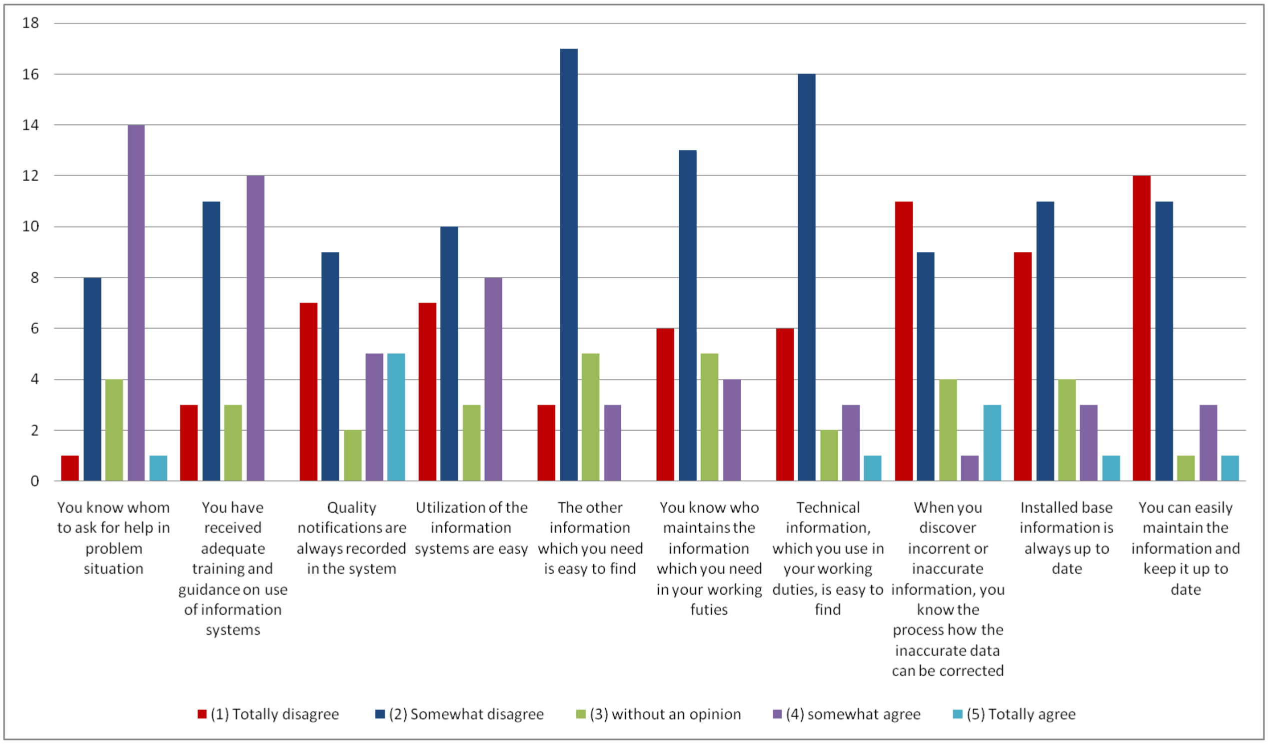

Figure 23. Root causes of problems. Poor quality and availability of installed base information is due to various reasons.

Respondents were asked to respond the several statements, which can be seen in the Figure 23.The aim is to identify where the problems come from and what are the root causes of problems. The following issues can be inferred from the responses. Most of the respondents know usually by whom to ask for help in the problem situation. However, the distribution is not entirely smooth, because about one thirds of respondents are not quite sure by whom to ask for help and support. A similar bisection can be also detected when examining the quality of training and guidance. Almost half of respondents think that training and guidance is in sufficient level and in proportion nearly half of respondents disagrees that proposition. The exact cause for that observation cannot be determined but dispersion can be explained partly by the respondents' background data, such as work experience.

Based on the survey, effective utilization of current information systems are not effortless. This statement is supported by the fact that the majority of respondents do not feel the systems easy to use. Information availability is not good enough. According to the responses, seems that it is difficult to find the needed piece of information. Over 70% of respondents estimated that technical information is not very easy to find.

Information management practices are also unclear for the majority of respondents. According to the survey, almost half of respondents don´t know how to proceed when they discover incorrect of inaccurate information. In practice, employee don´t know to whom should they contact about change management issues and where they should report these errors. Following conclusion can be made; the change management is not working well enough. The argument is also supported by the observation: the majority of respondents feel that the installed base is always not up to date. This is probably true, if the change management process is not working well, then the installed base reliability decreases.

3.3.3 Common challenges in installed base management

This chapter summarizes the main challenges related to installed base management and utilization. The challenges have been gathered through interviews and a questionnaire. The author's own practical experience and overall view have also been used in the investigation of the challenges. Based on these observations, the recommendations are given for improving installed base information availability and reliability.

Global service business poses certain challenges for installed base information collection and management. Dry-docking and service operations are usually performed around the world and service engineers who carry out maintenance operations can vary. Also, customers can conduct maintenance operations independently or the service operation is performed by a third party. This complicates data gathering because the data about parts changes and other service operations are fragmented into many different places.

Standard product design drawings are used in individual projects if possible. The product is still project-specific. Project-specific changes are made so that the product meets the customer's requirements. In practice, this means that every project is unique even though the products are based mainly on product models. Changes happening during the assembly and installation would be important to record in documents. Updating changes to documents and design drawings is difficult because standard product documentation cannot be changed. In practice, the designer has to draw a completely new CAD-drawing so that the change can be documented.

Most components are purchased from suppliers. The product data quality of these components varies and this causes problems. Problems are caused by the fact that all of the components are not supplied with a bill of materials or spare parts lists. This complicates the identification of needed spare parts and it is difficult to sell to the customer the necessary parts.

A long product life cycle also sets its own challenges. Lots of parts changes happening during the product life cycle and also upgrades and modernizations must be taken into account. The product owner, user, and location may also change during the life cycle. These factors also set unique challenges so that the system remains up to date. Challenges are largely related to change management.

At the general level, the challenges are crystallized in the fact that the installed base information is not up to date. Changes are not documented sufficiently comprehensively. Item data is not always in good condition. Heading information may be incomplete and duplicates may also occur. These factors increase the number of faults.

The effective use of service history is difficult. Currently, service history is typically collected by service reports. Service reports are fairly free-form and their quality depends largely on the authors of the reports. Service reports are primarily a textual description of the performed events and photos are attached to illustrate those events. Finding the necessary information on them is challenging and time-consuming. Service reports do not provide enough comprehensive information about the service events. Service reports are not located in one place. Exploitation of service reports globally is difficult because the company lacks a tool that allows sharing reports between offices in different countries. This is a reason why a service report, which has been made in the United States, is not necessarily available in Finland. For these reasons, effective exploitation of service history is difficult. For example, determination of maintenance intervals and the time between failures is inconvenient.

Problems related to change management and exploitation of service history are partly due to the fact that the information is stored in several different places. It is difficult to know where up-to-date information is located. Information such as change records, installed spare parts and maintenance intervals may be stored in different places. Up-to-date information may be located in personal Excel files, e-mails, network drives or in the document management system. The most valuable information may also be tacit knowledge which is not stored in any place. The incoherence of information is a major obstacle to the effective use of information and lengthens response times, since searching for information takes a lot of time. Different kinds of settlements and checks take up a lot of working hours.

The reasons for the above-mentioned problems are often derived from a lack of clear guidelines, processes, and practices. Also a lack of responsibility complicates maintaining installed base information. It is not well known who is responsible for the change management. The orientation of new employees is challenging because the overall perception of information management methods is not easy.

