Diriye Ismail

Product Data Management of Configurable After-Sales Products

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The purpose of this Bachelor's thesis was to support the management of configurable products of ABB Drives Service. The objectives of the thesis were scoped to cover the product data management processes of two configurable product groups. The key target was to understand how to manage the product data of configurable products in a standardized and defined way.

The thesis was conducted using action research methods. Qualitative research methods were utilized to gather data. This was done by conducting semi-structured and theme based interviews with functional specialists and process owners. Also the case company's existing process maps, technical and functional documentations were utilized.

The analysis of the current state was divided into two parts. Firstly, product data management of configurable products were analysed in ABB Drives generally. This helped to give an overview of the processes that initiate change in Drives Service. Also tools and information systems utilized to manage the product data of configurable products were analysed. Secondly, the current state was analysed focusing on how changes can be implemented in Drives Service. Also a more detailed analysis was conducted of how tools and information systems are utilized in Drives Service.

As a result of the study key improvement areas for managing product data of configurable products of Drives Service were identified. Based on the current state analysis and workshops with the steering group of this study, process maps were defined to manage product data creation for configurable products. Future research questions were also identified for a successful implementation and further development of the process.

Keywords	PDM, ECM, PLM, configurable products, business process re-engineering

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Tekijä Otsikko Sivumäärä Aika	Diriye Ismail Konfiguroitavien jälkimarkkina tuotteiden tuotiedonhallinta 72 sivua + 7 liitettä 29.3.2018
Tutkinto	Insinööri (AMK)
Koulutusohjelma	Tuotantotalous
Suuntautumisvaihtoehto	Teollisuuden Prosessit
Ohjaajat	Janne Kemppainen, Manager, Product Information Management Antero Putkiranta, Yliopettaja

Työn tavoitteena oli tukea konfiguroitavien tuotteiden tuotehallinnan kehittämistä ABB Drives Servicessä. Työn tavoitteet rajattiin koskemaan tuotetiedonhallinnan osa-aluetta kahden konfiguroitavan tuoteryhmän osalta. Keskeisenä tavoitteena oli ymmärtää miten konfiguroitavien tuotteiden tuotetiedonhallintaa voidaan hallita standardoiduilla ja määritetyillä menetelmillä.

Tutkimus toteutettiin toimintatutkimuksena. Kvalitatiivisia tutkimusmenetelmiä hyödynnettiin tiedon keruussa. Puolistrukturoituja sekä teemapohjaisia haastatteluja toteutettiin eri toimintojen asiantuntijoiden ja prosessien omistajien kanssa. Lisäksi kohdeyrityksen olemassa olevia prosessikaavioita ja teknisiä sekä funktionaalisia dokumentaatiota hyödynnettiin.

Nykytila-analyysi toteutettiin kahdessa osassa. Ensimmäisen osan tarkoituksena oli analysoida konfiguroitavien tuotteiden tuotetiedonhallintaa ABB Drivesissa yleisesti. Tämän avulla saatiin ymmärrys prosesseista, jotka vaikuttavat Drives Serviceen, sekä käytetyistä työkaluista ja tietojärjestelmistä. Näitä tietoja hyödynnettiin toisessa osioissa analysoimalla muutosten implementointia tuotetiedon osalta. Toisessa osiossa tarkasteltiin lisäksi syvällisemmin olemassa olevia työkaluja ja tietojärjestelmiä Drives Servicen näkökulmasta.

Tutkimuksen tuloksena tunnistettiin keskeisimpiä kehitystä vaativia osa-alueita Drives Servicen konfiguroitavien tuotteiden tuotetiedonhallinnassa. Nykytila-analyysin ja opinnäytetyön ohjausryhmän kanssa pidettyjen työpajojen pohjalta määritettiin prosessikaaviot kahden konfiguroitavan tuoteryhmän tuotetiedonhallintaa varten. Lisäksi työn aikana tunnistettiin jatko-tutkimusaiheita, joiden tarkoituksena on varmistaa onnistunut implementointi ja prosessien jatko-kehittäminen tulevaisuudessa.

Avainsanat	tuotetiedonhallinta, teknisen muutoksen hallinta, elinkaarenhallinta, konfiguroitava tuote, liiketoiminta prosessien kehittäminen

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Abbreviations

DS	Drives Service.
HPD	High Power Drives.
LPDA	Low Power Drives and Automation.
PIM	Product Information Management.
PDM	Product Data Management.
TPM	Technical Product Management.
SAP ERP	Enterprise Resource Planning system developed by SAP AG.
FISAP ERP	ABB Finland's SAP environment.
DMS	Document Management system.
BOL	Business Online. ABB Group's sales portal.
OMS	Order Management System.
ChaMan	Change Management tool used by ABB Oy Drives to manage engineering changes.
PS-Tool	Product Structure tool used by ABB Oy Drives to manage manufacturing structure of the products.
Master	Location where changes are managed and sent to other systems.
Master Plant	Non-production plant in ABB FISAP ERP system where as-designed bill of materials and item data are maintained.
BOM	Bill of Materials.
Super BOM	Configurable product's bill of materials that contains all relevant information to define manufacturing bill of materials based on customer's requirements.
Master Data (SAP)	Data that is created centrally and is valid for all applications.
IS	Information system.
Koodinhallintakanta	Item Management tool in Drives Service for product data creation requests and workflow management.
Plant	An operating area within the company.

1 Introduction

Product configuration gives companies flexibility to satisfy the demands of different types of customers by designing the product to fulfil a defined group of customer requirements. It also enables companies to postpone their supply chain processes by avoiding risk and uncertainties that are related to the product until customers have been committed and satisfied by a solution that fits them. (Peltonen et al. 2002, p. 79; Pagh & Cooper, 1998)

Global manufacturing companies own numerous plants to secure markets. Also, the structure of products and processes for managing all data that is related to the products can be complex. To ensure that product data is valid across the company, effective management of product data across the information systems utilized by the company is necessary. Traditionally, production lead times and capacity planning, or other supply chain related key performance indicators, are usually optimized to ensure competitiveness of the supply chains. However, managing the product structure effectively is an important factor as well. Therefore, comprehensive processes that take into account the nature of the business and design of the products are required to successfully manage the product's lifecycle and operational activities. (Lee et al., 2011)

1.1 Background

This thesis is carried out for ABB Oy, Drives Service, which is responsible for the case company's frequency converter's after-sales business operations. Frequency converters, known also as Drives, are manufactured by the HPD and LPDA manufacturing organization, which are going to be further described in the case company presentation chapter. Demand for case company's configurable after-sales service offering has lately been growing steadily. As customers have more options for customizing the products for their needs, problems in delivering the products cause more risk to the company's revenue and profitability.

Opportunity for this thesis rose from a need to define comprehensive processes that can be utilized to manage configurable products more effectively. To support the case company's objectives to improve configurable product's management processes, this thesis aims to provide solutions in the field of product data. Since the case company's configurable product's landscape is broad and complex, the scope of this thesis was defined to cover product data management processes of certain configurable products.

Currently, Drives Service's configurable product's portfolio is diverse. Thus, it is challenging to manage the products with a single process as the ownership and inputs for the changes are diverse. Drives Service has also carried out several projects in 2017 that have resulted in changes in operational activities and the configurable product's portfolio. These have also added dimensions to the future of the configurable product's management processes.

1.2 Objectives and Limitations

Objectives of the thesis were shaped to improve the product data management processes of configurable products. The two configurable product groups that were selected in this study are configurable active phase drives and configurable spare-parts. Configurable active phase drives are manufactured by the Drives Helsinki factory and sold by Drives Service for after-sales purposes. Configurable spare-parts are manufactured by Drives Service. Control unit spare-parts with software is the exact product family that is referred to as configurable spare-part in this thesis. It was selected to be part of the study to understand the additional dimensions that manufacturing activities add to the product data management processes of configurable products. Objectives of the thesis are included in table 1.

Table 1: Key objectives and scope of research.

Objective	Scope
1. Understand how to manage product data related to configurable products.	• Identify changes that lead to implementation of new product data.
2. Understand how to implement new product data more effectively into after-sales operations.	• Identify current challenges in all tools and processes for implementing changes into operations.
3. Define processes to manage product data of configurable products.	• Active phase configurable drives. • Configurable spare-parts.

This thesis focuses on operational processes needed to be performed before the product can be launched for sales. Other key activities that are part of change management, such as product development and sourcing, are only considered as inputs that are carried out through case company's engineering change management process. Furthermore, larger new product development projects and changes are excluded from this study. This study also does not take into account product ramp downs, version control processes and other change management activities that are usually part of the product's engineering changes.

1.3 Research Methodology

This thesis is conducted mainly as qualitative action research. The empirical part of this study consists of a case study on how the configurable after-sales product's product data is managed in Drives Service. The theoretical framework consists of a comprehensive literature review from areas of product data management, lean management and business process re-engineering. Qualitative research methodologies were used mainly to support the data gathering process of action research.

The purpose of action research is to use a scientific approach to study social or organizational issues together with those who are dealing with the issues directly. Its main objective is to make actions more efficient through a cyclical process which consists of sequences of events and approaches that change and solve problems that are in hand e. The nature of action research is to work collaboratively and democratically with the parties that are involved in the scope of the actions. (Coghlan & Brannick 2014, pp. 5-7)

A qualitative research method gives a flexible approach to gathering data to understand the nature and current state of the process. Qualitative data can mean, in the simplest form, data that is formed as a text. Qualitative data can be gathered from conducted interviews, observations or other written and graphic material created for a specific purpose such as work instructions. (Eskola & Suolaranta 1998, p. 15)

Interviewing is one of the most common way to gather qualitative data. It is not only a tool for qualitative research methods but can also be used for many other research types, such as quantitative data gathering. The main objective of the interview is to understand how someone thinks about certain things. It happens based on the interviewer's initiative and is, thus, pre-planned and led by the interviewer. There are several different ways and structures to conduct an interview. Interview types that were used to conduct the empirical part of this study were: (Eskola & Suolaranta 1998, p. 86-87).

1. Semi-structured interview
    - Questions are pre-defined and same for every interviewee, but they can answer freely.
2. Theme-based interview
    - Themes and topics are pre-planned by interviewer.
    - Interviewee steers the conversation and interviewer only makes sure that agenda stays under the topic's frames.

