FACULTY OF TECHNOLOGY

IMPLEMENTATION OF A PRODUCT DATA MANAGEMENT SYSTEM

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INDUSTRIAL ENGINEERING AND MANAGEMENT

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ABSTRACT
FOR THESIS

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Abstract

This thesis is made for Haltian Oy with an aim to study what needs to be taken into consideration when implementing a product data management (PDM) system. The goal of the thesis is to provide Haltian the knowledge needed for implementing the system as well as to form recommendations to improve the data flows of the order-delivery process. The research is qualitative by nature, and inductive research methods are used. This is a single case study where multiple ways of data collection are used to form a comprehensive analysis on the current state of product data management and data flows in order-delivery process of Haltian. The research is mainly based on interviews of relevant stakeholders, arranged together with consultants.

Currently, there is a lot to improve in terms of product data management. The data is fragmented and managed mainly manually. Also, changes are performed manually, which is time-consuming and exposes the organization to errors. Currently the precious working hours of engineers must be used for detecting the information to ensure the data are up to date, because the availability and traceability of the data are weak.

This thesis recommends Haltian to implement a PDM system called Teamcenter. It can fulfil all the requirements the organization has set for a PDM system and helps to clarify the product data management process and related responsibilities. In addition to system implementation, some adjustments to order-delivery process are recommended to be made to ensure more efficient ways of working and effortless product data flows.

The recommendations of this thesis can be taken into use by implementing the system and performing the proposed process changes. The generalizability is limited, as the results are accurate only for the case company. However, product data management is a general issue in companies of similar stage, and therefore the results can be generalized to some extent to learn about product data management and PDM system's implementation project.

Additional Information

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Tiivistelmä

Tämä diplomityö on tehty Haltian Oy:n pyynnöstä ja se pyrkii selvittämään, mitä asioita on otettava huomioon tuotetiedon hallintajärjestelmän implementoimisessa. Työn tavoite on tarjota Haltianille tarvittavat tiedot implementoinnin toteuttamiseksi sekä muodostaa kehitysehdotuksia tilaus-toimitusketjun tuotetiedon luomiseen ja hallintaan. Tutkimus on laadullinen ja käyttää induktiivisia tuktimusmetodeja. Diplomityö on toteutettu yhden yrityksen tapaustutkimuksena, jossa käytetään erilaisia tiedonkeruun menetelmiä. Tällä tavoin muodostetaan laaja käsitys tuotetiedon hallinnan nykytilasta ja siitä, miten tuotetieto tilaus-toimitusketjussa liikkuu. Tärkein tutkimuksessa käytetty tiedon keräystapa on konsulttien avulla järjestetyt haastattelut, joissa tuotetiedon kannalta keskeisimpiä työntekijöitä haastateltiin.

Tällä hetkellä yrityksen tuotetiedon hallinnassa löytyy paljon kehityskohteita. Tuotetieto on hajallaan ja sitä hallitaan pääasiassa manuaalisesti. Myös datan muutokset tehdään käsin, mikä on aikaavievää ja virhealtista. Tuotetiedon saatavuus ja jäljitettävyys on heikkoa, mikä haaskaa työntekijöiden työaikaa turhaan tiedonetsintään. Tiedon löydyttyä lisää aikaa menee löydetyn tiedon paikkaansapitävyyden selvittämiseen.

Tämän diplomityön tuloksena ehdotetaan Teamcenter-nimisen tuotetiedon hallintajärjestelmän implementointia, sillä se pystyy täyttämään Haltianin asettamat vaatimukset tarvittavalle järjestelmälle ja auttaa selkiyttämään tuotetiedon hallintaa ja siihen liittyviä vastuualueita. Järjestelmän implementoinnin lisäksi tämä tutkimus tarjoaa tilaus-toimitusprosessin parannusehdotuksia, jotka mahdollistavat tehokkaammat toimintatavat ja vaivattoman tuotetiedon kulun läpi prosessin.

Ehdotukset voidaan tuoda käytäntöön implementoimalla tuotetiedon hallintajärjestelmä ja toteuttamalla ehdotetut muutokset tilaus-toimitusprosessiin. Tutkimuksen tulosten yleistettävyys on rajallista, koska tutkimus on toteutettu vain kyseessä olevalle yritykselle ja täten ongelmat ja niiden ratkaisuehdotukset pätevät vain tälle yritykselle. Tuotetiedon hallinta on kuitenkin yleinen ongelma monessa vastaavanlaisessa yrityksessä, joten tutkimusta ja sen tuloksia voi käyttää tietyin varauksin hyväksi myös muiden organisaatioiden tuotetiedon hallinnan ongelmiin.

Muita tietoja

FOREWORD

This thesis aims to provide the case company a needed knowledge about implementation of a product data management system. I started to write this thesis in March and begun the actual work in Haltian in late April. In addition to learning about the topic, the research process taught me a lot about Haltian as a developing goal-oriented company and IoT as an interesting industry of the future. The writing process has been truly enjoyable and strengthened my interest towards scientific writing. Haltian took me delightfully well as a part of their work community and opened their company for me to research. I would like to thank all the employees that attended the interviews for honest and open conversations about their working tasks and daily routines. Huge thanks must also be addressed to the supervisors of my thesis. Thank you doctors Janne Härkönen and Erno Mustonen for your versatile and instructive help in the whole study process, it has been indispensable and past all my expectations. Equal thanks to my superior in Haltian for all the support, trust and responsibilities I have got. I would also like to thank my dear family for always encouraging me in my studies. Finally, thank you for my fiancé for all and everything: you are the biggest support of my life.

Oulu, 01.09.2020

Annika Haataja
Annika Haataja

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LIST OF ABBREVIATIONS

BOM	Bill of Material
CAD	Computer Aided Design
ERP	Enterprise Resource Planning
EBOM	Engineering Bill of Material
HW	Hardware
IoT	Internet of Things
MBOM	Manufacturing Bill of Material
PDM	Product Data Management
PDS	Product Development Service
PLM	Product Lifecycle Management
PMD	Product Master Data
R&D	Research and Development
SW	Software

1 INTRODUCTION

1.1 Study background

With big advancements in various digital technologies, some experts have proclaimed the arrival of "Fourth Industrial Revolution". Part of this revolution is the Internet of Things (IoT), an evolution of connectivity expanded from the internet. (Chou 2019) During the past years, it has been almost impossible not to come across with the term IoT. Companies have introduced numerous IoT-based products and services. (Wortmann & Flüchter 2015) IoT comprises a collection of digital technologies including sensors, communication modules and various software applications that all together can integrate analog physical systems with the digital world. This provides constant and readily available information about the systems. Being able to connect and perceive physical entities and environment digitally allows us to comprehensively capture information that enables us to understand issues more efficiently, effectively and precisely. (Chou 2019)