3.3.4 Installed base information requirements

The case company's installed base information needs were examined in the survey with multiple choice questions. The installed base information needs are studied through examining how often the different pieces of installed base information are needed in service operations. The results of these questions are shown in Tables 7, 8, 9 and 10. The following may be noted. Since the all selected information types (installed base information) are commonly used in the different service operations the major differences cannot be detected. If the average is greater than three, the information can be considered as valuable. On the other hand, information which got a value lower than 3, is not necessarily useless; it can have a significant impact on a particular business area.

At first, inspecting the need for different information sources and studying how often larger entities, such as maintenance reports, is needed. When considering the information needs from the average point of view, the most valuable piece of information seems to be information related to spare parts, as seen in Table 7. The information about spare parts is required for approximately 60-80% of service operations and working duties. Information about previously installed spare parts is needed in service operations nearly always. Also almost half of respondents estimated that spare parts lists are needed “Almost always” in their service operations. Very valuable piece of information is also the all kind of technical product data and site survey reports are estimated as the third most valuable with a value of 3.34.

Table 7. Information needs related to information sources

	Almost always (5)	**Often (4)**	**About every other time (3)**	**Sometimes (2)**	**Seldom (1)**	**Average**
Previously installed spare parts	10	8	4	5	3	3,57
Spare parts list	12	4	3	8	2	3,55
Technical data on the product (model, dimension, power, etc.)	9	8	5	3	4	3,52
Site survey report	9	5	6	5	4	3,34
Service history of the equipment	11	2	5	4	7	3,21
Maintenance report	8	5	5	6	5	3,14
Description of the failure	8	1	7	6	7	2,90
Condition monitoring data	7	3	3	8	8	2,76

Variability of distribution in this question was as low as expected. It should be remarked that different kinds of information are needed in different service operations and that is why the variation was so low. For example, one of third respondents needs the service history of equipment “Almost always”. So this need cannot be regarded as insignificant, even though measured by the average it was rated as fifth. All of the selected information is commonly used in the different service operations. Therefore, it is necessary to split the question into three parts. With these three separate questions it was possible to define more precisely what kinds of equipment data, location data and event data are needed. The research question was: How often the following pieces of installed base information are needed in your working duties?

Equipment data

When considering the product-related information (equipment data) needs, the following aspects can be identified. The most needed equipment information seems to be product definition data (such as model of the equipment, serial number or material number) and equipment manufacturer, as seen in the Table 8. . Also hierarchical product structures which indicate the last known configuration is considered necessary. The least necessary information seems to be warranty information, which is probably due to the fact that the warranty period has already expired in many cases when the project is in the after sales phase and service manages the projects documentation.

Table 8. Distribution of responses to the question: how often the different pieces of equipment data are needed in service operations.

	Almost always (5)	Often (4)	About every other time (3)	Sometimes (2)	Seldom (1)	Average
Model of the equipment, serial number, material number	14	6	3	4	1	4,00
Manufacturer of the equipment	10	12	4	1	2	3,93
Product structure	8	7	3	7	3	3,34
Item classifications	6	7	4	7	5	3,07
Maintenance plan	6	6	2	7	8	2,83
Physical condition	6	4	5	4	9	2,79
Cumulative usage (hours in operation)	4	7	2	6	10	2,62
Operational condition - product performs its required functions	5	4	4	7	9	2,62
Life cycle status	4	3	7	5	9	2,57
Warranty	4	2	2	10	10	2,31

Location data

In terms of the average, the most needed location information is item location, owner and user information, and site location information, as seen in Table 9. There are no unexpected results and the distribution is quite flat.

Table 9. Distribution of responses to the question: how often the different pieces of location data are needed in service operations.

	Almost always (5)	Often (4)	About every other time (3)	Sometimes (2)	Seldom (1)	Average
Item location	11	7	5	3	3	3,69
Owner or user	11	6	2	5	5	3,45
Site location	10	5	5	5	4	3,41
Application - description of the purpose of use at the customer	7	3	8	4	8	2,90
Accessibility - information for field service access	7	4	4	7	7	2,90
Installation dates	7	3	3	9	7	2,79
Environmental characteristics	6	3	5	5	10	2,66

Event data

Table 10 presents the needs related to the event data. According to respondents, the installed base item changes are the most important event data type and material usage is the second most important. This is an interesting issue, because respondents are more interested in the parts replaced during the event than the actual event itself. Respondents estimated that reason for the event is the third most valuable piece of information and event classification is the fourth most valuable piece of information in this category. According to Table 10 below, information about who has participated in events and how long the operations have last are not regarded as very major.

Table 10. Distribution of responses to the question: how often the different pieces of event data are needed in service operations.

	Almost always (5)	Often (4)	About every other time (3)	Sometimes (2)	Seldom (1)	Average
Installed base item changes	8	5	6	6	4	3,24
Material usage - spare parts and materials consumed by the event	8	5	4	7	5	3,14
Event reason - root cause for the event	6	7	1	6	9	2,83
Event classification - indicates what the event is about	6	4	5	5	9	2,76
Event performer - identifies people responsible for handling the event	6	3	4	8	7	2,75
Time stamps - identifies people responsible for handling the event	6	3	4	5	11	2,59
Personnel time usage - indication of man-hours allocated for the event	5	1	1	8	14	2,14
Travel expenses	5	0	2	8	13	2,14

In summary, it seems that all kinds of history information about parts, such as installed base item changes, are among the most significant information types in different service operations. This assumption is also supported by the fact that information about previously installed spare parts was found to be very important. In this context, Hierarchical product structures which indicate the last known configuration are considered very necessary. Technical data on the product are also very relevant. Identification data which facilitates finding the needed piece of information later and helps to determine the needed parts is needed also often. It should be taking into account that certain pieces of information are not needed very commonly, but some employees may need them every day. So the database should contain the information as comprehensively as possible.

Respondents also felt that the equipment-related information is more important than the actual service events-related information. Information relating to different kinds of service events was perceived as the least important among respondents when considering the results together. The overall average is only 2.7, when the overall average for location data is 3.11 and equipment data's overall average is 3.01.

3.3.5 Development needs

This chapter is divided into four parts, so that each service subunit is treated as a separate entity. The goal was to identify data requirements by service department's functional subunits, determine the challenges that cause the deterioration of the information quality. At first, all information gathered during the interviews has been collected together and then the case data was organized again by different subunits. Each case analysis consists of a short presentation of the subunit's functions and its objectives, and installed base information's role from the subunit's point of view.

Spare parts

This discussion will consider at first the key factors of a valuable spare parts service. It is important to understand what factors affect the efficiency of a spare parts service. It is easier to assess the impact of installed base information management in spare parts service efficiency when the key factors and bottlenecks are known. Then it is possible to explore how installed base information availability should be developed so that the performance of the key factors increases.

The spare parts subunit's goal is to provide a spare parts service to customers effectively and profitably. The most important factors in a valuable spare parts business are good availability of spares and competent and rapid customer service. Buying spare parts should be easy for the customer and they should also be easy to sell to a customer. In order to provide the spare parts to the right place at the right time, it is essential to know what kind of equipment is installed at the customer's premises right now and what kind of equipment the customer has in stock.

The key issue is time when trying to achieve the goal of a spare parts service. How long does it take a spare parts engineer to determine spare part information and send the quotation to the customer? The interviews indicate that the search for information and evaluation of the information reliability takes a lot of time. *"In some cases the search for information take significant amount of time"* (Spare part engineer). The interviewees agreed that if the information were more reliable and more accessible, the better the results that could be achieved.