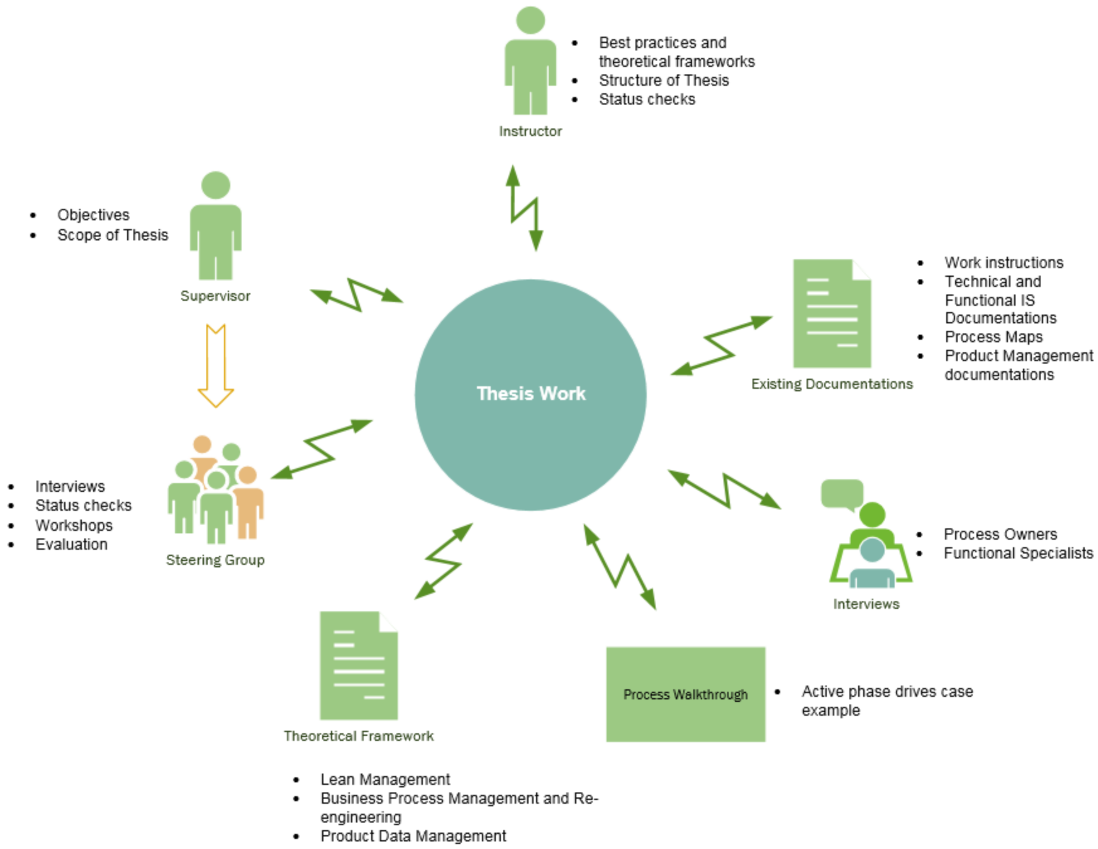


Figure 1: Nature of the action research methodology approach to the thesis.

Due to the objectives and resources that were available, applying a qualitative action research methodology was a natural choice for this thesis. Overview of the action research methodology approach utilized for this thesis is demonstrated in figure 1.

The theoretical framework of this study is gathered from the following three scientific areas: Lean management, business process re-engineering (BPR) and product data management. This broad view of the theoretical framework was chosen due to the current state of the case in hand, objectives of the thesis and existing procedures of the case company in process improvement. Product data management theories are used as a basis for the study to reflect the best practices and methods for the case company's product data management processes. Lean and BPR theories are used as tools to make the processes more efficient and customer oriented.

To get a better understanding of the empirical part of the research, several process owners and specialists from each function were interviewed. Also, steering group members' knowledge was utilized in the form of interviews, workshops and unofficial conversations. Appendix 1 includes persons and topics of the interviews that were carried out for the current state analysis of the empirical part of this study. Both semi-structured and theme-based interview methods were used to conduct the interviews. Interview templates for semi-structured and theme-based interviews are included in Appendix 2 and 3. Based on the current state analysis, two workshops were conducted together with the steering group to get a better understanding and shape of the future state processes so that they benefit all involved functions. In addition, all relevant and existing documentations and observations made during the process walkthroughs became part of the empirical portion of the research and were utilized in shaping the improvement proposals.

1.4 Structure of Thesis

The structure of this thesis can be divided into separate areas based on the chapters of the thesis. The introduction and selected research methodology gives support to these areas throughout the case study. Figure 2 gives an overview of the thesis structure.

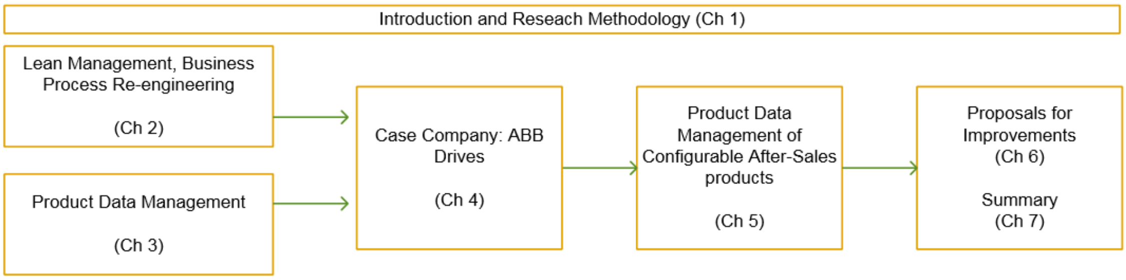


Figure 2: Structure of thesis.

Chapters 2 and 3 focus on the relevant theories that are related to the study. In chapter 4, case company ABB Drives is introduced. Chapter 5 covers the current state analysis of the processes that are in the scope of the thesis and related information systems. Based on the current state analysis, proposals for improvement are presented in chapter 6. Summary of the thesis in chapter 7 concludes the objectives and reflects on the results of the thesis. Future research issues are presented in chapter 7 as well.

2 Lean and Business Process Re-engineering

In this chapter, theories and methods of business process management and re-engineering are introduced. Since the Lean management approach was chosen to analyze and improve the empirical part of the case study's business processes, philosophy and requirements for effective Lean Management are also presented.

2.1 Lean Philosophy

Concrete roots of Lean Management philosophy are believed to be in the Toyota Motor Company from Japan. Toyota Motor Company created the Toyota Production System (TPS) in 1950s, which covered approaches, practices and instruments of Lean. The term *"Lean"* was first introduced by Krafcik (1988) as he defined the TPS as a comprehensive Lean production policy that strived to achieve leanness at all levels from inventory levels to human resources. (Bhasin 2015, p. 1; Krafcik, 1988)

The Toyota Production System is based on the *"Toyota Way*" management philosophy, which consists of 14 principles that are seen as basic principles of Lean. Liker (2004, p. 6) complemented the Toyota Way philosophy by categorizing the principles of the Toyota Way philosophy into the following four areas: respect and teamwork, continuous improvement (kaizen), challenging and "go and see" (genchi genbutsu) approach to problem solving. In addition, the four level model consists of philosophy, process, people and partners and problem solving. Figure 3 illustrates this as a pyramid. (Liker 2004, pp. 6-13)

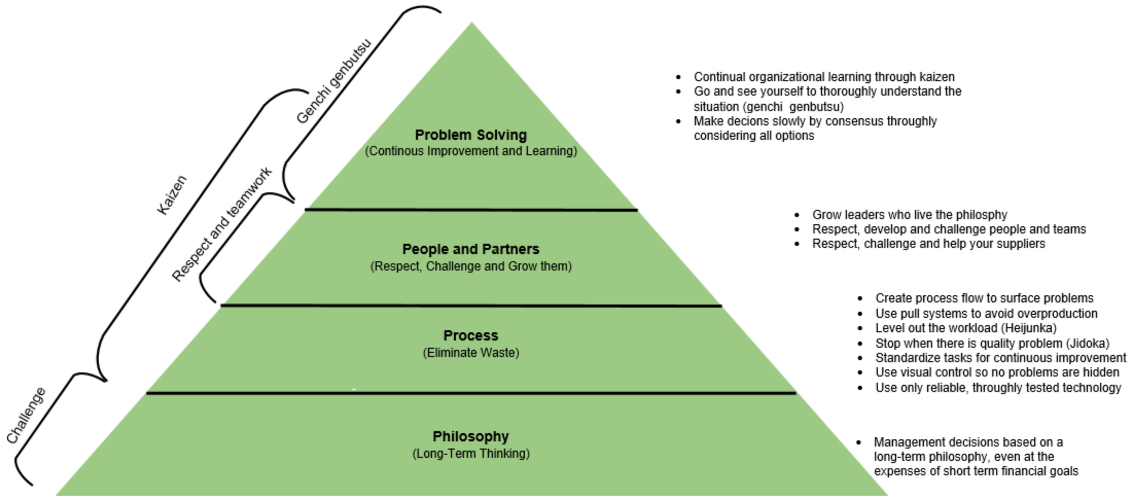


Figure 3: Toyota Way philosophy's four categories and its 14 principles (Adapted from Liker 2004, p. 6)

To be a Lean organization, manufacturers are required to adapt a mind-set that focuses on creating a process flow that goes through value adding activities based on customer's requirements, as well as, a culture in which everyone strives for continuous improvement. All processes that do not create value are treated as waste (muda). Wastes that Lean aims to eliminate from processes are overproduction, waiting, unnecessary transport, over-processing, excessive inventories, unnecessary motion, defects and failure to utilize employers creativity. Above mentioned objectives are part of TPS's first seven principles of the total 14. A key problem for most Lean organizations is that these principles are seen as simply Lean and the other principles of TPS are not adapted. Liker (2004, p. 87) sees these principles as only Lean philosophy's tactical and operational side. Therefore, it is important to also follow the supporting principles of implementing an organization wide culture and long-term management philosophy that the above mentioned Toyota Way philosophy is based on. (Liker 2004, pp. 7-8; 87-90)

2.2 Business Process Management and Re-engineering

Before going through the theories and practices used in managing business processes, it is important to understand the definitions of the terms business and process. Burlton (2001, p. 67) defines business as *"any organization whose aim is to create results of value for someone who cares about those results".* Processes are seen as entities which consists of resources, activities and outputs created by the businesses. According to Davenport (1993, p. 5) processes are defined as *"structured measured sets of activities* *designed to produce a specific output for a particular customer or market".* There are many ways to classify the business processes of an organization. Often, business processes are classified as "core" and "supportive" processes. Core processes can be seen as a chain of activities that, for example, results in delivering a product to a customer. The purpose of supportive processes is, instead, to provide conditions for primary processes to be carried out. Business process management is illustrated in figure 4. (Burlton 2001, p.67; Aguilar-Saven, 2004)

Figure 4: Nature of business process (Based on Burlton 2001, p. 67; Davenport, 1993, p. 5)

The need for effective management and improvement of business processes in today's businesses is essential because of customers, competition and change. These three C's form a combination that requires businesses to constantly challenge and rethink their existing processes. To succeed in gaining and maintaining a competitive edge, satisfying customers and reacting to changes in the business environment, organizations have to constantly seek to improve. (Hammer & Champy 2001, pp. 27-29)

Many theories and methods can be used to approach the improvement and re-engineering of business processes. Hammer & Champy (1993, p.35) view business process re-engineering (BPR) as a fundamental rethinking and a radical redesign of business processes in order to achieve dramatic improvements. The main objectives of BPR are for organizations to fundamentally rethink their processes, get to the root of existing challenges and work to find clear cut solutions to radically improve processes. Hammer & Champy (1993, pp.35-37)