Based on the information provided by IoT solutions, collaborative decisions and coordinated actions can be implemented in both timely and accurate manner and make the physical systems smart. This seamless integration of physical systems and the digital world can result in a substantial compression of time and space for managing for example the operations of societies more generally. (Chou 2019) The fields of application for IoT technologies are numerous as well as diverse, as IoT solutions are increasingly extending to new areas all the time. The most prominent areas of application are for example, smart industry, home, building, energy and transport. These include innovative solutions like intelligent thermostats, security systems and mobile ticketing. (Wortmann & Flüchter 2015)

In modern global economy, companies must continuously come up with these kinds of new innovative products to improve their market position (Kropsu-Vehkaperä et al. 2009). Shorter product lifecycles, growing product complexity and the need for a large amount of product variants have made Product Data Management (PDM) increasingly important for companies (Peltonen 2000). The business concept and related requirements reflect uniquely on the company data structure making the data a strategic asset for companies (Emmanouilidis et al. 2018). The increased technological complexity has also

increased the need for technical documentation to describe the products (Hameri & Nihtilä 1998).

Business information systems have continuously developed with these evolving business needs during the past decades. Data are becoming more critical success factor for companies as business processes increasingly rely on these systems. Regardless of the industry, companies are increasingly dependent on consistent, accurate and reliable data in every operation. The data help them to ensure financial health of the company, to understand the customer insights and to define future directions. (Hannila 2019; Kropsu-Vehkaperä 2012) Product data exchanges can now be brought closer to end use consumption, which enables users to become more proactive actors within the product management process (Emmanouilidis et al. 2018). The data itself are not enough, but the ability to realize the value that data provide; it can be understood as raw material for decision-making. Product data are also needed to produce, sell, deliver and invoice a product in information systems. (Hannila 2019; Kropsu-Vehkaperä 2012)

Product data management has become one of the most important considerations for companies in engineering and manufacturing industries. The main purpose of introducing a PDM system is to help a company to electronically manage their operations, making it more efficient and effective. The system brings standardized ways of working with relevant supporting applications. (Kropsu-Vehkaperä et al. 2009) In this world where information technology has a key role in the execution of processes, and in the exchange of information, a company that does not take proper care of its data is taking a considerable operational risk (Bonnet 2010).

Quite a lot of research has been carried out on the implementation of PLM (Product Lifecycle Management) in which PDM is also included, such as Saaksvuori and Immonen (2008) as well as Stark (2015, 2016 & 2019). PDM has also been studied by Peltonen (2000), Philpotts (1996) and Crnkovic et al. (2003), but there are not so many studies available purely on the implementation of a PDM system.

1.2 Research problem, objectives and scope

In addition to carrying out research on the field of PDM implementation, this thesis concentrates on Haltian Oy as a case company. Currently Haltian’s product data

management is fragmented and would need a lot of improvement. Therefore, the aim of this study is to examine the right procedures and methods, which to follow in the implementation project of a PDM system.

Before implementing a PDM system, many things must be considered. The processes of the company must be in an appropriate shape before the implementation is even possible to be started. The thesis starts with the literature review to understand the related terms, concepts and tools presented in previous research that could be utilized in this implementation project. After that, this thesis examines the current state of data transfer in Haltian business processes and tries to clarify the issues that are already working well and to identify those that could be handled better. Based on the analysis and the literature, this thesis aims to provide recommendations for the implementation project. The suggested actions include ideas on how Haltian could make their processes more efficient, how the PDM system could help the product data management and what changes would be necessary to be executed before the implementation. However, the presented suggestions do not go very deeply into developing details, for example on how the company should form their version control procedures.

The research problem can be formulated as follows: *What needs to be taken into consideration when implementing a PDM system?* The research problem is divided into three main research questions that are answered through literature review, practical research in the case company, or combining these two. The research questions are:

RQ1: What are the role and the data needs of a product data management system? This issue is covered by the literature review which is based on previous research in this field.

RQ2: What are the case company's current data needs, procedures and the ways of documentation? This includes examining the roles of current information systems in the documentation of product data, and answers are developed through practical research in the company.

RQ3: What needs to be considered in the implementation project in terms of change management? In addition to change management procedures, financial issues considering the PDM implementation project, and accountability of the financial benefits, enabled by the system are included in this question. The answer is a combination of the

knowledge gained through both the literature review and the practical research in the company.

1.3 Research process

The literature review forms the theoretical base for this thesis. It was formed and written as the first phase of the whole research process. Firstly, a solid ground for suitable references from literature was searched. The references used in this thesis are mainly research articles and books. The literature review was written by combining the information from these. The literature review answers the first, and partly the third research question, and forms the basis for the entire thesis, and the gained knowledge about the topic.

In the second phase, current state analysis was executed and documented. In conducting the analysis, consultant help was used to understand and analyze the current product data creation processes of the case company Haltian. The current state analysis was executed by arranging eight online interviews with top management, and the most relevant employees of Haltian who are creating, using and managing product data. For most of these interviews, there were 1-2 Haltian employees attending. The interviews took 1-1,5 hours each and were held over the period of two weeks. During the interviews tens of pages of notes were taken, and the current state analysis was composed mainly based on those notes.

After the interviews, the consultants put their thoughts together and hosted a final presentation of pre-investigation phase of business processes and data flows for the coming PDM system implementation. Section 3.3.1 “Data flows in business processes” is mostly composed based on the materials from this presentation. In addition to the interviews, knowledge for the current state analysis was gathered through the whole thesis writing period in Haltian, in the forms of conversations, meetings and documents. The current state analysis contains the answers to second and partly to the third research question.

Recommendations of this thesis were created by combining the literature review and the current state analysis. All the main product data management categories that were discovered to need an improvement during the current state analysis were considered. The

suggestions were generated based on the knowledge gained through the literature review and the information detected, and the actual company analysis. This was supplemented by researcher's own thinking and ideas about the processes and ways of working. The knowledge about features of the recommended PDM system is gained from the system supplier and is used to examine how the supplier can fulfill the needs of Haltian. Recommendations supplement the answer to the third research question composed based on the literature review and the analysis.

Finally, the key aspects from the literature review as well as the current state analysis were summarized. The summary contains answers to research questions and evaluation of the results. It also presents some ideas for possible future research that could be derived from this thesis and the topic.

Altogether, the different parts of the thesis create a whole that provides clarity to the initial research aims, and answers the research questions set for the thesis. Figure 1 illustrates how the different parts of the research process end up answering the research questions.