From the spare parts engineering point of view, it is significant that spare parts are easily available for purchase. Customer queries should be answered quickly and quotations should be forwarded to customers rapidly. Before quotations can be sent, spare parts engineering has to find the right spare parts. Secondly, need to find out spare part availability and pricing information is important. Shortening the time spent on searching for this information makes it possible to send quotations forward faster. Therefore, the shorter response time means usually more valuable business. The interviews pointed out several needs and development areas which would enhance the spare parts service's activities:

- There is need for a tool which would quickly find the necessary standard spare parts for shaft life maintenance, for example. This allows spare parts engineering to provide the necessary spare parts. The aim is the shortening of response times and the reduction of repeat work when the information would not have to be searched for every time.
- The content of maintenance reports should be developed. Maintenance reports should include more information about what activities have been done on the site and what activities have not been done. In practice, maintenance reports should include more information about: (1) the replaced components, (2) what components have possibly not been replaced, (3) what additional components, which were not included in the original maintenance plan or maintenance program, have been changed, and (4) what should be changed the next time. As a result, spare parts engineering will know better what spare parts should be offered to the customer when planning the next maintenance event.
- Maintenance and service history should be accessible more easily. Service history enables the better control of activities and predictability. Today, lot of history data is available, but its utilization is not effective or systematic.
- Site survey reports should be transferred to the place where they are easily available. Site survey reports should also be developed. They provide information that a component should be replaced. The spare parts team needs more detailed information about a needed

part. If a report shows that a filter should be changed, there should be more specific information about what type of filter is required.

- Information search tools should be developed. It should be possible to find information about a certain component without knowing in advance exactly where the information is located. Currently, only experience can help to provide the necessary and reliable information.

The interviewees felt that the quality of installed base information plays a significant role in the spare parts service business. Currently, installed base information is not regarded as very reliable. For example, all the changes have not been updated in technical drawings and also the product structure is outdated for many projects. Some of these changes have ended up in the database, but not all. The challenge in this issue is that the employee cannot always be sure about document version reliability. Also, the utilization and integration of data is difficult because they are scattered in different systems. It is difficult and time consuming to collect the needed information together. The interviews revealed the following types of issues and needs regarding installed base information:

- Large equipment assembly is added to the product structure with a single item identification code. An assembly's product structure is missing or a spare parts list has not been received from the supplier. This causes a problem from the spare parts service's point of view. The customer needs the spare parts for its equipment but the spare parts service cannot offer them because there is no accurate information about the spare parts' availability.
- There should be a person who is responsible for keeping up to date the existing product structures.
- Certain spare parts should be identified as critical.
- The need for information about critical components, failure rates, and maintenance intervals. Suppliers can provide default values for service intervals, but there is no place where the data could be collected and where it would be easily available.

- Item descriptions should be improved. Information about item descriptions should be added if the item cannot be sold or there is a newer version of an item.
- There are item duplications in databases. Duplications should be erased so that the data would be more reliable.
- Relevant changes that have been made between certain sister projects should be available in a single common place. This reduces the need to ask questions related to technical information from the chief designer. Technical data between sister projects may be very similar, but the documentation level may vary depending on the designer.

Product Support

The product Support unit is one of the main installed base information users and producers. Product support's role is to provide support in technical issues to the other service units and the customer. Product support refers to services that help the service units or customer to maintain, repair, use and solve problems related to items in their operations. Condition monitoring is also included in the product support unit. Condition monitoring consists of various tasks, such as oil analysis or vibration analysis. Installed base information management is also the product support unit's responsibility. The unit produces a lot of documents, such as service-instructions, site-survey reports, condition monitoring reports, and maintenance reports.

How well and fast the product support engineer can identify problem situations depends on the availability and reliability of information. Response time and quality of advice are key indicators when assessing the effectiveness of product support activities. The response time and quality of advice depends on how easily the necessary information can be found. Being able to identify the items where the support is requested quickly and correctly is fundamental to effective technical support. Product support engineer states: *"The solution to the problem can be very simple, but the necessary information, which enables the solution, can be very difficult to access. Time which is consumed to finding the relevant information extend the response time of problem solution"*. Cases of identification problems, having reliable records of items at the customer, might be valuable shortcuts to speeding up field service operations or problems related to maintenance.

The interviewees considered that information availability was at a satisfactory level. The required information refers to the major components usually found in maintenance reports. However, based on the reports, it is difficult to define the failure rates and service intervals. The quality problems of information and documentation are usually revealed when a product support engineer is making service instructions. When inaccuracies are found, there is no systematic process on how to proceed to correct those inaccuracies.

The role of installed base information in product support's operations is essential and it affects the efficiency and quality of product support's operations. Good access in installed base information reduces product support's response times and this affects directly the other service operations' response times. Reliable installed base information will also help to produce high quality documents. The interviews revealed the following types of issues and needs regarding installed base information:

- Technical drawings should be up to date
- Comprehensive bill of material for all equipments. At least maintenance and spare-part manuals should be available.
- Identification data of pipes and hoses should be improved. Identification should include dimension, bending radius and connectors. In addition, connectors should be accompanied by information about the gasket's (o-ring) material, size and hardness.
- Maintenance history including failure rates and service intervals.
- Technical specification list - a list collecting together the necessary technical information about the product
- Maintenance accessibility – layout data about the room where a product is located
- Master Assembly drawing's dimensional accuracy. In old projects the master assembly drawing is only a sketch and its dimensions are not necessarily correct. For example, the dimensions of shaft line may be incorrect. The master assembly drawing should be build on the subassembly drawings to ensure the dimensional accuracy.

Service sales

Service sales subunit's aim to find out what kinds of services the customer needs, tells the customer what kinds of services the company can provide, and sells the service products and operations to the customer. In practice, the goal of sales is to generate revenues for the company. Service sales' main tasks are: customer relationship management, responding to technical and commercial queries, participating in technical and commercial negotiations, marketing products and services, and developing and presenting sales and technical material. Installed base information can be used to identify the potential business opportunities with the customer. Installed base information is also used in the preparation of maintenance contracts. The interviews revealed the following types of issues and needs regarding installed base information:

- Installed base should be reflected in what kind of modernization has been sold
- Product structure and bill-of-materials. Easy to use and updated product structure facilitates the sales potential discovery.
- Spare parts list
- Maintenance reports should include more information about what activities have been done on the site and what activities have not been done.
- Damage and accident reports. Relevant and documented information about accidents and incidents.

Field Services

Thesis examines the needs of field services in perspective of project manager. Project managers plan and supervise the service projects and dry docking operations for example. Field operations' Installed base information needs are often directed towards to the Product Support. Due to lack of remote access to the installed base system and because the dry-dockings are busy events so there is no time for searching the relevant information. Therefore, when some information is needed on the site, it is easiest call to product support and asks for help. Product support acts as an intermediary when the project manager or site manager needs certain information related to installed base. Therefore, the Product support needs related to installed base information must be observed very carefully. The interviews revealed the following types of issues and needs regarding the installed base information:

- Physical properties such as strength calculations, torques and pre-pressing forces.
- Technical drawings
- Service bulletins

The interviews pointed out several needs and development areas which would enhance the field operations activities:

- Site survey reports should be standardized and designed to more simple form. It should be easy to see what has been inspected and is there need for take some actions. There should be a clear guideline how to fulfill the site survey reports
- Maintenance history should be better available. Standardized service report form. Traceability of maintenance reports should based to the identification-numbers and equipment codes.
- The necessary spare parts of each components
- Information on what tools are needed for the exchange of pars.
- Service bulletins should be transfer to the place where they are easily available. A list of the service bulletins, which has already created, so they are easier to find.