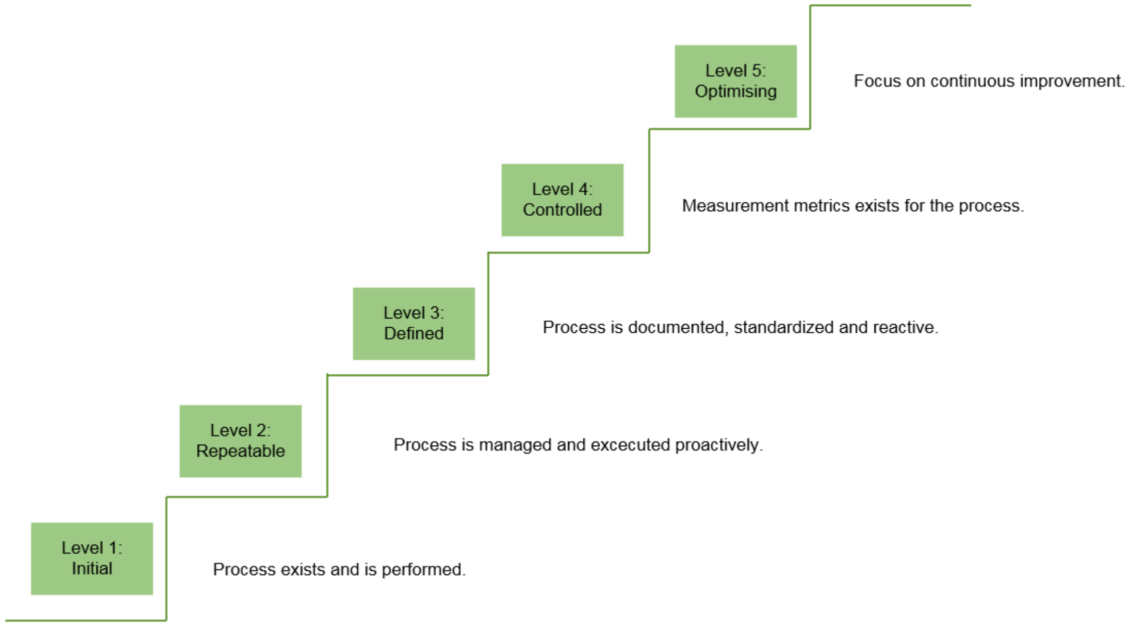


Figure 5: Process maturity model (Based on Macintosh, 1993)

Before choosing any approaches or methodologies to analyse or improve the business processes in hand, it is important to understand the maturity of the processes that are analysed. Figure 5 describes the maturity of the processes according to the Macintosh maturity levels (1993). It can be seen that the stages of process maturity consist of five levels. Therefore, it is important to understand the maturity level of the processes that are being managed and attempted to improve. Processes with a maturity level of 1-3 require methods for defining and modelling the processes. On the other hand, processes with a maturity level of 4 and 5 require methods whose purpose is to support the controlling and optimizing of the processes to find improvements. Therefore, for processes that are classified as maturity level 4 and 5, advanced tools can be applied to improve the processes. (Aguilar-Saven, 2004; Macintosh, 1993)

Another key issue in re-engineering and improving business processes is selecting the correct approaches to analyse and redesign the processes. Organizations have to understand and define the approach and focus areas for business process improvement. An effective and the most commonly used approach in re-engineering business processes is the process focused approach. The roots of this approach are in Lean and total quality management (TQM) practices, which were constructed in Japan. Process focused approach means that challenges in the organization are tackled by first understanding that all end results that the organization delivers consists of processes. Each process has either an internal or external customer. These processes are then analysed through mapping and defining the inputs needed by each process and the outputs that are delivered for the next customer in the process. (Grover & Malhotra, 1997)

2.3 Tools for Business Process Modelling and Improvement

In order to manage business processes effectively, it is important to understand the critical factors that affect the outcome of business process designs. There is a wide range of tools and practices available for modelling business processes. In this chapter, key tools and practices used in the empirical part of the research are introduced. Also, requirements, benefits and reasons for selecting these tools are explained.

High-Level Process Flow Chart Mapping

According to Lakin et al. (1996) a flow chart is defined as a *"formalised graphic representation of a program logic sequence, work or manufacturing process, organisation chart or similar formalised structure"*. A key requirement for a documented flowchart is that the process it describes should be easy to understand. (Aguilar-Saven, 2004; Damij, 2007)

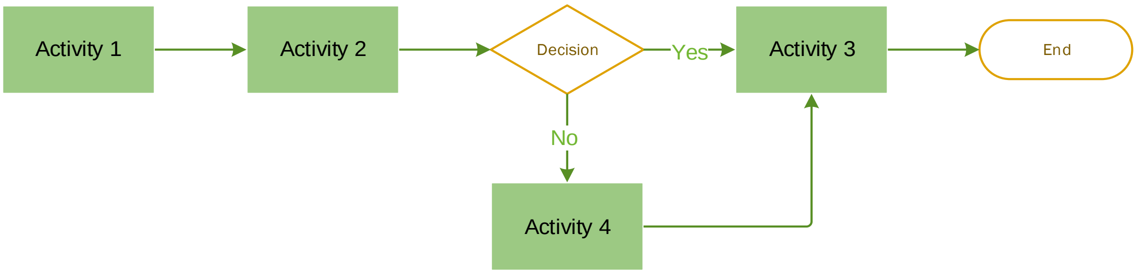


Figure 6: An example of a high-level flow chart. (Adapted from Aguilar-Saven, 2004)

The benefit of using a flow chart technique is an understanding of the processes from a high-level point of view. However, it does not describe responsibilities well. This makes it hard to connect to the functions performing the processes in the organization. Therefore, an ideal high-level flow chart contains around 2-6 steps that summarizes the process. Figure 6, demonstrates an example of a high-level process flow chart based on these requirements. (Aguilar-Saven, 2004; Damij, 2007)

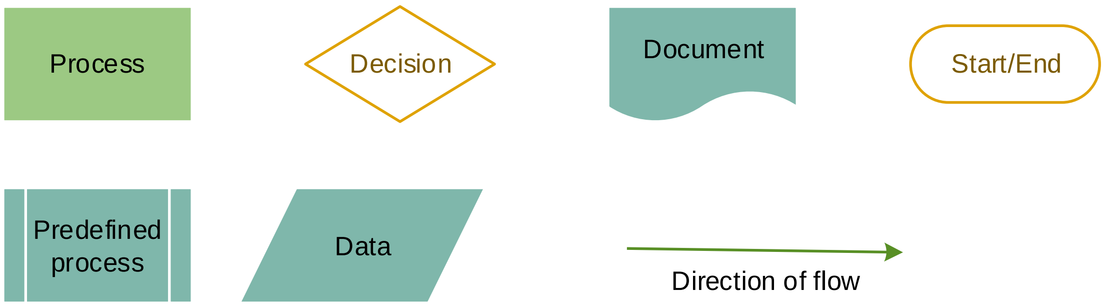


Figure 7: Common symbols used in process flow mapping. (Adapted from Sharp & McDermott 2009, p.220)

High-level process maps can be described in various types of ways. Figure 7 demonstrates some of the common symbols that are used in process flow mapping. These symbols can be usually applied to all levels of process maps. Used symbols should be simple, clear and commonly understood. By choosing simple symbols and defining them, the visual appearance of the process map is more approachable for the people in the organization. Also, any other symbols that are used should be described in the process map documentation. (Sharp & McDermott 2009, p.220)

SIPOC Diagram

"Understand your suppliers and your customers and you are 75% of the way to success" (Voehl et al. 2014, p.363)

A SIPOC diagram is a tool that can be used to identify all relevant elements of a process that is being improved. Its objective is to help describe complex entities in improvement projects. SIPOC is an abbreviation for Supplier, Input, Process, Output and Customer. (Voehl et al. 2014, p.363)

The purpose of a SIPOC diagram is to describe the essential steps in a process. Only the steps that provide real value are mapped. Therefore, it shows the essential steps needed in the improved process, as well as, what outcomes should come out of the process. A key strength of the SIPOC diagram is that it is simple to create and with its information it enables participants to learn together. In order to successfully map a

SIPOC diagram that includes key steps of the outcomes that are desired from the process, teams should ask and answer these key questions: (Voehl et al. 2014, pp.364-368)

- What does the process do?
- What are the stages of the process?
- What are the starting and finishing points of the process?
- What are the inputs and outputs from the process?
- Who are the suppliers and customers of the process?

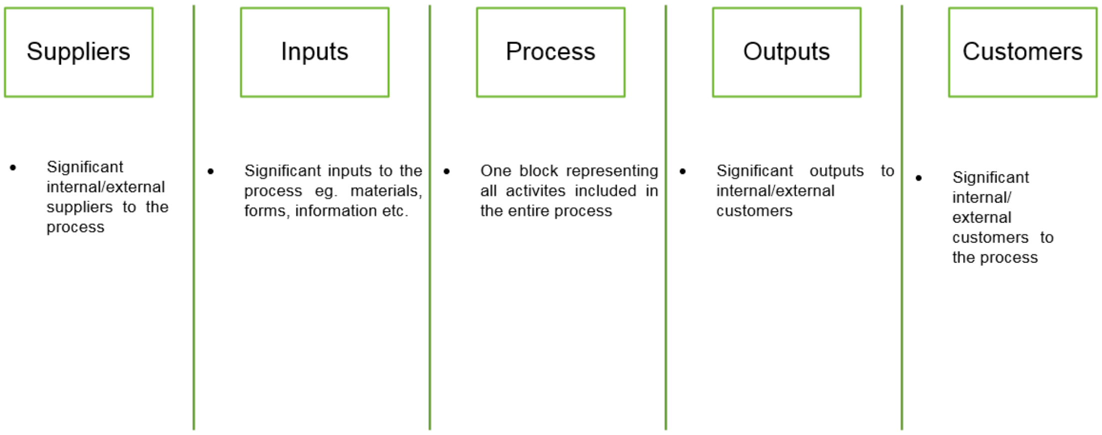


Figure 8: Example of a SIPOC diagram (Adapted from Voehl et al. 2014 p.367).

Figure 8 demonstrates the structure of a SIPOC diagram. SIPOC diagrams are built by starting in the middle from the processes and listing all the major steps that the entire process consists of. The next task is to understand what is delivered (outputs) and to whom (customers). An effective way to approach understanding customers and outputs is by brainstorming and documenting the most critical outputs that provide value to the customer of the process. Finally, based on the process, its outputs and the customers for the process, the inputs needed to perform the process, as well as the supplier of those inputs, can be analyzed. (Voehl et al 2014, pp. 364-369)

Cross-Functional Flowchart (Swimlane Diagram)

A cross-functional flowchart, which is also known as a swimlane diagram, is one of the most popular methods used by businesses to define and document processes. It can be used to show the processes at any level from a high-level approach to a detailed view that shows each activity of the process. The key benefit of a swimlane diagram is that it provides answers to “how, who and when” questions regarding the business processes in hand. (Sharp & McDermott 2009, p.202)

A cross-functional flowchart is set up based on the following three R’s principles: roles, responsibilities and routes. According to Sharp and McDermott (2009, p. 203) the meaning and purpose of these three R’s are:

1. Roles are the actors who complete steps in the process.
2. Responsibilities are the activities that each actor performs.
3. Routes are the flows and decisions that connect activities to the end results of the process.