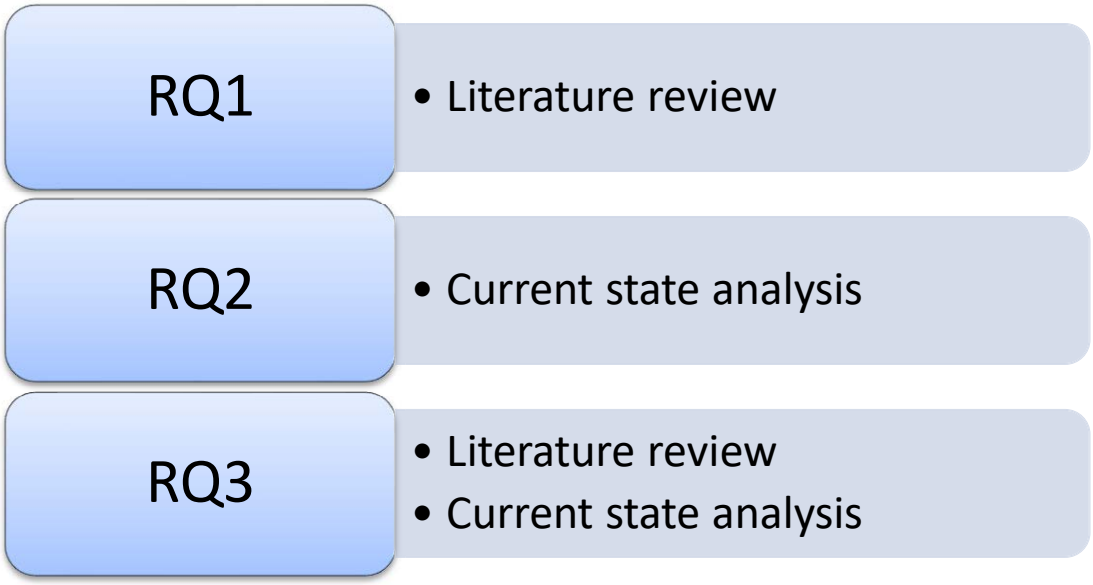

Figure 1. Research process for answering the research questions.

2 LITERATURE REVIEW

Successful product data management system implementation necessitates that many aspects are considered. Everything starts with the company's products and data related to the products. The data includes enormous amount of different kinds of information, which needs to be handled, understood and used in a good manner. In addition to the technical side of the new tool, the company considering product data management system implementation needs to examine their implementation objectives and change management procedures.

2.1 Product

Product is often understood to mean physical products that can be owned, traded and distributed to different places without changing their identity. However, in addition to physical products, the product can be a provided as a service, or in the form of other intangible product, such as software or an algorithm. (Saaksvuori & Immonen 2008) The concept of product is sometimes taken even further as Philpotts (1996) even considers projects, plants, facilities and assets as products. Generally, products are the source of revenue for a company and therefore they have a great importance. Without products there would be no companies. Products also relate to a great deal of information and data that companies need to manage. (Stark 2015)

2.1.1 Product lifecycle

Product lifecycle illustrates the different phases of products in which they are in the different states along their life. The lifecycle can be seen from different views between different stakeholders of the product. In the view of user, product lifecycle can include five phases: imagine, define, realise, use and dispose. The manufacturer, marketing and environmental viewpoints may have different lifecycle phases as well as different numbers of them. Stark (2015) Lahtinen et al. (2020) introduce five phases from the viewpoint of productization: R&D, maintain, warranty, limited warranty and archive. On the other hand, Saaksvuori and Immonen (2008) counts the product lifecycle to have six phases of planning, introduction, growth, maturity, decline and retirement.

2.1.2 Product structure

Product structure can be seen as a way to model products and product data. To be able to efficiently manage product data in information systems, there is a need to have a common product data model throughout the company. In the case of configurable products, a general product structure is represented as being a typical way to describe the products and their arrangement of parts. In addition to describing products, product structure represents data linked to the specific product and the relationship between product components. Product structure includes both components used in the product as well as the relationship between the components. (Kropsu-Vehkaperä 2012) According to Lahtinen et al. (2020), product structure can be divided into technical and commercial structures. Commercial structure consists of product families, configurations and sales items, whereas the technical structure is formed through a version item (Härkönen et al. 2019). Figure 2 illustrates the differences between these two over the product lifecycle (Lahtinen et al. 2020).

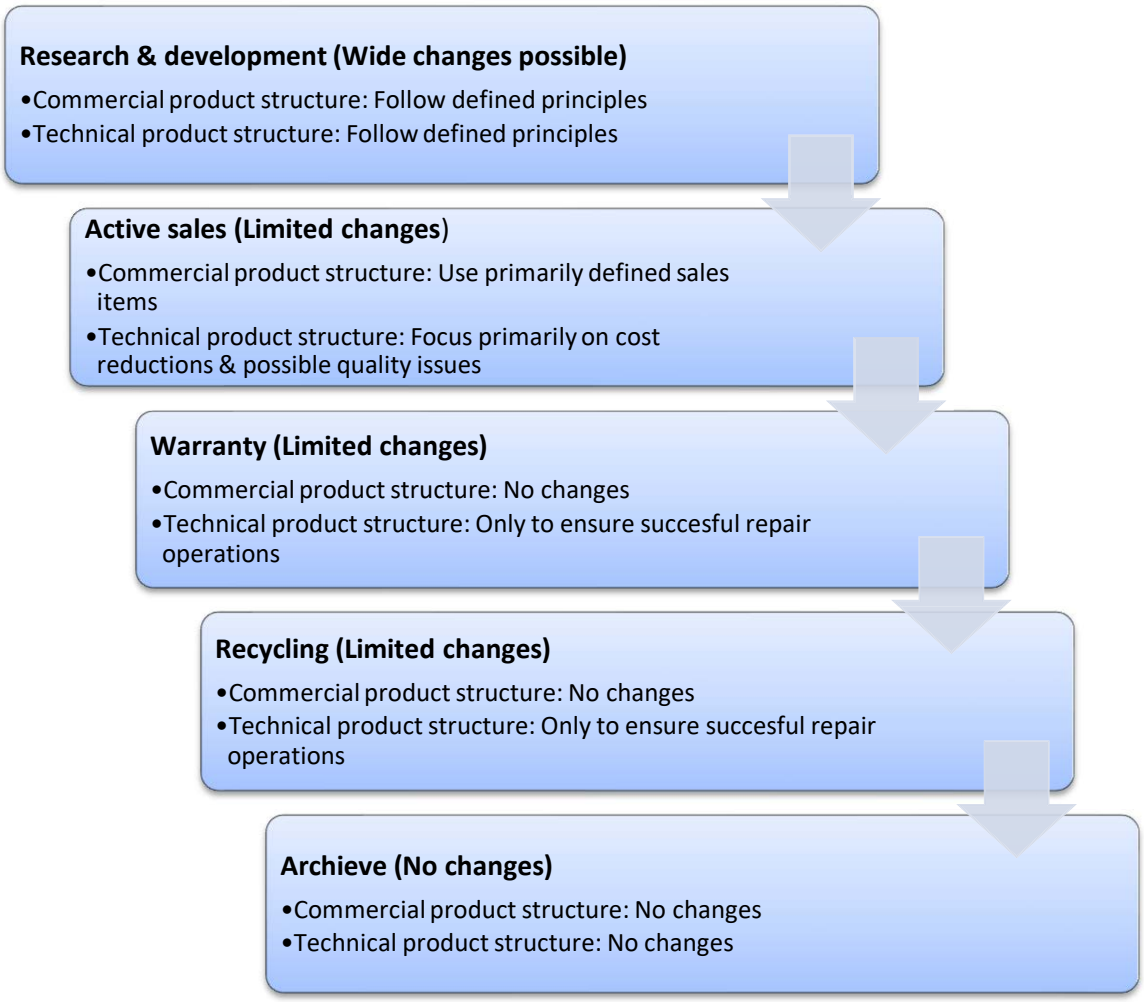

Figure 2. Commercial and technical product structures over product lifecycle.