4 RECOMMENDATIONS

This chapter synthesizes the findings and the results of the case study. In this chapter the opportunities, challenges related to installed base information management, and the needs for information are discussed and. Based on the observations the recommendations are given. The recommendations aim is to improve the reliability and availability of installed base information and highlight factors which need to be developed if the case company wants a more efficient installed base management system and practices.

4.1 Recommendations for the case company

The availability of different technical documents and installed base information varies and the data is scattered in many places. While data is stored for example in numerous Excel-tables makes searching, exploiting and maintaining information very challenging. Therefore, installed base information must be together under one or two systems. This clarifies the information search process and makes it easier to maintain the installed base. When data is provided in certain places, one can be sure that the necessary information is there or else it does not exist. Uncertainty decreases and this will facilitate decision-making because the data can be trusted. Based on the reasoning above the following recommendations to the case company are made:

1. Installed base information should be concentrated in one place.
2. Installed base information should be up to date so that equipment identification is possible.
3. Changes in the installed base should be documented clearly.
4. The case company should collect service history information more comprehensively and use service history information more effectively.
5. Technical specification information should be gathered together
6. The company should collaborate with customers and suppliers in order to gather more comprehensive installed base information.
7. The quality and reliability of documentation should be ensured throughout the product’s life cycle.

Recommendation 1) Installed base information should be concentrated in one place.

If high quality information were better available, it would reduce the need for queries regarding additional information. For example, when the necessary spare parts cannot be identified or it cannot be certain what kinds of components were installed to the customers device so that one has to ask for additional information from the customer or supplier. This increases response time and the service task is delayed. It is important to know what spare parts are needed because the delivery times are often long and maintenance events last only a short time, so there is no time for post-delivery. This is why it is important that the parts can be identified quickly and reliably. Then it is possible to provide the right spare parts maintenance instructions and tools in the right place and at the right time. This reduces the response time and number or errors. This is the reason why the products' identity should be improved so that employees can easily find the needed information related to the product. This is stated as recommendation 2.

Recommendation 2) Installed base information should be up to date so that equipment identification is possible.

During a product's long life cycle, a number of maintenance and other service events cause changes to the original product structure. Old parts are replaced with a newer version, components are upgraded in order to increase performance or large modernizations are made to lengthen a product's life cycle. These changes result in the fact that the product's original documents are no longer up to date and their reliability decreases. This is why the following recommendation is made:

Recommendation 3) Changes in the installed base should be documented clearly.

Well-documented changes will help the case company keep the installed base up to date. Change management is one of the most important tools for keeping the installed base up to date. A well-defined change management process, good guidance, and clear operational procedures and the determination of the persons responsible are essential in order to manage changes effectively.

There are also other service events than just maintenance activities. The case company performs a variety of condition monitoring measurements and software upgrades. It is important to know the condition and performance of the equipment in order to predict failures and needs for maintenance. To improve to availability of service history information, the following recommendation is stated:

Recommendation 4) The case company should collect service history information more comprehensively and use service history information more effectively.

The main reason for this recommendation is that systematic information gathering facilitates installed base system maintenance. When changes have been recorded extensively and service events are adequately documented, it is easier to define maintenance intervals and mean times between failures. Service history can also be used to assess customer needs and in predictive maintenance. A service report is the easiest way to gather information. Service reports should include not only a description of repair activities and replaced parts, but also information about what has caused the actual problem and how it was solved. It would be good to gather information also on what parts were not changed, and what kinds of maintenance activities should be done next time.

Service technicians often need very detailed technical information (such as power values, oil pressures or torques) to solve problems. These pieces of information are often crucial and their availability must be as good as possible. According to a product support engineer, certain pieces of information are hard to find because the needed information may be located in numerous places. This will not only slow down problem solving, but in the long term the same information will have to be found again and once done work for finding the correct piece of information must be done once again. This use of working hours is not very productive for the company. Based on the above the following recommendation is made:

Recommendation 5) Technical specification information should be gathered together.

The company should collect together the most often needed technical information for each project in a single document and this document should be easily available. When technical data is grouped together and its location is known to all, changes are easy to record and the data will be updated. This will accelerate the solution of technical problems and the quality of customer service improves.

The case company gains installed base information by keeping their own records but a completely comprehensive service history and information about installed spare parts are not possible to get in that way. There is a lot of information available which does not end up in the company's information systems. The customer or some other service company may do some service operations and then the case company does not have any information available on what actions have been done in these operations. Also it buys certain equipment from suppliers whose supply does not contain a list of spare parts or bill of materials. Because of the above-mentioned issues, there are situations where the part needed cannot be identified or a spare parts list is not available. When product support engineering or spare part engineering is lacking some piece of information, they may need to contact the customer, manufacturer or supplier to ask for advice. This slows down carrying out the current service activity because responses may take a long time. This is why the following recommendation is made:

Recommendation 6) The company should collaborate with customers and suppliers in order to gather more comprehensive installed base information.

In practice, the case company should agree with the customer that the customer will also provide the service history information for the service actions which the case company has not carried out. The customer has information about these events. It is important to motivate the customer. Therefore, the case company must show that information sharing is also an advantage to the customer. Otherwise the process will not work.

The case company's installed base will be more comprehensive and more reliable. Then the case company can provide better advice and guidance to the customer. It is possible to avoid any unnecessary instructions when the service history is better known. For example no advice to change oil if it is known that the customer has already done it the previous week. Do not provide any unnecessary part replacement service if it is known that the customer has changed it itself. The customer avoids unnecessary expense if the company can further analyze the service needs better.

Recommendation 7) The quality and reliability of documentation should be ensured throughout the product's life cycle.

In practice, this recommendation refers to the formation of clear policies and guidelines to ensure data quality throughout the life cycle. It is absolutely important that data quality remains good throughout the life cycle. Documents and other data must be updated systematically. Afterwards is difficult to bring the installed base information and other documentation to up to date. When the service makes some changes to the equipment, these changes should be documented and all the documents should be saved in one common place where they can be easily found and used again when needed.

4.2 Guidelines to improve installed base information management

In the previous chapter, recommendations for the case company were presented. This chapter will introduce what kinds of applications for managing the installed base information effectively and improving the installed base information availability could be implemented and how the implementation could be carried out. The purpose of this chapter is to give guidelines and advice on how the previously stated recommendations might be implemented in practice. By better installed base information management practices it is possible shorten response times and then improve the effectiveness of after sales service operations. <u>The proposed actions are:</u>

1) A decision to improve installed base management practices
2) A clearly defined change management process
3) Service report development
4) Ensuring the quality of project documentation in the early stages of the life cycle.

4.2.1 A decision to improve installed base management practices

The entire service history of a single product should be in a place where it can be managed and accessed easily. The management system should be easy and fast to use. If the system is too complicated, operators do not use the system. This chapter will introduce what kinds of actions are needed for managing the installed base information effectively and improving the installed base information availability. This application can be divided into 3 steps: Decision, Selection, and Implementation.

1) Decision

Management must make a clear decision about the systems in which the installed base information will be collected. The application would meet recommendation 1. The starting point is: only one comprehensive database which includes all needed information would improve information management practices significantly. The decision to use an installed base must be considered and consistent instead of changing the system used every three years.