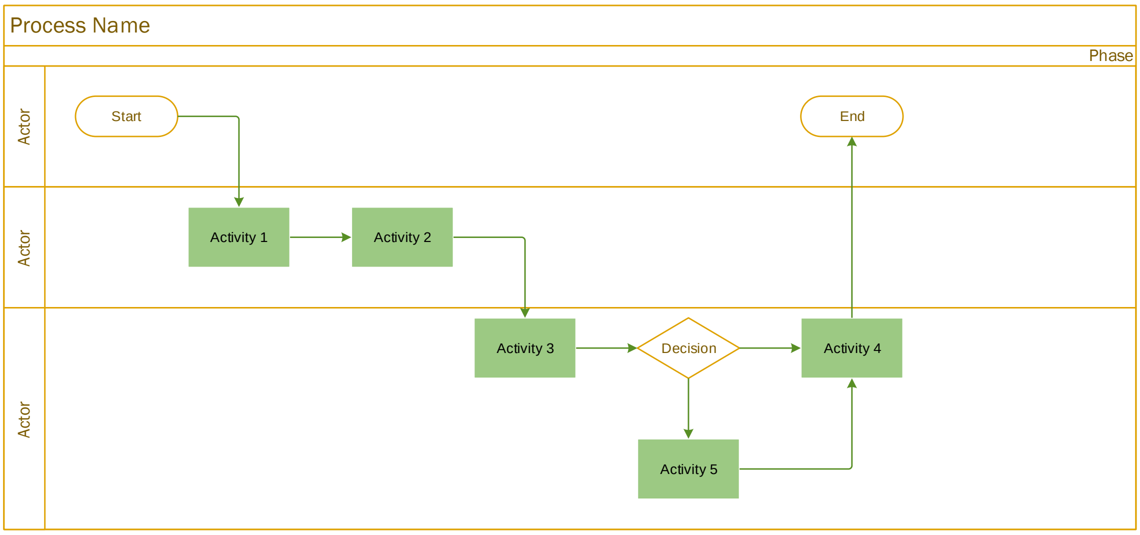


Figure 9: An example of a Cross-Functional flow chart diagram. (Adapted from Sharp & McDermott 2009, pp. 202-220.)

Figure 9 illustrates a defined cross-functional flowchart. Based on the three R’s principle each actor or function that is involved in the process gets its own swimlane. Activities that each actor is responsible for are mapped in their swimlane. Routes and decisions demonstrate the flows of the process from start to the end. Also, in order to understand “when” the activities happen, swimlane is built to show the flow of the activities from left to right in chronological order. (Sharp & McDermott 2009, pp. 204)

Despite the simplicity and clearness of a cross-functional flowchart, there are several important factors to understand in order to design it correctly. Cross-functional flowcharts bring the most value when the following factors are taken into account: (Sharp & McDermott 2009, pp. 202-222)

- Logical sequence and dependency in the flow of activities.
- Describe only activities that add value, move the work along or introduce delay.
- Simplest possible set of symbols are used.
- Every actor that is included in the process is described.
- Different scenarios and situations that arise from the process are described.

3 Product Data Management

This chapter aims to provide an overall view of the theories and practices used to manage product data of complex industrial products. First, Product Data Management is introduced generally. In later parts, configurable products and added elements needed to manage configuration rules and product structure of configurable products are also introduced.

Product Data Management (PDM) has different types of definitions. It is also known as Product Information Management (PIM) and can be seen as part of Product's Electronic, Document, Engineering and Commercial Management, as well as, Product Lifecycle Management (PLM) activities. In an industrial environment, PDM is utilized as a systematic approach to manage and develop the data of manufactured products. Field of Product Data Management can be used to cover product development, commercialization, supply chain management and all other relevant data that is created, as well as, maintained in the whole lifecycle of the product. The term PDM is also used to refer to information systems (IS) and processes used to manage technical aspects of the product. (Peltonen et al. 2002, p. 9; Sääksvuori & Immonen 2002, p.13)

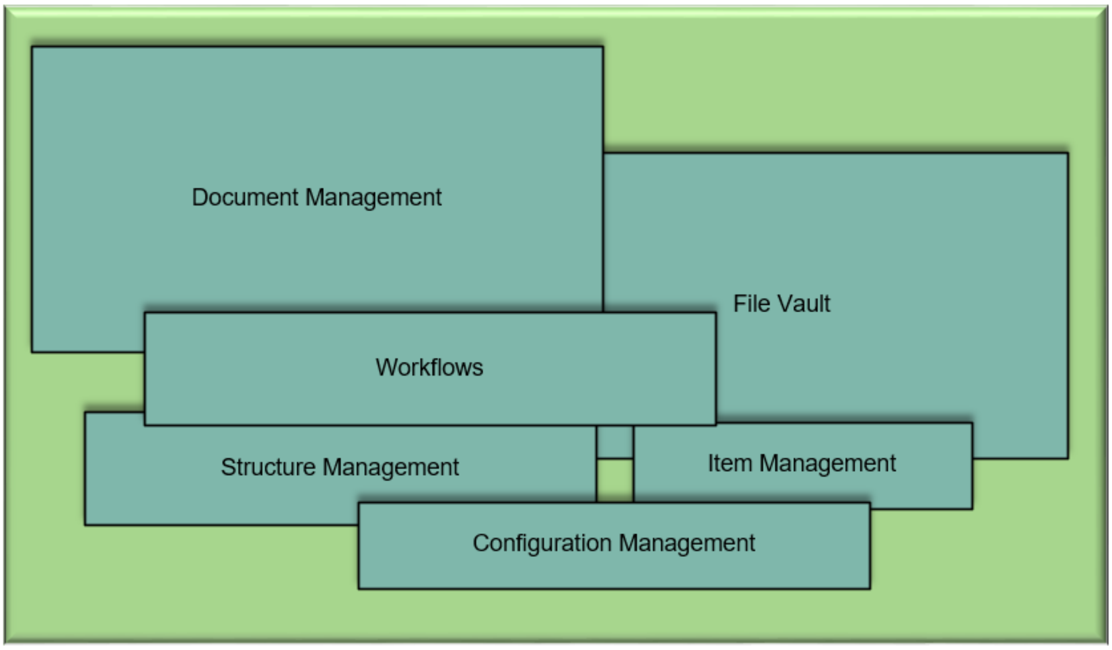


Figure 10: Areas of Product Data Management. (Adapted from Sääksvuori & Immonen p. 23)

PDM aims to provide tools and processes to manage effectively product data so that large companies can operate globally. Complex industrial products are also manufactured in large stakeholder networks and, therefore, one product is created through the collaboration of many organizations. Since products are designed, manufactured and delivered with multiple partners and stakeholders, effective PDM processes are key to communicating and ensuring that products meet the end customers' requirements. Figure 10 describes the main areas of PDM, which are Item Management, Document Management, Product Structure Management and Configuration Management. (Sääksvuori & Immonen 2002, pp.13-14)

3.1 Item Management

Item data is a core component of product data management. Items are used as a way to manage and store data related to certain individual, physical or intangible elements. There are no specific boundaries on what kind of elements can be standardized as items since they depend on company's products, processes and policies. (Sääksvuori & Immonen 2002, pp.19)

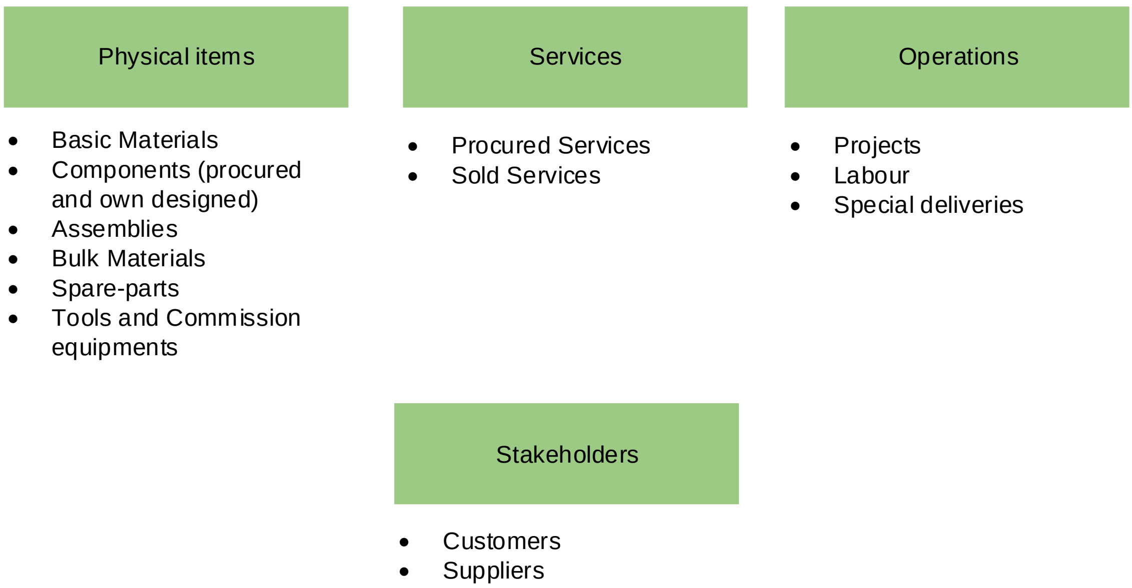


Figure 11: Different types of items. (Adapted from Peltonen et al. 2002, pp. 15-16)

Item Management's key objective is to manage all items used for manufacturing, delivering and selling products, both, throughout the lifecycle and supply chain process. Figure 11 illustrates the variety in the item data landscape. Businesses today are data oriented and managed through information systems. Therefore, item management can be seen as the backbone of all types of information systems, where data that is related to the products and operations of companies are maintained. In order to effectively manage item data in different information systems from design to end of lifecycle, items are needed to be classified and standardized in a commonly agreed way. Modern PDM, ERP and other product data related information systems offer effective ways to classify and manage product data. Particularly in large global companies where organizations and functions differ from each other, using single item codes is not always possible. Therefore, different types of additional data is used to classify items. According to Peltonen et al. (2002, pp. 15-18 & 20-27) and Sääksvuori & Immonen (2002, pp. 17-21), the following areas of item data management are key to an effective PDM:

- Items are classified into logical use case groups.
- Items' description methods are standardized globally with all organizations within the company.
- Items are created based on agreed standardized hierarchies.
- Creation and maintenance of items are controlled.