2.1.3 Bill of material

Many companies have hundreds or thousands of products. The number of parts in a product may vary from one all the way to millions; all the products with all the parts must be managed. (Stark 2015) Bill of Material (BOM) refers to a manufacturing part list that is a technical side of product structure (Härkönen et al. 2019). It is typically a single-level list of necessary components used by the manufacturer in assembling the product. (Saaksvuori & Immonen 2008) BOM tends to fall into two main types: Engineering Bill of Material (EBOM) and Manufacturing Bill of Material (MBOM). EBOM is the cornerstone of the designed product structure that describes 'what' the product is which is later converted into MBOM. MBOM refers to 'how' the product is produced and assembled by maintaining manufacturing interactions through the planning of production processes. (Essamlali et al. 2015)

Product structure and Bill of Material are not synonyms. BOM presents a single product breakdown structure, whereas product structure is more complex. As Saaksvuori and Immonen (2008) stated, BOM does not contain product structure, assembly or component hierarchy. Product structure can have several common structures for different purposes, such as manufacturing or maintenance. These structures can be also referred to as views of a product for different functions of a company, for example product development and sales. (Kropsu-Vehkaperä 2012) However, sometimes these two concepts are mixed and BOM may also be used when referring to a structured part list to which a hierarchy has been given. (Saaksvuori & Immonen 2008)

2.1.4 Product variant

In addition to having different products, each product of a company often has multiple variants. This is due to customers worldwide requiring personalized products. (Mortensen et al. 2010) The products contain several interchangeable and configurable components; variant is a changed physical property or subsection of a product. During the product development process, a generic structure containing possible variants is created. Individual product variant is formed during the order-delivery process, when actual physical products are created, manufactured, and delivered to customer. (Saaksvuori & Immonen 2008) Usually a customer can choose a standard product variant,

select among existing options, or require a customized product which must be designed more specifically (Lahtinen et al. 2020).

2.2 Product data

Product data refers to information related to the product. It can also be seen as a definition of a product; it is all the knowledge and know-how about the product as well as how it is designed, manufactured, supported, used and recycled. Product information is considered as a strategic resource for companies. (Stark 2015) It can be divided into three groups: data defining the product, life cycle data, and metadata. The definition data determines the physical and functional properties of the product, such as form, fit and function. The life cycle data is always connected to, not only the product itself, but also to the product's stage and order-delivery process status. The metadata can be described as information about information. It can describe for example where the data is located and who has recorded it. (Saaksvuori & Immonen 2008)

Companies have enormous amount of data that describe their products. This means for example thousands of drawings and other documents that have information about the products. (Stark 2015) Both external and internal functions of a company use and produce product data in their daily activities. This makes considering the data and related practices so vital. The internal functions include planning, design and engineering as well as procurement, production and customer service organizations. The external functions that provide data include at least collaborative partners in maintenance service, design and engineering, manufacturing and assembly. (Saaksvuori & Immonen 2008)

2.2.1 Product data ownership

Business processes are usually assigned to a process owner, but when it comes to the ownership of data, things are not that simple. It is often unclear whether certain data is owned by information process units, data management units or non-IS (information system) business units. It may also be unclear how the responsibilities should be assigned for data that go through a multi-step derivation sequence from operational systems all the way to data pools of decision support systems. (Winter & Mornar 2001) Bamford et al. (2004) state that the assignment of data ownership should improve system performance and throughput. The concept of data ownership should create a foundation for defining the roles, responsibilities and data management processes (Winter & Mornar 2001).

According to Winter and Mornar (2001), only business units of a company can be data owners because they own the operational applications managing the data as well. Therefore, the data owners can be identified by analyzing business processes. However, the once determined data owner may be changed to a new one either temporarily or permanently (Bamford et al. 2004). Data ownership has three aspects that are contents, methods and development and supply. The data owner is responsible for correct modeling, documentation and quality control of data. They are also responsible for specifying correct extraction, transformation and aggregation methods to derive relevant information from all the operational data Thirdly, they oversee development and operations of an infrastructure that provides information for decision making support. Data owners are the real sponsors of data management systems and they should use this role to guarantee that the entire data management process is aligned with their information requirements. (Winter & Mornar 2001)

2.2.2 Traditional product data issues

Stark (2015) introduces a traditional environment where each department is responsible for its performance and therefore wants to manage its own data. Even if companies have tried to deploy information solutions across departments, they have encountered significant technical and cultural roadblocks (Liu & Xu 2001). The problems of traditional environments often appear when the data is also needed by people in other departments. The easiest way to solve the issue would be to take copies and share them to everyone. However, this brings up a new, even deeper challenge: when changes are made, some of the copies will always remain unchanged. This results in errors.

Traditional environments also have other issues: finding specific data, people having to search through a lot of paper and electronic files, which obviously is pure waste of time. In addition, data entry may have originally been poorly controlled leading to misspellings and loss of data without possibility to retrieve it. Also, manual data-transformation always exposes for errors from which not all are discovered until they cause bigger problems to the product. (Stark 2015) Hence, as Saaksvuori and Immonen (2008) declare, large companies with lots of data cannot operate without effective data management.

2.2.3 Master data

Master data is standardized critical business information relating to business entities, such as product, customer or supplier. It needs to be integrated and managed enterprise-widely at strategic, tactical and operational levels. (Hannila 2019) Master data is a single source of information and should be used across the systems and business processes without changing (Silvola 2018). All transactions in an organization are always performed against master data (Hannila 2019). Companies often confuse master data to other types of data, although all the company's data is not master data. Defining the master data is a common challenge in organizations that should be fixed since master data have a significant impact on how company's products are understood within the organization. (Silvola et al. 2011)

Product Master Data (PMD) is created at the beginning of the product lifecycle while developing a new product. It is usually stored in a product data management system and then transferred to other systems afterwards. The role of PMD is to connect the systems and business processes via master data. (Hannila 2019) PMD forms a logical whole along with product data, company business processes and the enterprise applications. (Härkönen et al. 2019). It usually contains data about product's definitions, structures, classifications, change data and lifecycle status as well as configuration rules (Kropsu-Vehkaperä 2012).