In practice, there may be one, two or even several places where information is gathered, but unsystematic data collection must be stopped. Information gathering in individual Excel tables and storing these files in vague folder structures has to stop. Tables can be a great way to collect certain special information but even then these tables must be located in one place so that their management is possible, and they are easily available.

System selection is very clear milestone in the implementation of Installed base and is often thought that this is the aim of the project. Perhaps this is because people who are involved in selecting the installed base system are rarely going to be users of the system. The purpose of an Installed base project is not to select an Installed base system. The real benefits of Installed base come from its use not from selecting the Installed base system. The Case company should focus much more on actually getting the installed base system working and producing measurable financial benefits. “The main purpose for the installed base selection is to get people to use selected system and improve the business processes”.(PDM selection is just the first step of a PDM project 2011).

The system selection is not a big step in improving installed base management. More important is that the decision is the first step to change current practices. Once the decision has been made, it is possible to create new practices based on the decision, which can help gather information. The case company should clearly define responsibilities, tools, processes, and above all the instructions. If the decision is not made, valuable information will be scattered and the effective use of information is very difficult. The decision must come from the top management so that different departments can comply with the decision. Currently, all the units have their own practices for how they deal with information and these practices may be difficult to give up.

The objectives of installed base project must define very clearly. Objectives should be oriented towards the use of Installed Base. The case company should focus to develop the utilization of installed base, not on the selection process. It is important to point out that project is not over after the selection process. The project can be considered to be successful once the Installed base system produces benefits to the company. Before a decision can be made, it is important to determine what aspects must be taken into account in the system selection. Following system requirements have been collected from the research material:

- The system simplicity for the end user point of view.
- Less data locations where to storage data – One comprehensive database which includes all needed information.
- Better integration of between items and drawings.
- Equipments must be identifiable.
- Closure of old systems.
- User-friendly user-interface.
- Finding the information should be easy.
- Clear product structures.
- Determination of responsibilities.

2) Selection

It is clear that existing systems form the boundaries for the decision (systems are presented in section 3.1.4). The installed base can be managed through ERP-system or Web-based installed base tool or any combination thereof. ECM document management software can be used to support these, but it is not suitable for actual installed base data management. Systems are compared briefly in *Table 11*. It is very difficult to give direct instructions which system should be selected. Neither system is perfect for installed base information management. Web-based installed base tool´s possibilities should be examined more closely and monitor its development. Currently, it is worth of thinking to use the ERP to manage installed base information. There is already a complete product structure where case company can gather spare parts lists, information about modernization and save the tacit knowledge. System should be slightly improved so that information about equipment changes can be stored more efficiently. The case company should also examine the opportunities and possibilities of completely new system that is designed entirely for maintenance.

Table 11. Comparison between the ERP and global web based tool

ERP System	**Web-based tool**
Non-global, system is only available in finland	Global system
Installed base product structure and item data exists	Development of the system is still pending
Product structure is designed for the service point of view	Designed primarily to support sales
transfer of data from the PLM-system to ERP-system is enabled	Data transfer process is manual
Already being used for storage spare part lists and legacy data	Opportunites are unclear

3) Implementation

Once the decision has been made and the program is selected, the implementation should be carried out at first in the case company´s service department. First the case company should be concentrate on the service department. It is easier to implement new practices and monitor the progress when the changes are made in a smaller scale. When the new practices and operation model about gathering the installed base information works efficiently in the service department, then they can be introduced in wider and global scale. Global scale means in this case the service centers which are located around the world. Clear rules for system usage are needed. If the rules are missing, employees easily keep old traditions. To avoid problems in installed base usage, all system users must be well trained in using the system. It is also important to point out the benefits of the system.

4.2.2 Clearly defined change management process

Changes should be documented systematically. To keep the installed base up to date, the company must have an effective change management process. The current method to manage changes related to the installed base does not work well enough. According to the questionnaire, most employees do not know the process how inaccurate data can be corrected or how the quality notifications should be made. Because of this quality notifications are not always recorded in the system, since the process in unclear. The solution to this challenge is a clearly defined process, as seen in Figure 24. Change management process. The case company should define more precisely: actions, responsibilities, tools and instructions.

- What actions should be taken when there is a need change installed base information?
- What are the tools used to create and submit to a change request?
- Who is responsible for carrying out the change?
- Clear instructions should be made and sufficient training should be given.

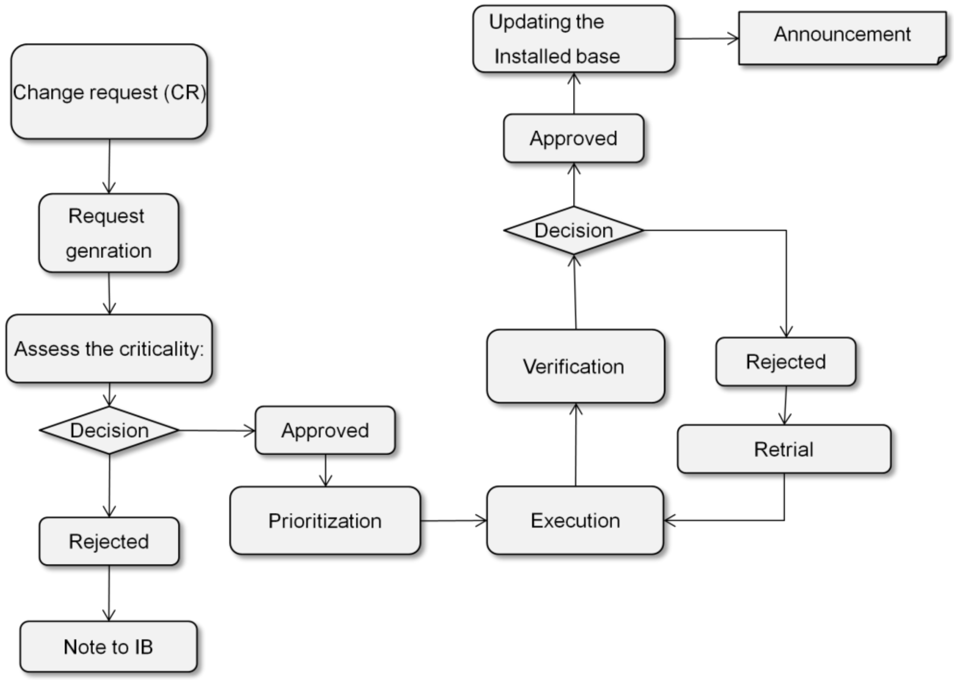

Figure 24. Change management process

This section examines the key factors of the change management process. When the change request is made, the process owner should evaluate the request criticality. Since the resources are limited it should always be evaluated case by case whether the documents really need to be updated. The Pareto principle (also known as the 80-20 rule) should be remembered, which states that roughly 80% of the consequences come from 20% of the causes. The 80/20 rule can be applied in this case, 20% of the changes cause 80% of problems and errors. Since resources and time are limited the case company should focus on the 20% of the changes that have the greatest importance. (Haughey 2009)

A gatekeeper should assess the effects of the change. If the change is such that it may cause significant miscalculations and problems unless documentation is updated, then the request should be approved. Otherwise the request will be rejected. However, if the request is rejected, it should be recorded in the installed base system. The most important thing is that information about the change should be documented in some way.

A gatekeeper plays a key role in the process. The gatekeeper not only assesses the request criticality but will also help to collect information about changes more centrally. When all the requests are targeted to the gatekeeper, it is easier to control the quality and quantity of the notifications. If the change requests are sent without any control, they may end up in the wrong places and with the wrong people. A change request may no longer be taken seriously and employees may start to make their own assessments of the necessity of the actions. In practice, gatekeepers simplify the process, because the employee only needs to create and send a request for approval. When the operating methods are simple, they are also easy to use.