3.2 Document Management

Since most documents today are created with personal computers, creating and maintaining documents is relatively easy. Key challenges in document management are ensuring that the valid version can be found and that later versions are not being created currently or in the future. One of the key objectives of product data related systems and processes is to ensure effective document management. (Peltonen et al. 2002, p 47)

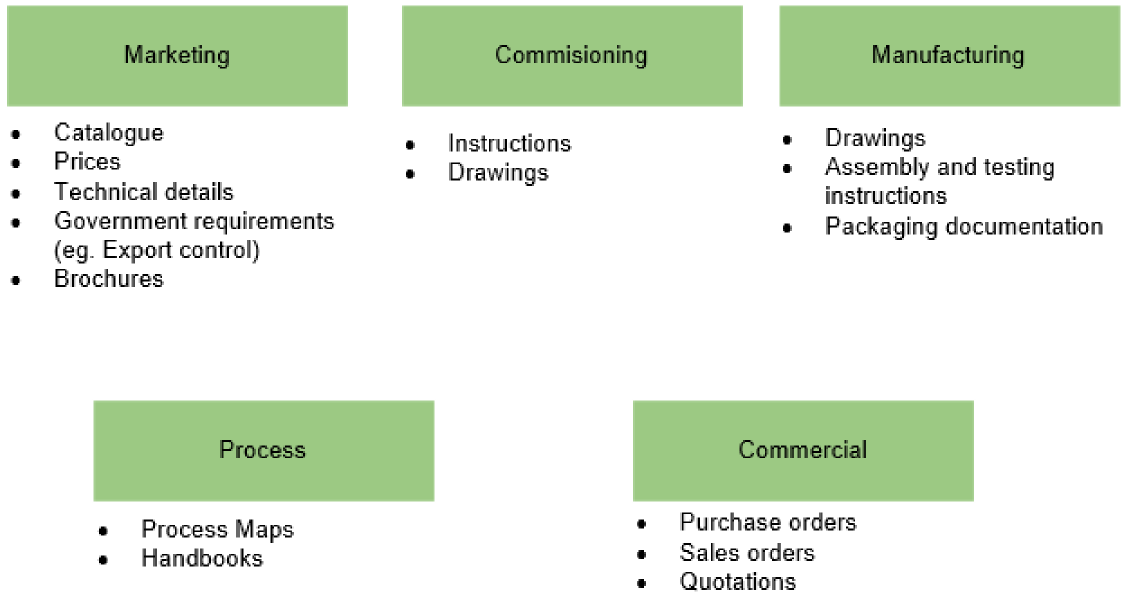


Figure 12: Different types of documents. (Adapted from Peltonen et al. p 48)

Figure 12 describes different types of documents that are created and used in business operations. Documents can also be seen as unique items in the document management systems landscape. In addition to characteristics of items described in chapter 3.1, content of documents adds another dimension to managing and classifying documents. Also, not all types of documents are necessarily needed to be maintained centrally in information systems. Rather, there have to be commonly agreed locations for all relevant documents. Key documents that are related to lifecycle management of products are marketing, manufacturing and commissioning documents. Typically, all of these documents can be integrated into the information systems that are used to manage product data throughout the lifecycle of the product. These are, also, usually stored in centralized document management systems where all key stakeholders can have access to the latest versions. In order to avoid duplicate versions, PDM and other Document Management Systems (DMS) usually enable features for effective document management. (Peltonen et al. 2002 pp. 47-52)

3.3 Product Structure Management

Product models and all other data that describe the structure of a product are closely associated with the field of PDM. Product structure management is also referred to as the Bill of Materials (BOM) management. However, technically BOMs only describe the materials, components and assemblies that the product consists of. Product structure, on the other hand, refers to the overall documentation and information about the product, including BOMs, hierarchies, references, catalogues, configurations and all other key information that is not necessarily part of the physical product structure. (Peltonen et al. 2002 pp. 59-61; Sääksvuori & Immonen 2002, pp. 36)

Product Structure Management (PSM) is mostly considered to be part of PLM and ECM activities, but it impacts and affects most of the key business functions in a company. It creates a baseline for managing all other types of functional or operational areas that are needed to successfully manage the product throughout its lifecycle. Tichem et al. (1997, p.45) define the role of product structuring the following way:

"Product structuring plays an important role in creating products, which have good functional and life-cycle related properties, in design process management, and in several other company functions like production control."

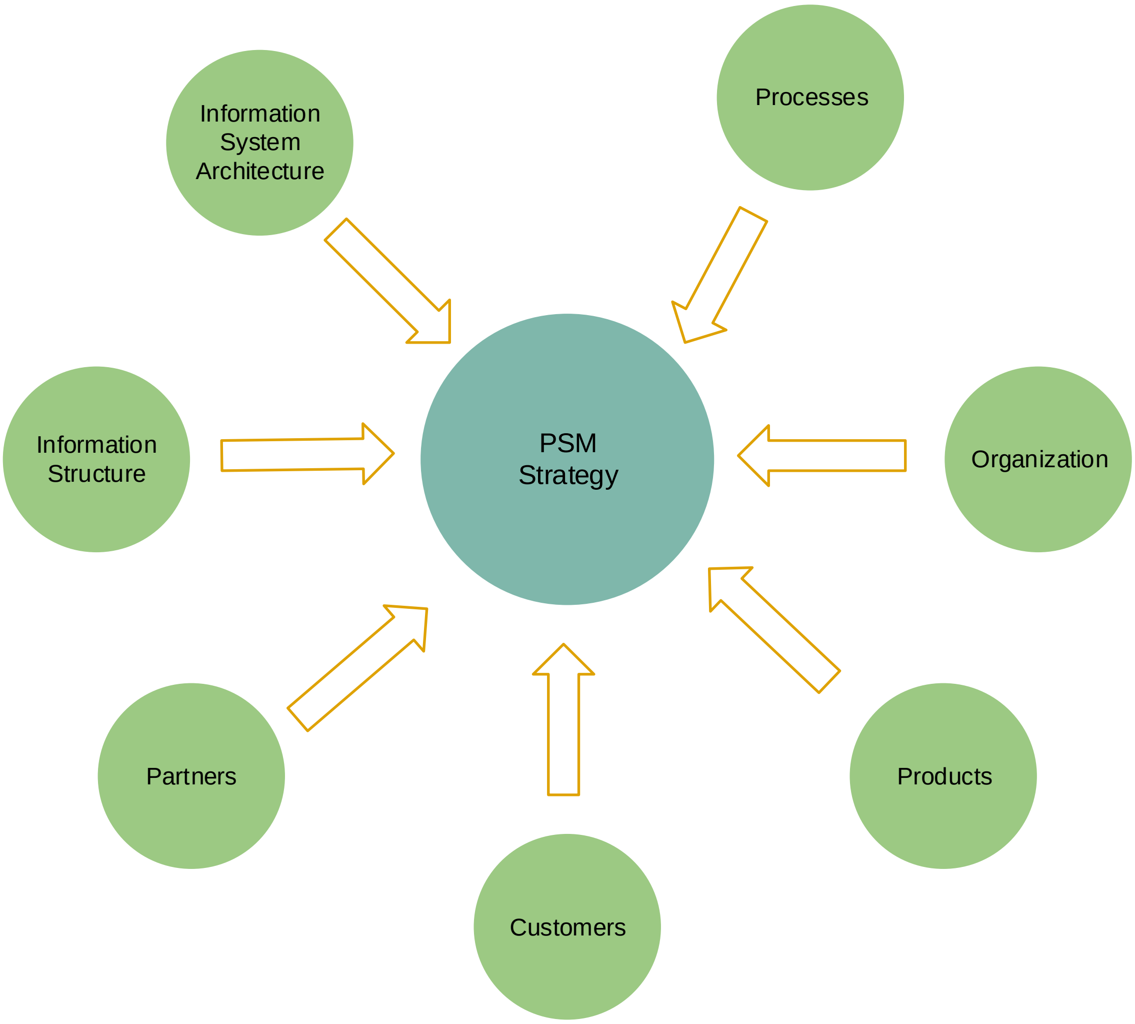


Figure 13: Factors that have implications on product structure management. (Adapted from Svensson & Malmqvist, 2000)

Since product structure management is a change initiative activity, it is closely related to change management processes and, therefore, affects many areas of the business. Figure 13 describes the key areas that the product structure management processes affect. All stakeholders and systems that are in figure 13 are in some way dependent on having the most up to date information about the product structures.

For complex industrial products, a comprehensive approach to manage product structures is needed (Svensson & Malmqvist, 2000). CIMdata (1998), sees the following as key tasks and responsibilities of product structure management:

- Facilitate the creation and management of product configurations.
- Track versions, effectivities and design variations.
- Link product definition data to the structure.
- Allow various discipline specific views of product data and structure.
- Transfer product structure in both directions between PDM and ERP systems.

Since BOM is one of the key areas of product structure management, it is important to understand the nature of it. A product's BOMs can either change during the product's life-cycle or can also live separately since different functions have different needs and processes, which creates a demand for specified BOMs (Svensson & Malmqvist, 2000). Shilovitsky (2015, p.13) sees the role of BOM as a method to integrate engineering processes to the rest of the company's processes. Usually in ERP systems the product structures are mainly managed as BOMs. Therefore, it is common that one product has many BOMs depending on the needs of the business. These are different views of BOM and named based on the application area of BOM. (Sääksvuori & Immonen 2002, pp. 36).

3.4 Configurable Products

Product configurations are utilized for different types of business processes and, therefore, there is no consensus on the definition of product configuration and the order-delivery process environments that it is used for. Wacker & Miller (2000) see that configuring products for customers requires a substantial engineering, design and manufacturing capacity, which means that product configuration is mainly meant to be utilized in an Engineer-To-Order (ETO) environment. Mittal & Frayman (1989) see that products are configured from pre-defined rules and specifications and therefore, for example, new components cannot be designed for the product based on customers' demand. From a PDM and information systems point of view, configurable products are mainly seen as mass customized products as Blecker & Friedrich (2007, p.1) concludes that:

"A configurable product is designed once, and this design is used repetitively in the sales-delivery process to produce specifications of product individuals meeting customer requirements."

Table 2: Benefits and challenges of configurable products. (Based on Blecker & Friedrich 2007, pp. 4-28).

Benefits	Challenges
• Efficient way to fulfil a wider range of customer needs • Reduction in inventories • High customer satisfaction as they participate in design • Potential for premium pricing	• Increase in information management • High-level of product and configurator expertise required • Integration of information systems • Delays in the introduction and improvements for products due to complexity of products

Table 2 gives an overview of the benefits and challenges of configurable products. Configurable products offer pivotal benefits that result in an organization's competitive edge. However, benefits do not come easy as configurable products introduce a lot of additional dimensions in different areas of the business. Configuring products to customer orders can enable higher sales margins as customers are typically willing to pay more for customizations. It also enables a reduction in inventory value and work-in-progress (WIP) as products are manufactured and finished based on orders rather than based on forecasts. Enabling customers to participate in the configuration process also ensures higher customer satisfaction as customer can have more influence on the attributes of the product that they are getting. However, there are challenges in several areas of the business and a lot of trade-offs have to be made in the organization to achieve the above mentioned benefits. Manufacturing and configuring products to order requires additional resources and processes which may lead to higher delivery times and operational costs. Also, the complexity of the configurable products increases the workload in many aspects of the organizations. There are key challenges in managing all of the information that is related to the configurable products and integrating configurators to other information systems. This complicates product management as well as change management activities of configurable products. (Blecker & Friedrich 2007, pp. 4-28; Pulkkinen 2007, p. 97)

Since PDM does not take into account how manufacturing and operational processes are carried out, but only focuses on maintaining the product data up to date in all relevant information systems so that products can be ordered, manufactured and delivered, configurable products PDM processes can be viewed as the above mentioned Blecker & Friedrich definition (2007, p.1). This means that the customer specification process results in additional dimensions to the PDM processes that were introduced in earlier chapters. Configurable products can be seen as product families that contains product variants. Variant products within the product family are generally based on:

- Alternative components (A or B).
- Optional components (A can be selected in variants B and C).
- Classified components (A can be X, Y or Z).