One master data refers to the importance of understanding that master data should be created once. Three main elements related to one master data are data, processes and information systems. Product master data describes the product in detail, giving the DNA to each product. Product data includes models, attributes and definitions. One master data is a cleansed and rationalized version of this data. Data accuracy comes from the excellent data quality over the whole lifecycle of the product. Processes include data ownership definitions as well as procedures for cleansing, publishing, protecting and sharing of data. The final element of one master data is the information systems, such as PDM systems. (Silvola et al. 2011)

2.3 Product data management

Product Data Management (PDM) emerged in the late 1980s when engineers in the manufacturing industries recognized a need to keep track of the growing volumes of product design files generated by CAD (Computer Aided Design). (Saaksvuori &

Immonen 2008) Stark (2015) defines PDM as an activity of managing product data. Philpotts (1996) considers it as a tool that helps engineers and other employees manage data and the product development process. It is a common term encompassing all systems that are used to manage product definition information, such as Engineering Data Management (EDM) and Product Information Management (PIM).

Product data management should not be confused with product management, which includes business aspects such as marketing and introduction of new products (Peltonen 2000). PDM's main goal is to manage all information needed throughout a product's life making correct data accessible to all people and systems that have a need to use them. Product Data Management integrates and manages processes, applications and information that define products. It helps to make products profitable by orderly and efficient development, fabrication and distribution. PDM manages all product-related information including electronic documents, digital files and database records. (Philpotts 1996)

According to Philpotts (1996), companies in every industry segment that design and manufacture products can benefit from the usage of Product Data Management. He also states that the benefit is for the whole organization from chief executives to product engineers and purchasing officers. With proper implementation, the usage of PDM will result in faster work, fewer errors, less redundancy and smoother workflow for an organization (Liu & Xu 2001). Basics of data management apply when managing product data. That means defining and documenting objectives of data management, identifying and setting targets for Key Performance Indicators (KPIs), measuring and reviewing performance as well as training employees. All these actions are made to make sure things are working well and to notice what improvements could be made. (Stark 2015)

Product Lifecycle Management (PLM) is a systematic concept for managing and developing product and product related information over the whole lifecycle of the product. PDM can be seen as a subset of this boarder concept of PLM. In addition to PDM, PLM is not only about managing the product data, but it also creates the data. PLM is also making necessary, tough changes in processes, practices and methods and gaining control over product lifecycles and lifecycle processes. (Saaksvuori & Immonen 2008) PDM is a crucial element of PLM because information is all-important during the whole product lifecycle (Stark 2015).

2.3.1 Product data management system

In high-tech companies, product development would not work without computers and a wide range of applications. In practice, the applications are often discrete and poorly integrated. PDM system is the tool that links those applications together and makes sure that they fit well in support of the overall process. (Stark 2016) It integrates and manages processes, applications and information that define products across multiple systems (Siddiqui et al. 2004).

According to Stark (2015), a product data management system is a computer system that has the primary purpose of managing product data. The system keeps track of huge masses of data and information required for example to design, manufacture or build products as well as support and maintain them (Philpotts 1996). The main task of a PDM system is to provide necessary conditions for connecting separate information data systems, processes and automation islets. The system brings considerable value to companies by seamlessly integrating information from organization-wide processes. (Saaksvuori & Immonen 2008)

PDM systems are meant to provide a structure in which all types of information used to define, manufacture and support product are stored, managed and controlled. Typically, PDM is used to work with documents, digital files and database records. As PDM has its roots in the engineering aspects of product development, the systems mainly deal with engineering data as well (Peltonen 2000). Below is listed some of the types of information that a PDM system usually contains. (Stark 2015; Philpotts 1996)

- user manuals
- part definitions
- specifications
- CAD drawings
- images
- analysis models and results
- manufacturing process plans
- software components
- documents, notes and correspondence
- audio and live video annotations

- project plans
- failure reports
- disposal lists
- maintenance info
- patent reports
- hardcopy documents
- label information
- geometric models
- product configurations
- customer requirements

A PDM system is ideally an information processing system or set of systems that integrates the functions of the whole company. However, PDM systems will not cover all the information of a company: it usually does not deal with costs, prices or other financial issues (Peltonen 2000). The integration is done through connecting, integrating and controlling the company's business processes and produced product design by the means of product data. Above all it is a connecting technology instead of an individual technology islet. (Saaksvuori & Immonen 2008)

PDM systems ensure that users always get and share the most up to date information by providing data management and security. This means that in addition to product data, PDM system also manages product development process by controlling product information, states, approval processes, authorizations and other activities that impact on product data. (Philpotts 1996) The system can provide exactly right information at precisely right time. It gets information under control by making it available whenever, wherever and whoever in need. (Stark 2015)

2.3.2 Functions of a PDM system

In addition to product data management, PDM systems may have multiple other features that are listed below. (Saaksvuori & Immonen 2008; Liu & Xu 2001)

- item management
- product structure management and maintenance
- parts management

- user privilege management
- maintenance of the state or status of documents and items
- information retrieval
- change management
- configuration management
- tasks management
- file/document management
- backup management
- history/system log
- file vault

2.3.3 Benefits of a PDM system

Organizations that successfully implement PDM can achieve multiple advantages in terms of productivity and competitiveness (Liu & Xu 2001). According to Stark (2016), PDM systems help reduce lead times and costs as well as improve quality. Reduced lead times can open new market opportunities and improve profits. They also reduce market risk by reducing the time between product's specification and delivery. The usage of PDM will also improve development productivity due for example better resource assignment.

According to Härkönen et al. (2019), in the companies that do not use PDM systems the technical structures of products may have more inconsistencies. A PDM system collects many kinds of information on the daily operations of a manufacturing company, such as the number of changes made to a certain product or assembly. This information is valuable for developing the whole supply chain of the company. The system generates reports based on the information in the database. These reports can be used as a support for the company's decision-making. (Saaksvuori & Immonen 2008)

Siddiqui et al. (2004) summarize the benefits of PDM systems to improved effectiveness for users, improved collaboration among users, improved change management, faster time-to-market, better product quality and improved speed and flexibility. Liu and Xu (2001) have distributed the benefits of PDM systems to six paragraphs as follows:

Interdisciplinary collaboration. At the earliest stages of product definition PDM system can help marketers, designers and project planners in defining a way in which they will

collaborate and identify the relationships between the new product and range of earlier products and others currently in production. The usage of system can lead to collaborative development of new products as well as improvements on existing products.