When the request is approved, it will need to be prioritized. Prioritization aims to determine how significant the change is, what kinds of measures it requires and which party makes the changes to the documentation. Significant project specific changes need to be updated to the project structure and to the project documents. Problems and suggestions for improvement related to the standard product model should be updated to the standard product structure and to the standard documentation.

When a request is prioritized and prepared, it can be implemented. After the implementation the updated documents have to be approved in order to ensure that the documentation has been properly applied. The main task of the approval process is to ensure that changes are sufficiently robust and that they are carried out properly. Once the approval has been carried out, the documents will be updated in the system. And finally the relevant persons are informed of the changes.

The case company should pay attention to the following issues when developing the change management process. The issues were collected from the research material. User-friendliness should be considered. If the process is easy to use, it is also easier to assimilate. Every updated document should be inspected and approved by another person. Guidelines must be clear and sufficient training must be given.

4.2.3 Service report development

Studies have shown that reports are the best way to collect installed base information and especially service history information. According to the interviews, service reports are currently the best way to find service history information which is up to date. When a service engineer wants to find out what changes have been made, it is often easiest to examine the service reports and try to find the needed information. However, the interviews revealed that service history reports encompass a very general description of the service events. Service reports should include more specific information about service activities and changed parts. Also the quality of service reports will vary, depending on who has prepared the report. This is due to the fact that the service report format and content are not defined.

The aim for this application is to improve the availability and utilization of service history. This application can be divided into three steps. It makes sense to divide the development project into steps because it is not reasonable to try and take advantage of the service history more effectively if it is poorly available.

A. Comprehensive data collection
B. Collect the service history together
C. Efficient use of the collected information

A) Comprehensive data collection

Service history should be collected more comprehensively. At this stage, the case company does not need to resolve where to store the service history or how to use service history efficiently. The most important thing is that the service history can be collected in some way. A service report is a good tool for information transfer from the field to service. Based on the interviews it can be concluded that the service reporting methods should be developed. It is recommended to pay attention to the following issues when planning the development of reporting.

- What kind of information does the case company need to collect?
- What form should be used to collect information?
- How should data gathering be implemented?

It is proposed to use InfoPath forms for reporting service operations. The proposal to exploit that software is based on the fact that the corporation's other service departments are already investigating the use of the InfoPath form to develop reporting methods. It would be profitable to cooperate and get guidance and advice from other departments. There is an opportunity to save resources and costs.

InfoPath is a Microsoft Windows-based application that is used to create forms based on Extensible Markup Language (XML) and its associated technologies. Example of the InfoPath form can be seen in the Appendix I. In this case it is not necessary to understand all of the detail of these XML technologies. XML is a set of rules for encoding documents in machine-readable form. The design goal of XML emphasizes simplicity, generality, and usability over the Internet. The point is that XML can make it easier for an organization to repurpose the data that is collected by using forms. For example, a single InfoPath form template for a service report can be used to provide XML data to an ERP-system, travel expense system, and installed base. (Microsoft Office - InfoPath 2010)

With InfoPath it is possible to design and publish interactive, user-friendly form templates which can be easily modified and republished. In addition to inserting standard form controls, such as text boxes or list boxes, one can insert controls that offer users the flexibility to add, remove, replace or hide specific sections of a form. Depending on the design of the form template, users may also be able to merge the data from multiple forms into a single form or export the data to other programs. In addition, when a user fills out a form, the data that they enter can be checked for spelling and data validation errors. If a form template is connected to a database of web service, the user will not be able to submit data until they correct these errors. This helps to ensure that the collected data is accurate and error-free and that it conforms to specified standards

Users are not required to have InfoPath installed on their computers to fill out a form. It is possible to fill out the form in a Web browser or on a mobile device. Forms do not have to be filled out while a user is connected to a network. Users can save forms to their computer, work on them offline, and then submit them to the company network. The data that users enter in an InfoPath form does not have to remain locked inside that form forever; it can be reformatted or reused in a variety of ways. This flexibility enables integrating the form into existing business processes. This makes the information better available and it is possible make better-informed decisions.

Table 12. Content of the field service report.

Field service report	
Service event	**Definition of the type of service event:**
Service provider	Which party has carried out maintenance and when?
Person responsible	Employees involved in the service event
Customer identification	Customer and site identification data
Product identification	Functional location code
Purpose of the visit	-
Equipment serviced	Equipment ID, litter code, serial number
Fault description	-
Serviced parts, modules, and options	Part identification code, description, old/new serial number
Work description	-
Recommendation to the customer	Next service according to the service schedule
Recommendations to the service department	-

A precisely defined report structure ensures that the desired information can be collected. Reports should include at least the above mentioned information (table 12). Clearly defined identification data facilitates finding the needed piece of information later. Service events can also be targeted more specifically for certain equipment. This would also improve availability and utilization of service history. When the serviced/replaced parts are clearly defined, it is easier to keep the installed base up to date and predict the spare parts needs in the future. When the faults have been recorded, it is easier to define maintenance intervals and mean times between failures.

The following advantages can be achieved by using interactive form templates:

- Information can be collected globally. Standard form reports made by different service centers can be collected together.
- A well-defined and standard structure ensures that the desired information can be collected.
- The collected data is accurate and error-free.
- User-friendliness of the form – the form can be made very easy to fill out.
- Facilitates installed base maintenance and change management.

B) Collecting the service history together

The case company can take the next step when the service report has been developed and it allows gathering information comprehensively. Service needs a place where service history can be saved. The case company should decide to where the collected data is exported. When making the decision, the decision-maker should consider the following: the information should be accessible globally. According to the interviews, information availability should be good. Search functions should be as simple as possible. The use of littera codes should be considered in the identification of the equipments and related service history.

C) Efficient use of the collected information

Finally, when the first two steps have been carried out, the case company can begin to use the service history more efficiently. When high quality service history is easily available, it is easier to refine data to add value to the company. Information can be used for predictive maintenance, to analyze customer needs, and to analyze new business opportunities. More efficient use of service history requires further studies.

4.2.4 Ensuring the quality of project documentation in the early stages of life cycle.

As previously mentioned, changes in the product structure that have occurred in the early stages of product life cycle were not documented properly. The proposed solution to ensure project documentation quality is the following: the service department must be involved in the project from the beginning of the product life cycle. The aim is to ensure that document quality stays at a good level throughout the life cycle. When the project is progressing from one phase to another, the service should ensure that significant changes have been documented properly and the documentation is up to date.

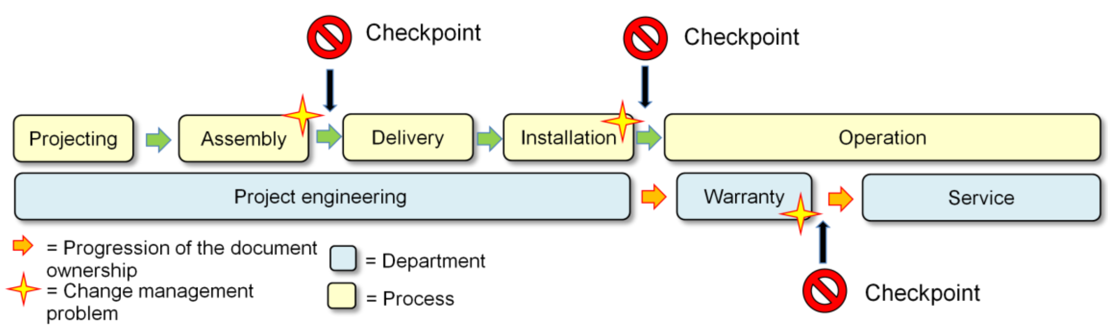

Figure 25. Product´s life cycle and the change management problems.