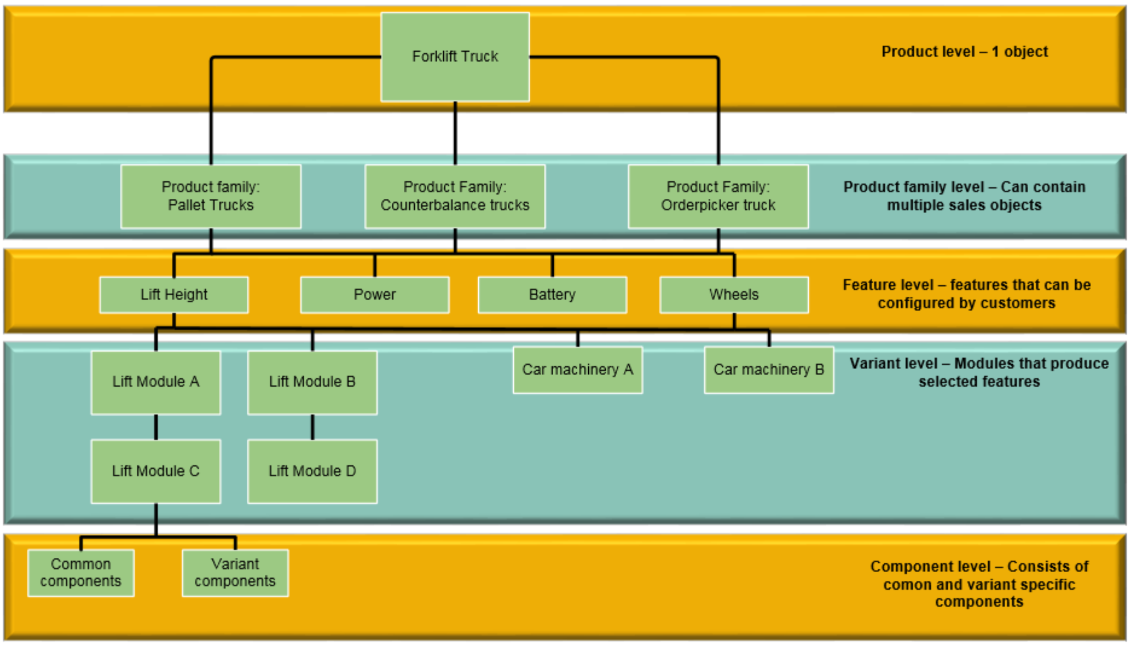


Figure 14: An example of configurable product's structure. (Adapted from Sääksvuori & Immonen 2002, pp. 55-56)

Figure 14 demonstrates a simplified structure of a configurable product that is common in industrial environments. Configurable products are usually structured based on features that are produced for a customer. Features are structured usually from a set of modules that are customized based on the customer's needs. Lastly, common and variant components needed to manufacture all products are illustrated in the structure. Since product structure contains a substantial amount of data, there are different methods to manage the overall structure of configurable products. In ERP systems, a configurable product's structure is managed through one "structure" that contains all variations and other relevant information regarding different alternative, optional and classified components related to the product. The structure of configurable products is referred to as configurable material's bill of material (CBOM) and Super BOM. (Peltonen et al. 2002, pp .81-82; SAP Documentation, 2018)

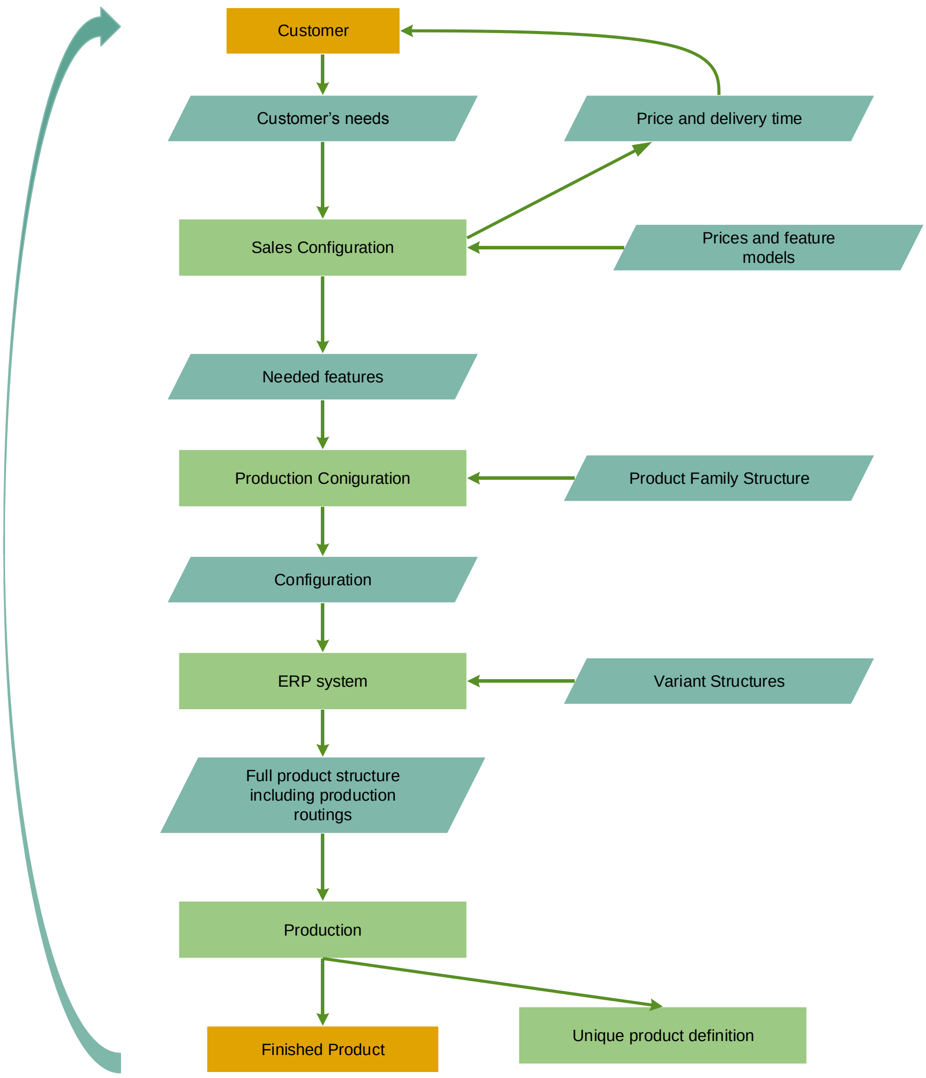


Figure 15: Product configuration in an order-delivery process. (Adapted from Peltonen et al. 2002, pp. 82-83)

Figure 15 illustrates how the configuration process is generally carried out during the order-delivery process. To transform configurable products into a finished end product that meets the customer's demand, the key additional dimensions used in the order-delivery process compared to standard products are configurators. Generally, configurable products are configured in two phases, which are sales configuration and production configuration. The two phases of the configuration are usually carried out through specific sales- and production configurators. Production configurators are also known as order-fulfillment configurators in the broader landscape, as there can be additional types of configurators used, such as, engineering configurators based on the order-delivery process environment. These configurators are not always necessarily separate information systems and can either be used, internally, based on customers' needs or, externally, by the customers itself. (Peltonen et al. 2002, pp. 82-83; Blecker & Friedrich 2007, p. 42)

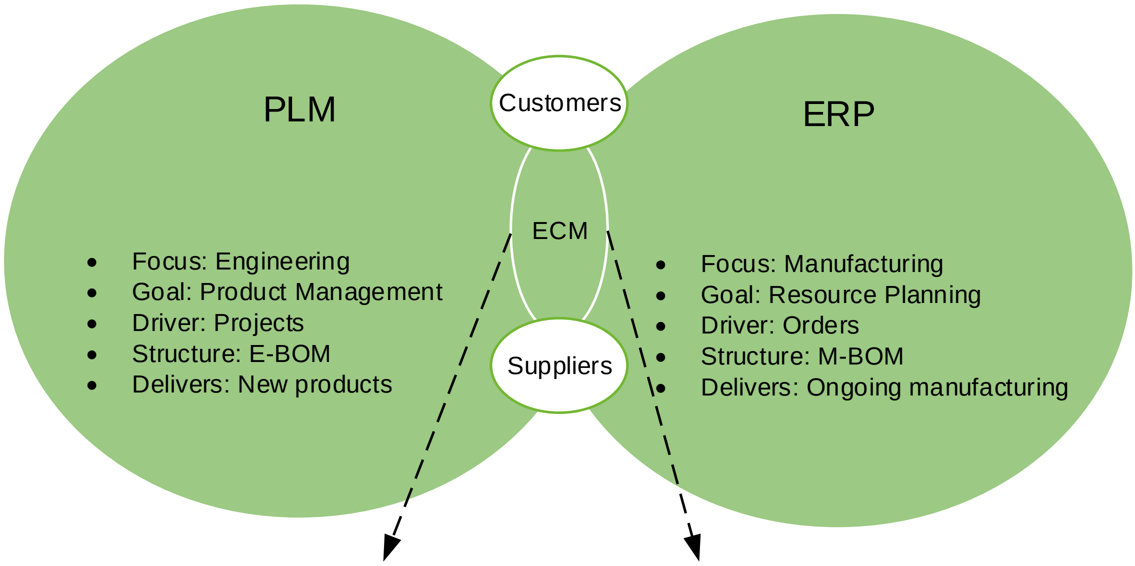
A sales configurator is structured to support the sales process of the company and offer a portal where products can be customized. It presents the user, customer or sales representative with all of the relevant functionalities of the products, as well as the different available variants. The key purpose of the sales configurator is to provide information regarding a products' features, prices and delivery times in a simple and user friendly way. Since configurable products' variations are pre-defined, the configuration process is usually controlled by dependencies that ensure that the variations can be manufactured. Another key requirement of the sales configurator is that it is interactive and enables customers to see how different variations affect the features, prices and delivery times of the end product. (Peltonen et al. 2002, pp. 82-84; Blecker & Friedrich 2007, pp. 41-43)

Sales configurations results in a list of all features that are wanted by a customer. This works as a baseline for production configuration. The purpose of a production configurator is to form a configuration that will include all necessary information needed to manufacture the product. Therefore, production configuration simply offers a more detailed description of the needed product so that all necessary processes for manufacturing the product can be done. Production configurators that usually conduct the final configuration process utilize the configurable product's full structure that is maintained in the ERP system. (Peltonen et al. 2002, pp. 84-85; Blecker & Friedrich 2007, pp. 42-44)

3.5 Engineering Change Management

A key objective of the engineering change management (ECM) is to complement new product development. Since typical new product development (NPD) consists of several stages from opportunity identification to detailed design and testing, ECM offers a more flexible approach to improve design, product performance, reduce production costs or exploit new market opportunities. ECM can be seen as the following four stages: engineering change proposal, approval, planning and implementation and documentation. (Krishna & Young, 2010). According to Krishna & Young (2010) the purpose and objectives of ECM can be summarized as:

- Communicate changes to all necessary stakeholders.
- Manage organizations' response to new and changing market opportunities.
- Influence product's lead time, cost and productivity.
- Control and establish procedures and policies that are used to interact and share information between stakeholders.



Engineering Change Management (ECM)		
Phases	Design Activities	Manufacturing Activities
Identify the Issue Conduct the Analysis Planning the Change Release the Change Change Product Configuration	Problem Report Engineering Change Request Engineering Change Notice Validation/Audit/Release Engineering Change History	Customer Requirement Business Analysis Supplier Process Release Product Change Product Traceability

Figure 16: ECM framework that takes into account PLM and ERP activities. (Adapted from Wu et al., 2014)

Wu et al. (2014) recognize an advanced ECM framework which is illustrated in figure 16. The framework follows Configuration Management II (CMII) standards and aims to provide a comprehensive approach to solving fundamental product functionality and quality issues within the manufacturing industry. In the field of engineering change management, configuration management refers to a systematic control of changes that are related to the products. The phases of CMII based ECM process are: identifying the issue, conducting the analysis, planning the change, releasing the change and changing the product configurations. Actions are needed to be taken in each of these phases in PLM and ERP perspectives in order to reach the objectives that are illustrated in figure 16. Both domains also need to effectively coordinate the activities in order to ensure effective and comprehensive ECM of the product's lifecycle while ensuring the operational capacity for the product.