Reduced product development cycle time. Due to the increased collaboration with all areas of an organization and the easy access to product information, the product development time can be reduced meaningfully. This enables organizations to respond to the market with better effectiveness and consistently provide their customers new and initiative products.

Reduced complexity of accessing information of a company. When properly implemented, PDM system can simplify many daily user operations by managing and automating routine tasks, such as searching for drawings, tracking approvals and completing status reports. This improvement significantly decreases the user's non-value-added time.

Improved project management. Project management is made easier by PDM system due to all those involved in the project have access to the same information and can work with a common product model. A PDM system also allows project managers to track the progress of a project more effectively and therefore make sure that the work being carried out is correct, on schedule and on target.

Improved life cycle design. The easy access to information on new product development help organizations to use "design for X" philosophy. It allows manufacturing staff and production engineers to access design data at a much earlier stage of the product development and therefore making it easier to identify problems earlier as well.

Supply chain collaboration. PDM systems are considered to have a strong impact on supply chain relationships by linking subcontractors, vendors, consultants, partners and customers by giving them access to the same information. The systems can also act as a data store for both internally developed parts as well as external parts available from suppliers. By utilizing a PDM system and its database of existing parts, a designer can avoid duplicating work which leads to reduction of development time and cost.

2.3.4 Financial savings enabled by a PDM system

Before the implementation project, it would be necessary to estimate how much money the system will generate and how much it will save (Stark 2015). On the other hand, Saaksvuori and Immonen (2008) state that it is difficult to convert the benefits of a PDM system directly into euros. Also, a study made by Siddiqui et al. (2004) shows that it is challenging to produce a cost-benefit analysis, as there are many factors that contribute to the cost of a PDM and these cannot be represented in a simple cost benefit analysis. Olson (2003) points out that it is impossible to place a direct value on accurate data, since the costs come from the inaccurate data. An organization cannot know what impact the data management system will have; they just know that without it they will lose money.

According to Siddiqui et al. (2004) up to eighty-nine per cent of respondents to a survey by Tackbrook Consulting considered that PDM provided good return on investment. The advantages received from a deployment of a PDM system can be divided into two different forms: the savings achieved in operations and the new and increased earnings possibilities of the business. The savings come basically from intensification of the operative operation and the decrease in expenses and working capital. (Saaksvuori & Immonen 2008) As Stark (2019) states, the real-time data availability that a PDM system provides saves big money by a considerable reduction in wrong decisions and operations. This ultimately removes the reject work and rework costs, which furthermore improves the production development and production costs.

One of the most typical costs of poor data management is the cost of rework (Olson 2003). A Coopers & Lybrand study has shown that quite a small part (29%) of the working time of an engineer is used in planning and designing. Up to 24% of the time is used for information shearing and retrieval. Additionally, even 20% of the working time is spent redoing things that have already been done. This is due to the difficulty of finding the work that was done earlier. (Saaksvuori & Immonen 2008) This is illustrated in figure 3.

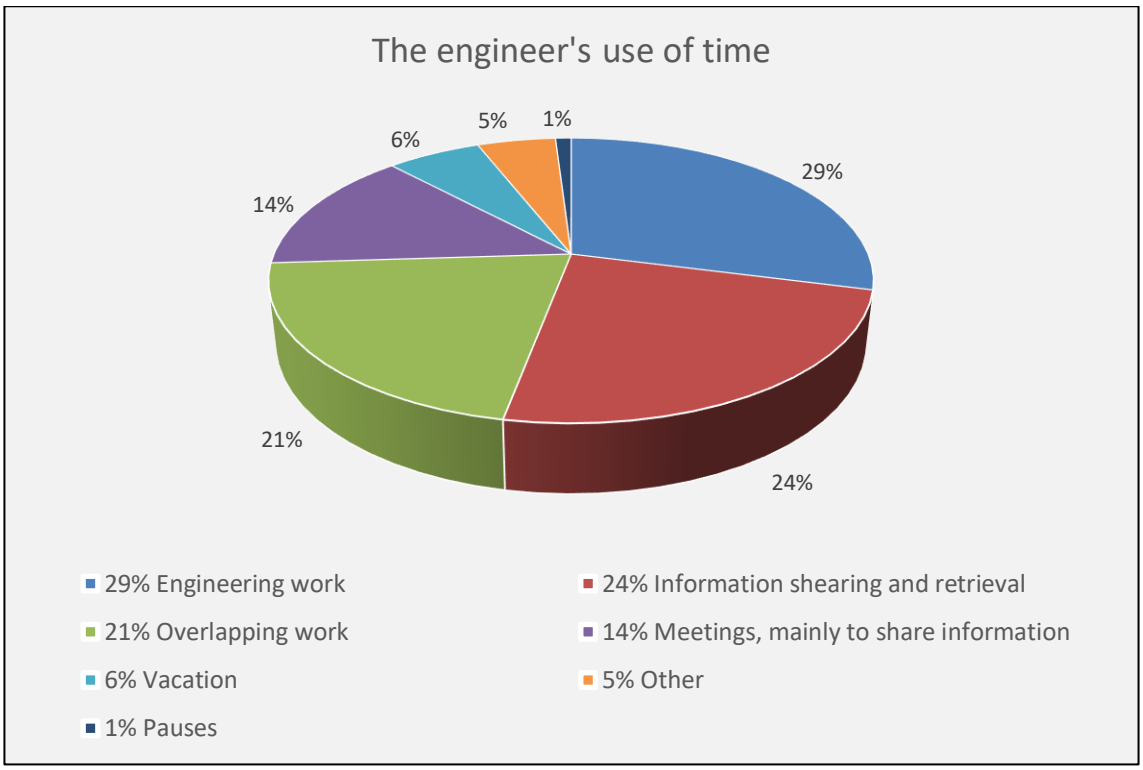

Figure 3. The engineer's use of time.

Problems with products can cost a lot of money for a company. Many of these problems can be overcame with the usage of a PDM system. (Stark 2015) Without data quality assurance, data is certain to have inaccuracies that are very costly to an organization (Olson 2003). According to Saaksvuori and Immonen (2008), the savings gained by the company from the usage of a PDM system can be divided into three categories: saving time, improvement in quality and reduction of tied-up capital.

Timesaving can be seen via less time used for defining product structures, decreasing amount of overlapping work, part lists being available to everyone, fever corrections to information necessary and quicker retrieval of historical information. Quality improvements are achieved through electronical acceptance and release of changes in documents, less faulty distribution of change information, records and test results being connected to a product, standards being reachable for everybody, information security improvement and increase in flexibility of operations. Tied-up capital is reduced by the reduction on number of different items and smaller component stock due clearer product structure. (Saaksvuori & Immonen 2008) Olson (2003) counts the money savings to come also from eliminating following issues caused by poor data management: cost of lost

customers, cost of late reporting and cost of wrong decisions. Counting all the costs mentioned in this paragraph can help to estimate the money savings received from the deployment of a PDM system. In addition, other costs probably exist but have not been identified.