Figure 25 shows that most of the changes happen during the assembly, installation and warranty phases. When one of these phases has been carried out, the service should arrange a meeting. The meeting's aim is to examine what possible changes have been made and what are the implications for the service business, if the changes are not updated to project documents.

- Service's active participation in the project's early stages. Service can put forward their own needs related to the documentation
- Benefits should be evidenced. What kinds of business benefits can the company achieve by improving the quality of documentation?
- Responsibilities should be determined. Who will determine whether the changes made or not? Which party is responsible for updating documents?

5 SUMMARY AND FUTURE RESEARCH

This chapter consists of three parts, which summarizes this thesis and discusses the main findings of all the previous chapters. First part of the chapter presents the conclusions and evaluation of the results. Recommendations for further research are introduced in the second part. Third part is a brief summary of the Master´s thesis.

5.1 Conclusions and evaluation of the results

In this part the results are evaluated. The motivation and goal for the research was stated as: *How should installed base information be managed and how can it be effectively utilized in global after sales business?* The objective of this study was to identify possible challenges and give recommendations how to solve these challenges. The research problem was divided into three separate parts as seen in below.

What kind of information should the case company's after sales service unit gather on the installed base? History information about equipment and parts, such as installed base item changes and previously installed parts, are the most valuable information types in different service operations. Hierarchical product structures which indicate the last known configuration are considered very necessary. All kind of technical data on the product are also very relevant. Identification data which facilitates finding the needed piece of information later and helps to determine the needed parts are very necessary in most working assignments. Needs of the installed base information was collected comprehensively, but it was difficult to determine what kind of information was most important. Studies show that scale of needed installed base information was very wide. It should be point out following: even certain pieces of information may not be needed very commonly; it could be significant for somebody in his working duties.

What kind of installed base information management practices and guidelines are needed to support effective information management? The key challenges were identified comprehensively and reasonable solution recommendation could be given. By developing the maintenance reports it is possible to ensure the efficient and comprehensive collection of installed base information.

Clearly defined change management process is a key for the keep the installed base up to date. The case company should focus much more on actually getting the installed base system working and get people to use selected system and improve the business processes. The aim of Installed base project is not to select an Installed base system. Service should ensure the quality of project documentation in the early stages of life cycle. Clearly defined working models, instructions and guidelines, responsibilities are key factors for the efficient installed base information management.

What are the benefits of the good availability of information from the after sales point of view?
Benefits were found in the literature and interviews. It can be assumed that with better availability of information it is possible to improve the planning and implementation of operations. If the customer installed base is up to date, it is possible to determine the needed parts and maintenance events can be performed in one visit. Decreasing the time spent on searching for information, processes can be improved and accelerated because decision-making is easier. Faster response times mean faster solutions to customer problems, when reliable information is available. Service efficiency increases by analyzing customer needs it is possible to find new business opportunities. Reliable installed base information helps to forecast spare-part needs, analyze the customer needs and identify the service improvement needs. It would be good to bring out more clearly these advantages of the utilization of the installed base information.

5.2 Recommendations for further research

In the following, future research areas identified during the study are proposed.

- How can service history be used more effectively? Maintenance intervals and mean times between failures can be used to support predictive maintenance planning, but how else can service history be utilized? What benefits can be achieved?
- What is the true potential of utilizing the installed base information for design improvements and modernizations? How should the information be distributed to other departments and how would they utilize it?
- What is the potential of remote monitoring systems to support installed base information management? Can the remote data gathering systems used in the identification of component changes, usage recording or measuring the operating environment? Diagnostic equipments are probably expensive, but it is also expensive to send a service engineer to a site to investigate a situation. Is there any potential in using RFID chips to improve equipment traceability and identification?
- How well can the installed base information managed with real maintenance management software? What are the benefits of maintenance software?
- The case company should consider developing indicators to monitor the installed base. It would be good to measure the impact of development projects. How can the reliability of the installed base be measured?

5.3 Summary

The research problem of this thesis was how to manage and utilize installed base information efficiently. The purpose of this Master's thesis was to study how to improve installed base management practices and identify the advantages and challenges related to an installed base system. The study was necessary because the case company's information management practices were not at a sufficient level and the company's information management was handled by many different practices. Policies, responsibilities, and instructions were partially incomplete.

Reliability and availability of documentation had deteriorated over the years and information was scattered in different places. For these reasons the effective utilization of installed base information was poor. Also change management was not working optimally. There was no clear guidance on how to proceed when changes were observed. Installed base information management without clearly defined practices, processes, and guidelines and user-friendly software is nowadays too complicated a task to handle because of the amount of information is huge and business is global.

The problem was approached first through a literature review and after that using empirical research material. The empirical research was conducted through a survey and interviews. The aim was to determine the needs related to installed base information and clarify the challenges associated with information collection and management. By using the theoretical and empirical material the conclusions was made and the following recommendations to the case company were given:

- Installed base information should be concentrated in one place.
- Installed base information should be up to date so that equipment identification is possible.
- Changes in the installed base should be documented clearly.
- The case company should collect service history information more comprehensively and use service history information more effectively.
- Technical specification information should be gathered together.

- The company should collaborate with customers and suppliers in order to gather more comprehensive installed base information.
- The quality and reliability of documentation should be ensured throughout the product's life cycle.

Based on the recommendations proposals and guidelines to improve installed base information management practices were made.

- A decision to improve installed base management practices
- A clearly defined change management process
- Service report development
- Ensuring the quality of project documentation in the early stages of the life cycle.

Guidelines emphasized defining the change management process more clearly, improving the content of service reports, ensuring documentation quality in the early stages of a product's life cycle, and advising management to make a clear decision about the systems in which the installed base information will be collected. In the short term, the case company should concentrate on getting its installed base information processes defined and consider the best ways for doing its tasks. Defining the change processes and installed base management practices at a low level is an improvement. The organizational boundaries must be banished and the organization must embrace change as the natural way of working. It is absolutely essential to get the whole organization participating in the new operational models and process improvements. In the long term, improving the processes themselves becomes more important.

In general, the research for this Master's thesis was very challenging. The background for this study was difficult to find in the existing literature. The literature on installed base management and utilization is limited and sparse. Some research in the field has been done, but the true value of information from the after sales point of view is not fully understood and discussion is limited to a secondary role in the PDM and PLM books. There were no existing examples of generally accepted practices on managing installed base information. Installed base management practically does not differ from PLM/PDM system management. Therefore instructions on the management of PDM/PLM systems were applied to installed base management.