The CMII based ECM framework consists of PLM and ERP perspectives. The PLM side is the design domain. The focus on the PLM side is managing the engineering activities, while the goal is to manage the product. The PLM perspective is structured to deliver new products to markets and its main driver is internal projects. However, since customer requirements are also key drivers for PLM, co-operation with ERP perspective is required to transfer relevant issues into the PLM side. The ERP perspective can be seen as the manufacturing domain. Here, the focus is on manufacturing and ensuring all resources that are needed. The process is delivered to ensure that the manufacturing keeps going and its key driver is orders.

From a PDM point of view, there is a lot of information related to complex industrial products, in addition to, a lot of dependencies between the product data. Minor changes in some areas might require changes or reviewing in other areas of product data. Changes are, therefore, usually managed centrally to ensure efficient management of the product and collaboration between all relevant functions within the organization. (Sääksvuori & Immonen 2002, p. 38; Peltonen et al. 2002, p 71)

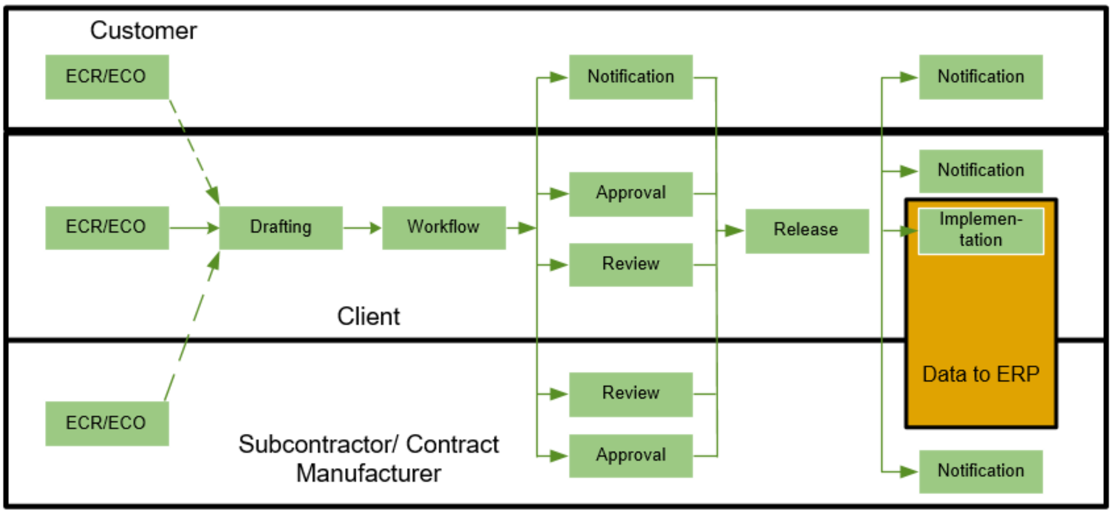


Figure 17: High-level ECM process from IS point of view. (Adapted from Sääksvuori & Immonen 2002, p. 39)

Figure 17 illustrates the engineering change management process from the information system point of view in a general level. Information systems that are used to manage engineering changes, such as PDM systems, usually take into account the flexibility and overall landscape of ECM. Different types of technical and non-technical changes can be managed through the ECM related information systems. The main benefits of information system based engineering change management are the drafting features that allow ECR initiators and stakeholders to quickly gather all documentations that are related to the change. Also, engineering change specific information systems allow systematic workflow for different phases of the ECM. This enables organizations to effectively negotiate, review and approve the changes. Furthermore, releasing changes to ERP systems can be scheduled to ensure operational capability. ECM specific systems also usually offer version control features to ensure effective lifecycle management of products in order to implement changes in a controlled way and avoid overwriting all existing product data. (Sääksvuori & Immonen 2002, p. 39-41)

4 Case Company: ABB Drives

The case company, ABB is a large global Power and Automation Technology Corporation. In chapter 4.1 the ABB is introduced first as a whole and, its business segments and presence in Finland. Chapter 4.2 details ABB Oy Drives and the organizational structure that is relevant to the case study.

4.1 ABB Group

ABB is a pioneering global leader in the power and automation technology industry. ABB enables its customers to improve performance of utilities, industry and transport and infrastructure, while reducing environmental impact. Globally, ABB operates in over 100 countries and employs over 136 000 people. (ABB intranet, 2017)

ABB business segments are divided into four divisions, which are Robotics and Motion, Electrification Products, Industrial Automation and Power Grids. Each division is further divided into business units which represent unique sets of business activities. ABB Drives is part of the Robotics and Motion division which is responsible for the manufacturing of Motors and Generators, Drives and Robotics for increasing productivity and energy efficiency to many industry segments. (ABB profile, 2017)

ABB Group was established in 1988 when the Swedish Asea and the Swiss Brown Boveri companies merged into one of the largest electrical companies of its time. Strong Finnish roots of ABB originate from Oy Strömberg Ab, which was acquisitioned by Asea in 1986. Oy Strömberg has especially had a strong impact on the industry because of the development of frequency converters for the use of controlling induction motors. (ABB Historia, 2017)

In Finland, ABB is one of the largest industrial employers with a workforce of approximately 5100 people. Plants and manufacturing operations are concentrated in the Helsinki and Vaasa areas. In Helsinki, two major plants are located in Pitäjänmäki and Vuosaari. Motors and Generators and Drives are manufactured in Pitäjänmäki. In the Vuosaari plant, Azipod rudder propeller systems and other marine industry specific products are manufactured. (ABB Suomessa, 2017)

4.2 ABB Oy Drives

ABB Oy Drives is a local business unit in Finland that is part of ABB Oy. Globally, it is under the ABB Drives business unit, as well as, the Robotics and Motion division. The Organizational structure of ABB Oy Drives is illustrated in figure 18. (ABB intranet, 2017)

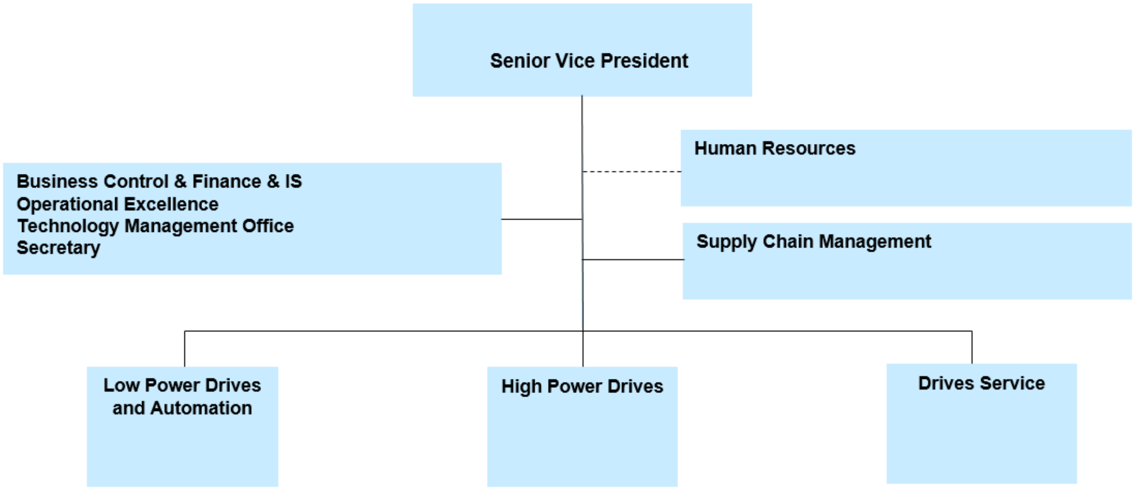


Figure 18: ABB Oy Drives organizational structure. (ABB intranet, 2017)

ABB Oy Drives is divided into three organizations, which are Low Power Drives and Automation (LPDA), High Power Drives (HPD) and Drives Service. HPD and LPDA are responsible for the manufacturing operations of Drives. HPD and LPDA are seen as manufacturing organizations of ABB Oy Drives and also referred to as the Drives Helsinki factory. Drives Service is responsible for the After-Sales operations, both, locally and globally. Drives Service also operates under the Helsinki factory and is responsible for the manufacturing of certain classic phase products, drive modernization products and workshop operations. Drives Service is also responsible for the spare-part business of ABB Drives to support installed base products around the world.

5 Product Data Management of Configurable After-Sales Products

Empirical part of this study is only for the company's internal use.

6 Proposals for Improvements

Proposal improvements of this study are only for the case company's internal use.

7 Summary

Part of this chapter is only for the case company's internal use.

This chapter summarizes the purpose and objectives of the thesis. In addition, the applied methods and results of the study are evaluated. Future research opportunities for the case company are also presented.

The purpose of this study was to analyze the current state of the product data management processes. Opportunity for this study arose from the case company's need to manage more effectively a growing configurable products' portfolio. The thesis was carried out to support the organization's objectives to improve the management of configurable products. Also, the tools and procedures used to manage the product data of configurable products were analyzed. Due to the comprehensiveness of the product data management landscape for configurable products, the selected objectives cover certain areas of the overall product data management process. The objectives of the case company and the scope of research were the following:

1. Understand how to manage product data related to configurable products.
    - Scope: Changes that lead to the implementation of new product data

2. Determine how to implement new product data more effectively in after-sales operations.
    - Scope: Identify current challenges in all tools and processes used for implementing changes in operations

3. Define processes to manage product data of configurable products.
    - Scope: Active phase configurable drives and configurable spare-parts

Qualitative and action research methodologies were utilized throughout this research. The applied action research methodology used also supports the reliability and validity of the results, since they were conducted in co-operation with the stakeholders. The theoretical part of the study was constructed from a comprehensive literature review that consists of theories of Lean management, business process re-engineering and product data management. The empirical part of the research was conducted by utilizing the case company's existing technical and functional documentations, process maps and the employees' knowledge in the form of interviews and conducting a process walkthrough.

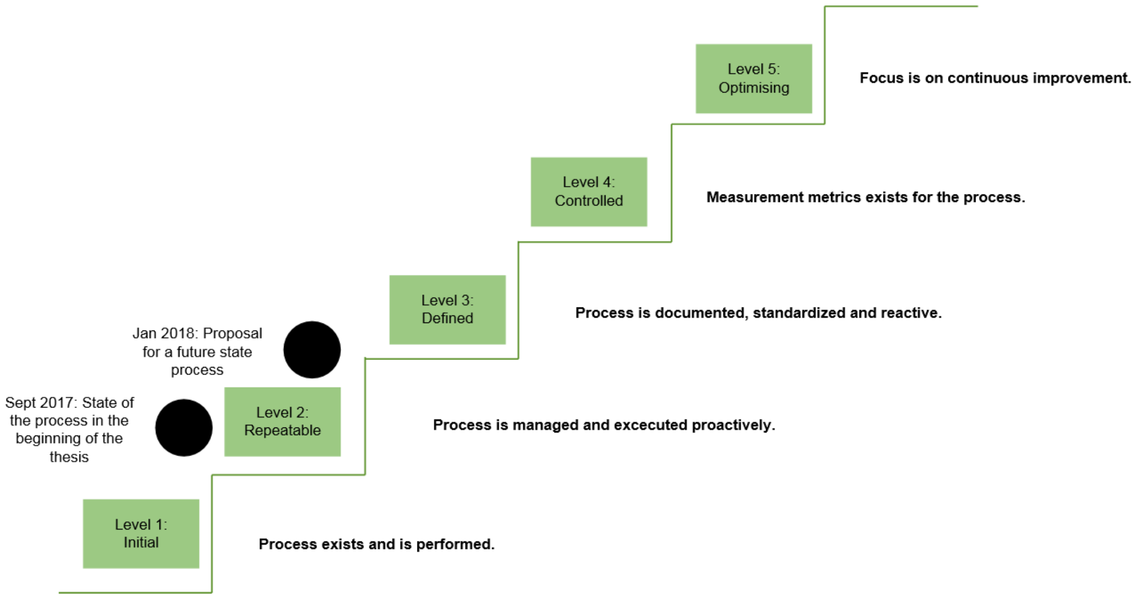


Figure 19: Results of the thesis based on a process maturity model. (Based on Macintosh, 1993)

The key objective of the thesis was to define a process for the case company's configurable products' product data management processes. Objectives one and two were formed as supporting objectives for the definition of the new process. As a result, process maps were defined for two product groups that were part of the analysis of the thesis, which were configurable active phase drives and configurable spare-parts. The maturity and implementation of the processes are affected by several issues that are related to the complexity of the product data management landscape. Although these issues could not be solved, they were presented in chapter 6 as a part of the future state improvement areas.