2.3.5 Challenges of a PDM system

Several tools such as CAD are used to create product data. The data is also stored and utilized by different systems like ERP (Enterprise Resource Planning) and other operational tools. (Kropsu-Vehkaperä 2012) This is why the role of PDM in an organization may be vague. It can be difficult to organize where different functions and pieces of data should be controlled. Some companies may have for example technical structures in ERP system, even though they are utilizing PDM as well. (Härkönen et al. 2019)

IT landscape and its requirements are not identical between different companies. Therefore, the roles of different data in an organization must be understood before implementing a PDM system. Also, the products and related logical product structures should be well productized. The executives must share common understanding of the company products. Without this, the related data assets cannot be consistently combined, analyzed and reported in a PDM system. (Hannila 2019) Kropsu-Vehkaperä et al. (2009) state that because a PDM system creates the basis for interlinking product information, without common definition and understanding of product structure the whole development of a PDM system may be impossible.

If the application integration is done poorly, it can cause needs for manual data entry and transfer. Too much data managed outside the PDM system may also create many problems (Stark 2016). This leads to information being stored in different forms in different data systems, which further blurs the correctness of data. (Kropsu-Vehkaperä 2012) The PDM system as well as other IT systems of the company should support data flows effortlessly and fluently, or they may become worthless. Also, the data must be governed company-wide instead of isolating them from each other; otherwise it would lead to siloed data, inconsistencies and wasted resources. (Hannila 2019)

Implementing a PDM system to a company has different kinds of costs that must be considered. The costs start running from the creation of a project team, which needs usual

resources such as computers, training and administration support. Additional costs are incurred by people outside the project team for example to participate in issues discussions, reviews and interviews. The real costs come from the implementation of a PDM system itself which includes for example license costs (Stark 2019). The implementation costs can be high because in addition to system itself it may involve application renovation or modification of existing applications. Yet another cost to consider is the cost of disruption of operational systems, which can go up to tens of thousands. (Olson 2003)

Another challenge for implementing a PDM system is people. Many people from across the organization will be expected to change their working habits. (Stark 2015) Instead of their daily tasks, they must concentrate on becoming familiar with the new system (Liu & Xu 2001). Typically, organizations may have difficulties if their employees are not adoptive enough, do not learn new skills or have a slow response to new technologies. Because all these are needed to be able to deploy the new system to a company, the lack of empowered and disciplined employees may become an obstacle of successful implementation project. (Stark 2016)

2.4 Implementation of a PDM system

Traditionally, many companies have developed their own PDM tools. The commercial tools available were too expensive, difficult to use and inflexible with inadequate functionality. The situation changed during 1990s as new PDM tools appeared on the market with more acceptable prices and improved functions. Nowadays, most companies have not built their PDM tools by themselves. (Crnkovic et al. 2003) When the system is not generated by the company itself, a designed implementation project is in place to avoid problems (Stark 2016).

According to Crnkovic et al. (2003) the integration process of a PDM tool can be divided into two phases:

1. Tool evaluation: to find and select the most appropriate tool
2. Tool deployment: to introduce the tool in the everyday process

This thesis will concentrate on the second part of the process.

Tool deployment is a separate phase of integration process that is performed as a separate project. The final goal is a successful use of the tool in everyday work. As the organization deploying a PDM system is usually not familiar with the tool, it might consider including usage of consultants to assist in the development process. Consultants can provide much-needed expertise but on the other hand they add costs and may even inhibit the team from finding its own way forward. (Crnkovic et al. 2003) Regarding to Nilakant and Ramnarayan (2006) the solutions to organizations' problems cannot be found outside the organizations. An organization must have the capability to solve its own issues.

Having a commercial PDM tool does not mean that a company has started to use the tool directly. The systems support many activities and therefore are seldom implemented in one single tool with precisely recognized purpose. Often additional support must be provided to ensure the adjusting to processes of the company. This can be done for example by tailoring the tools. The PDM support is provided in the form of a collection of different tools that are rather different. The tools are used by different categories of users, are different size and manage different types of data. The systems are made complex by the heterogeneous characteristics of the systems as well as the involvement of many different roles in their use. (Crnkovic et al. 2003) In addition to technical aspects of PDM systems, there are even more important issues to be considered (Peltonen 2000).

Once implemented, a PDM tool is seldom replaced. For this reason, the implementation project into the organization is extremely important. According to Siddiqui et al. (2004), getting the implementation project right is the key that will make the system succeed or fail. If the integration process is not managed in a systematic way with clear goals, the process may result in financial disaster with decreased development and production efficiency. Furthermore, the failure in the implementation and the lack of understanding over the tool will lead to frustrated employees as well as delayed and low-quality products. (Crnkovic et al. 2003) To achieve the PDM vision, a strategy needs to be developed. The implementation strategy shows how resources will be organized to execute the change from today's environment to the desirable one in the future. Implementation strategy will be developed for a similar period as the system vision and may then be reviewed annually. The implementation strategy is the starting point for developing the implementation plan. (Stark 2016)

2.4.1 Challenges of implementation

Implementation of a PDM system and especially getting noticeable benefits from it is not an easy task. Users often have to undergo a long learning curve when a new PDM system is implemented. (Liu & Xu 2001) The implementation is likely to be faced by people who do not want to change the status quo. To prepare for reluctant people, anyone who wants to implement PDM needs to be well-armed with good reasons. There are many generic reasons for implementing PDM systems in companies. However, the specific reasons are different for each company and therefore it is important to understand what is specific about their use of PDM. In addition to people, the implementation project may face issues with system itself, project team, process, organizational structure, funding, information, installation and everyday usage. (Stark 2016)

There are many issues that may cause difficulties in the implementation project (Hameri & Nihtilä 1998). At first, the system is cross-functional. It does not belong to any of functional departments and therefore may not be obvious which practices should be followed in addressing it. Secondly, the financial part may be unclear, for example which department should pay the cost. Also, the cost-calculations may easily be over-optimistic. Thirdly, the targets set for the implementation and usage of a PDM system may be unattainable. (Stark 2016) The desired results may also leave unachieved if the focus is solely on technology and not business strategy (Hameri & Nihtilä 1998).