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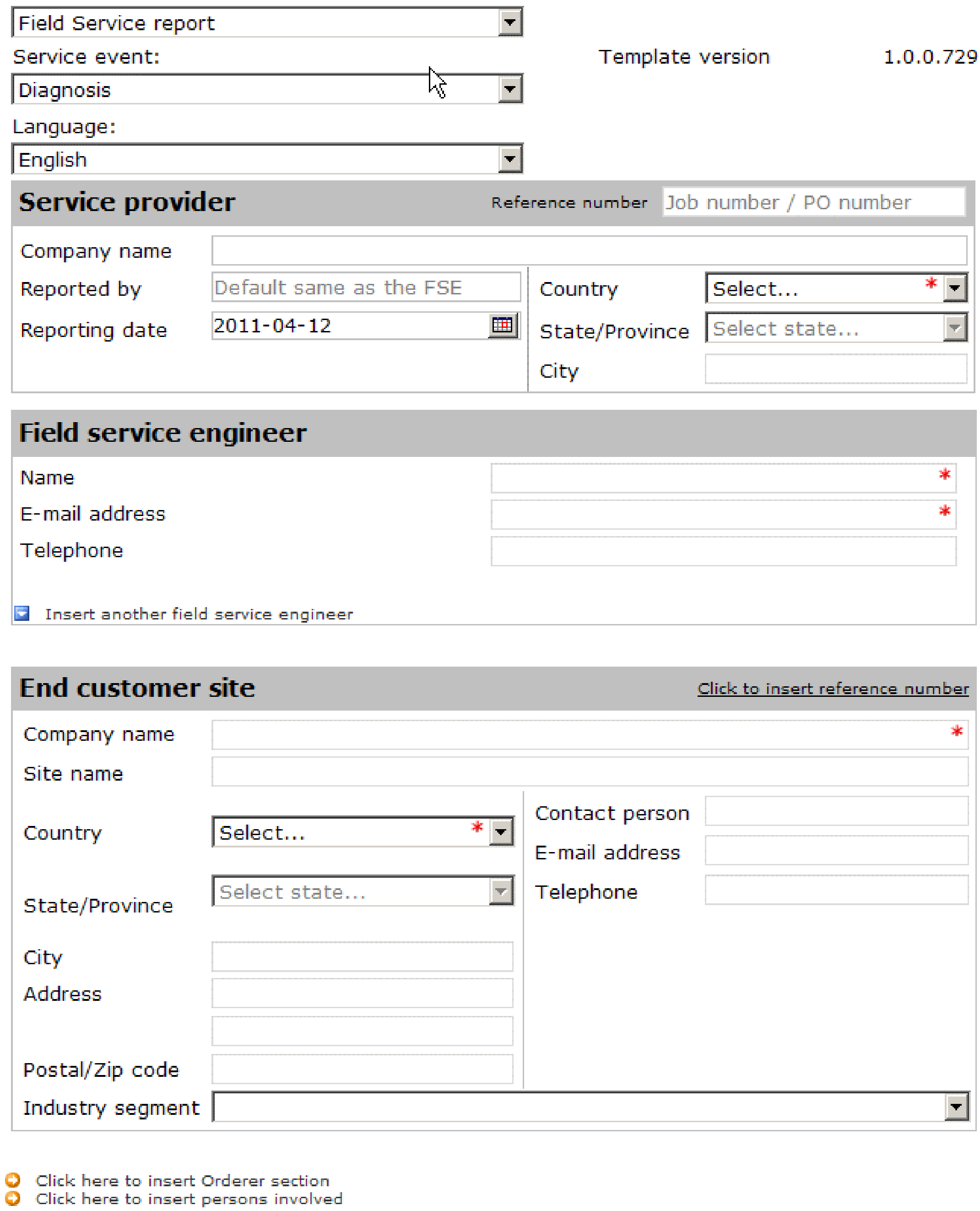
APPENDIX I: InfoPath form – Service report



Field Service report

Service event: Diagnosis

Template version 1.0.0.729

Language: English

Service provider

Reference number: Job number / PO number

Company name

Reported by: Default same as the FSE

Reporting date: 2011-04-12

Country: Select... *

State/Province: Select state...

City

Field service engineer

Name *

E-mail address *

Telephone

Insert another field service engineer

End customer site

Click to insert reference number

Company name *

Site name

Country: Select... *

State/Province: Select state...

City

Address

Postal/Zip code

Contact person

E-mail address

Telephone

Industry segment

Click here to insert Orderer section

Click here to insert persons involved

Purpose of visit

Equipment serviced

Serial number: Top level serial number *

Equipment typecode	
Customer's equipment ID	
Application	*
Commissioning date (yyyy-mm-dd)	If exact date is not known use estimate
Sales ID/Project number	For warranty purposes
Type of module	For warranty purposes
Serial number of the module	For warranty purposes

- [ ] OEM equipment
- [ ] Safety functions affected

Faults

Fault list: Select product type...

Fault description:

Additional fault description:

Serviced parts, modules and options

Reference number: POL reference number

Part number	Description	Old Serial number	New Serial number	Qty	Source
				1	Select...

Insert new part or module

On site visit result

As left condition of equipment

Daily work description

Date	Description

Insert another day

Click here to insert warranty related information

Click here to insert environmental conditions
Click here to insert Updated software information
Click here to insert attachments

Recommendations to the customer

Next service according to the service schedule. See www.abb.com/drivesservices for further information.

Click here to insert additional information

Working hours

Date	Field service engineer	Preparation / Follow up	Travel time to and from site	Working start	Working finish	Lunch break	Working hours	km/mileages
Totals:		0,00	0,0				0,0	0,00

Insert new line

Customer acknowledgement

Field service engineer:

Date:

Customer:

Date:

APPENDIX II: List of Meetings

Interviews

Participants	**Action**	**Date of interview**
Product support manager 1	Meeting 2 h	8.12.2010
Development engineer 1	Meeting 2 h	9.12.2010
Metso Oy	Benchmarking 3 h	10.12.2011
Product support manager 1 Product support engineer 1	Meeting 2 h	29.12.2011
Spare part team	Meeting 3 h	11.1.2011
Sales person	Meeting 1 h	12.1.2011
Spare part team	IB training 2 h	14.1.2011
Project manager	Meeting 2 h	18.1.2011
Metso Oy	Benchmarking 3h	20.1.2011
Product support manager 2 Product support engineer 2	Meeting 2 h	2.2.2011
Spare part manager 2	Internal Benchmarking 3 h	8.2.2011
ERP super user	Meeting 1 h	18.2.2011
Product support engineer 3	Meeting 1 h	28.3.2011
Manager, Project engineering Product support manager 2	Meeting 2 h	7.4.2011
Manager, Warranty Product support manager 2	Meeting 2 h	14.4.2011

Master thesis meetings

Participants	Action	Date of interview
Supervisor	Project planning	1.10.2010
Supervisor	Project planning	25.10.2010
Product support manager, Spare part manager, Development manager, ERP application owner	Master Thesis info	11.11.2010
Supervisor	Progress report	1.12.2010
Supervisor, Professor	Meeting	13.1.2010
Supervisor	Progress report	10.2.2010
Supervisor	Progress report	28.3.2011
Supervisor	Progress report	20.4.2011
Supervisor	Presentation of the results	9.5.2011

APPENDIX III : Survey Results

Problems related to utilization of installed base information.

Statement	**Almost always (5)**	**Often (4)**	**About every other time (3)**	**Sometimes (2)**	**Seldom (1)**	**Average**
The information in the document that you need can be found in several places and it is difficult to say which document is valid	7	5	7	7	1	**3.28**
Definition data of documents or item descriptions are incomplete	6	8	2	2	2	**3.26**
Relevant information cannot be found in the existing system	4	8	7	9	0	**3.25**
You have to ask for advice to find the valid information	8	4	4	4	3	**3.14**
The information is not up to date	5	4	10	11	0	**3.1**
The reliability of the information is not good enough	3	6	9	9	1	**3.04**
Can´t find the latest version of document	6	4	3	3	6	**2.79**
Documents do not conform to agreed standards	4	1	5	5	4	**2.6**
Sum of average						**3.06**