In addition, as part of the objectives, several key improvement proposals were introduced to support the new process and to ensure the effectiveness of the process. Since the scope of objectives was limited, these findings cover only the new product data creation processes and, therefore, are not valid for the whole engineering change management field of configurable products. Also several future research question were discovered during the thesis to support the successful implementation of the process and long-term development of the configurable products.

The theoretical framework of Lean Management and BPR, as well as the company's Lean culture, can be utilized as a basis for future state improvements. In addition, continuous improvement mind-set with an emphasis on value adding processes are the key to improve the processes in the future. Furthermore, the existing data and information systems' architecture should be analyzed thoroughly and future decisions should be made with a long-term perspective. Lean and Toyota way philosophy of making long-term decisions by sacrificing short-term objectives also plays a major part in the future development, as configurable products differ from the current high volume standard after-sales products.

References

ABB Intranet. ABB Oy Drives Organisaatiorakenne. Internal document. ABB. Referred on 3.11.2017

ABB Intranet. ABB Profile. Internal document. ABB. Referred on 3.11.2017

ABB Intranet. Engineering Change Management. Internal document. ABB. Referred on 1.12.2017.

ABB Intranet. High Power Drives - Product Information Management. Internal document. ABB. Referred on 16.10.2017.

ABB lyhyesti. Webpage. <http://new.abb.com/fi/abb-lyhyesti>. Referred on 3.11.2017

Aguilar-Savén, R.S. 2004. Business process modelling: Review and framework. International Journal of Production Economics. Vol. 90, No. 2, pp. 129-149.

Bhasin, S. 2015. Lean Management Beyond Manufacturing: A Holistic Approach. Coventry, United Kingdom. Springer International Publishing AG. 291 p.

Blecker, T. & Friedrich, G. 2007. Mass Customization Information Systems in Business. London, United Kingdom. 313 p.

Burlton, R.T. 2001. Business Process Management: Profiting from Process. Indianapolis. Sams Publishing. 416 p.

CIMdata. 1998. Product Data Management: The Definition. CIMdata Inc. Ann Arbor, Usa.

Coghlan, D. & Brannick, T. 2014. Doing action research in your own organization. Dublin, Ireland. SAGE Publications Ltd. 200 p.

Damij, N. 2007. Business process modelling using diagrammatic and tabular techniques. Business Process Management Journal. Vol. 13, Issue 1, pp.70-90.

Davenport, T.H. 1993. Process Innovation: Reengineering Work through Information Technology. Massachusetts, Boston, USA. Harvard Business School Press Books. 352 p.

Eskola, J. & Suoranta, J. 1998. Johdatus laadulliseen tutkimukseen. 3. Painos. Jyväskylä. Gummerus. 266 p.

Grover, V. & Malhotra, M.K. 1997. Business process reengineering: A tutorial on the concept, evolution, method, technology and application. Journal of Operations Management. Vol. 15, Issue 3, pp. 193-213.

Hammer, M. & Champy, J. 1993. Reengineering the corporation: a manifesto for business revolution. London, United Kingdom: Nicholas Brealey Publishing. 223 p.

Krafcik, J.F. 1988. Triumph of the Lean Production System. Sloan Management Review. Vol. 30, Issue 1, pp. 41-42.

Krishna, R. & Young, B. 2011. System dynamics modeling of engineering change management in a collaborative environment. International Journal of Advanced Manufacturing Technology. Vol. 55, Issue 9-12, pp. 1225-1239.

Lakin, R., Capon N., & Botten, N. 1996. BPR enabling software for the financial services industry. Management Services. Vol. 40, No. 3, pp. 18-20.

Lee, C., Leem, C.S. & Hwang, I. 2011. PDM and ERP integration methodology using digital manufacturing to support global manufacturing. International Journal of Advanced Manufacturing Technology. Vol. 53, Issue 1-4, pp. 399-409.

Liker, J. K. 2004. Toyotan tapaan. Jyväskylä. Gummerus Kirjapaino Oy. 323 p.

Macintosh, A.L., 1993. The need for enriched knowledge representation for enterprise. Artificial Intelligence in Enterprise Modelling, IEE Colloquium on, pp. 3/1–3/3.

Mittal, S., Frayman, F. 1989. Towards a generic model of configuration tasks. In Proceedings of the 11th International Joint Conference on Artificial Intelligence - IJCAI'89. San Mateo, California. pp. 1395-1401.

Mellanen, A. 2016. Manufacturing Bill of Materials for Configurable Products in Time-phased MRP-controlled Manufacturing Planning & Control Systems. Master of Science Thesis. Tampere University of Technology. 99 p.

Pagh, J.D. & Cooper, M.C. 1998. Supply chain postponement and speculation strategies: how to choose the right strategy. Journal of Business Logistics. Vol. 19, Issue 2, pp. 13-33.

Peltonen, H. Martio, A., & Sulonen, R. 2002. PDM – Tuotetiedonhallinta. Helsinki. Edita Prima Oy. 169 p.

Pulkkinen, A. 2007. Product Configuration in Projecting Company: The Meeting of Configurable Product Families and Sales-Delivery Process. Dissertation. Tampere University of Technology. Publication 712. 184 p.

Sääksvuori, A. & Immonen, A. 2002. Tuotetiedonhallinta – PDM. Jyväskylä. Gummerus Kirjapaino Oy. 201 p.

SAP Documentation. 2018. Webpage. Variant Configuration (LO-VC). <https://help.sap.com/saphelp_erp60_sp/helpdata/en/c1/62b6531de6b64ce10000000a174cb4/frameset.htm>. Referred on 3.1.2018.

Sharp, A. & McDermott, P. 2009. Workflow modeling: tools for process improve-ment and application development. 2nd ed. Norwood, Massachusetts, USA. Artech House. 471 p.

Shilovitsky, O. 2015. How the idea of single BoM can fit variants and configuration management?. PLM-seminar: Product Configuration and Variant Management. Gardermoen, Norway. Presentation. 23 slides. < https://www.slideshare.net/olegshilovitsky/plmseminar-at-gardermoen-how-the-idea-of-single-bom-can-fit-variant-and-configuration-management>. Referred on 27.11.2017.

Svensson, D. & Malmqvist, J. 2000. Strategies for Product Structure Management in Manufacturing Firms. Proceedings of the ASME Design Engineering Technical Conferences. Baltimore, Maryland, USA.

Tichem, M., Storm, T. Andreasen, M.M., & MacCallum, K.J. Product structuring, an overview. In: (edt. Riitahuhta A.) World class design by world class methods. 1997. Proceedings of ICED Vol. 2, pp. 45-50. Tampere University of Technology, Laboratory of Machine Design.

Voehl, F., Harrington, H.J., Mignosa, C. & Charron, R. 2014. The lean six sigma black belt handbook: tools and methods for process acceleration. Boca Raton, Florida, USA: CRC Press. 558 p.

Wacker, J.G. & Miller, M. 2000. Configure-To-Order Planning Bills of Material: Simplifying a Complex Product Structure for Manufacturing Planning and Control. Production and Inventory Management Journal. Vol. 41, pp. 21-26.

Wu, W-H., Fang, L-C., Wang, W-Y., Yu, M-C., & Kao, H-Y. 2014. An advanced CMII-based engineering change management framework: the integration of PLM and ERP perspectives. International Journal of Production Research. Vol. 52, Issue 20, pp. 6092-6109.

Interviewees, topics and time of the interviews.

Person and Function	Topic	Time
Manager, Product Information Management	Introduction to the case and objectives of the thesis	60 minutes. 15.8.2017
Technical Product Manager, Technical Product Management	Product structure management of configurable after-sales products. ECM and new product introduction processes	120 minutes. 12.9.2017
Application Specialist, Product Information Management	Product data creation and maintenance process	120 minutes. 13.9.2017
Application Specialist, Product Information Management	Transactions of FISAP ERP for ECM of configurable items and BOM’s	120 minutes. 15.9.2017
Pricing Manager, Sales Management	Pricing of configurable after-sales products	120 minutes. 18.9.2017
Variant Configuration Specialist, Research and Development	Variant configuration in FISAP ERP	90 minutes. 20.9.2017
Application Specialist, Product Information Management	Item management database and automated item maintenance transactions of FISAP ERP	90 minutes. 12.10.2017
Systems Development Specialist, Operations Development	Drives Configurator systems architecture and inputs needed for maintaining the configurator rule table.	120 minutes. 16.10.2017

Interview template, semi-structured interviews.

Semi-structured interview template for interviewees.

Process elements, objectives and scope

1. What is the name of the process?
2. How/Where does the process starts?
   - What kind of actions trigger the process
3. What is the scope of the process?
   - Which products the process is meant for?
   - Which types of situation this process can be used?
4. What are the objectives of the process?
   - What tasks are to be done

Process workflow

5. What inputs are needed in order to perform the process?
6. Who is the supplier for the inputs?
7. What outputs are produced from the process?
8. Who is the customer of the process? (Next step)
9. What are the common problems that affect the input of the process? Why?
10. What kind of problems comes back from the customer of the outputs? Why?
11. What process activity is currently most challenging? Why?

Process Control and improvement

12. Is there any documentations or control methods currently for the process?
13. What kind of improvements are identified? Why?
14. How improvements should be prioritized? Why?
15. Is there any process that could be eliminated or done other way? Why?
16. What are the processes that can be done differently and how they can be done? Why?
17. How the process is measured? If not, how it could be measured to control the process?

Theme based interviews, topics and themes.

Topic and themes that were presented to process owners.

1. Variant Configuration in SAP ERP
    - Variant Configuration set up process.
    - Inputs required for implementing changes.

2. Drives Configurator
    - How HPD and LPDA configurable products are managed.
    - How Drives Service configurable products are managed.
    - Inputs that are required for implementing changes.

Process Map, Configurable Active Phase Drives.

Internal document for the case company’s use.

Process Map, Configurable Spare-parts.

Internal document for the case company's use.

Sub Process, Active Phase Drives, Product Information Management.

Internal document for the case company’s use.

Sub Process, Configurable spare-parts, Product Information Management.

Internal document for the case company’s use.