The deployment of a complex tool is difficult to perform in one step. It involves both process and infrastructure changes. In addition, changes in the information architecture such as data structures must be specified, and the data migration performed. The new system may not immediately function 100% at the organization's environment. There may be problems in the interfaces between the PDM system and other applications used in the company (Stark 2016). The new tool requires education and training of the personnel, often best performed in smaller groups. It may be wise to first train users and then deploy the system gradually. (Crnkovic et al. 2003)

2.4.2 Best practices of implementation

Implementation of a PDM system is not an easy task. A Carelessly prepared project would carry a great risk of failure (Saaksvuori & Immonen 2008). Because the system is cross-functional, costly and long-term, the first requisite is to have top management's full

support. According to Stark (2015), without it the whole project will fail. Top management should define the objective of the project as well as give authority to the PDM project leader. The second requisite is to understand the starting position for the project, which means the current situation in the company. Without knowing the current situation, it would be impossible to know what requirements there are for the PDM system. (Stark 2015)

The business objectives for the PDM system and implementation project should be clear before the project itself. Everyone must clearly see the reasons for creating the system as well (Saaksvuori & Immonen 2008). This would provide the implementation project team a clear business focus and therefore help them greatly. The objectives are given by top management or developed by the project group. They should answer to questions such as what the system should achieve for the company and how will project success be measured. The objectives should have clear targets set. (Stark 2015)

The goal of founding out the business objectives is to clarify the business vision, organizational structures and functions of business units (Chen & Tsao 1998). In addition to knowing the current situation, it should also be documented. Each activity should be described in the scope of the project including its objective and position in the product lifecycle. The different structures of product data, such as BOMs and part lists should be identified as well as the users of product data. To be able to describe the current situations, the following issues should be clarified (Stark 2015):

- The scope of the product data that the PDM system should manage
- Creators and users of product data
- Activities creating and using the product data
- PLM applications that create and use the product data
- Systems currently managing the product data
- Equipment used for PLM applications
- Equipment used for systems that manage product data
- Product data organizing and management
- Product data release and change
- Product data communication

2.4.3 Change management

The organizations confront a world that is challenging in many ways. The only certain thing in this changing world is that you cannot escape the change. Change management focuses on why and how organizations change. Organizational change involves changing the routines of an organization. (Nilakant & Ramnarayan 2006) The implementation plan created for PDM deployment must match with the organization's ability to change (Hameri & Nihtilä 1998).

At the worst case, an implementation project wastes a lot of effort and money, but the result will meet no one's expectations (Stark 2019). A study made by Siddiqui et al. (2004) shows that the difficulties faced in the implementation of a PDM system have usually nothing to do with the system itself. Most of the problems were clustered around change management. Especially big problem was the involvement of senior management. Key themes were the lack of buy-in from both users and senior management and the difficulty in changing the working practices. The importance of having senior management involved comes from the fact that it reduces the resistance to change by users as well; it demonstrates that the senior management are familiar with the subject and taking it seriously to make it work.

The key to successful deployment of a PDM system is to make sure that management understand all the implications of the rollout as well as the impact on the design teams. The senior management can show their support for example by communicating their view about the PDM system and being personally involved in the implementation project. The buy-in of users must be gotten before they start to use the system. Other key issues of a success are appropriate training delivered at the right time and the need for user-friendly systems. (Siddiqui et al. 2004) It is important that the new tool does not introduce complexity into the company's processes and the services are accessible in a smooth way (Crnkovic et al. 2003).

According to Nilakant and Ramnarayan (2006) change management is mostly about changing people's mindsets. A mindset includes certain assumptions, values and beliefs. A paper written by Moon (2009) introduces the importance of common sense in the change management. A crucial task in leading change is to make the rationales for change initiatives seem like common sense to as many stakeholders of the organization as

possible. It is imperative that the one operating the change is in touch with the key stakeholders of the organization to constantly assess their perceptions.

Change management in organization requires engagement and connection with the employees whose mental models need to change (Nilakant & Ramnarayan 2006). While developing the team for implementation project, it is important to have someone who can sell the system to users and at the same time relates to the people in the business. It is someone who has technical ability and therefore understands the needs of the server. (Siddiqui et al. 2004) Reduced ambivalence about the planned change is not a determinant of buy-in, but it may increase the degree of buy-in among stakeholders. The greater the extent to which genuine buy-in and motivation can be generated for a planned change, the better the chances for successful and sustainable change. (Moon 2009)

There are different models and tools for change management. Kotter (1996) introduces an eight-stage process. Those eight changes are: establishing a sense of urgency, creating the guiding coalition, developing a vision and strategy, communicating the change vision, empowering employees for broad-based action, generating short-term wins, consolidating gains and producing more and anchoring new approaches in the culture. The process is illustrated in the figure 4.

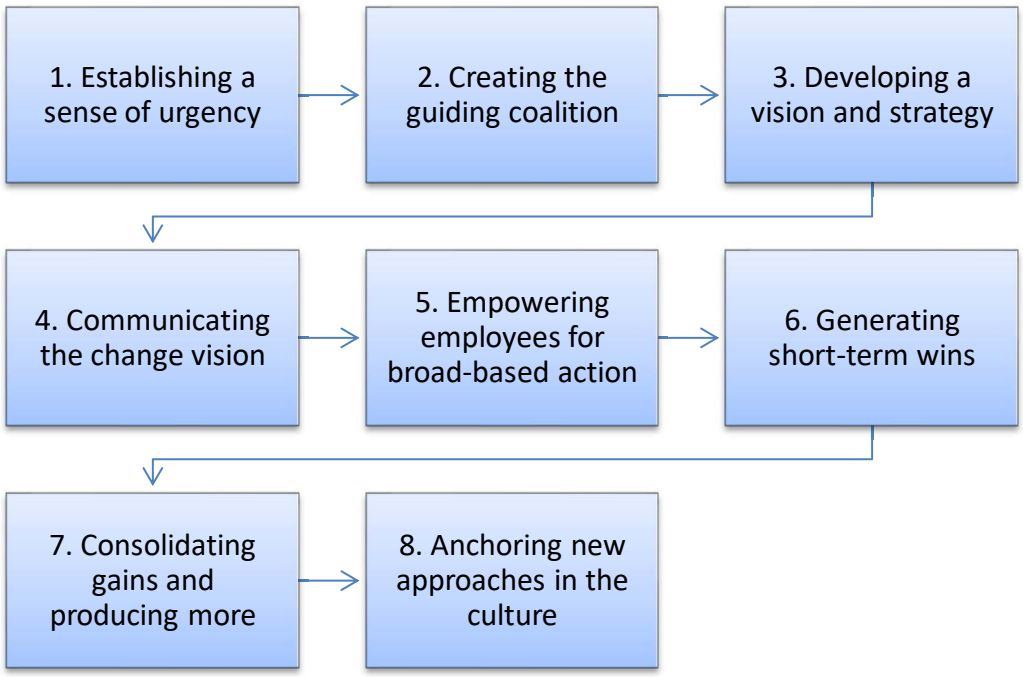

Figure 4. The Kotter's Eight-Stage Process.

2.5 Synthesis of the literature review

The base of product data management is the definition of product, or company products in general. At the beginning of the product lifecycle during the product creation a lot of data is generated. The data contains information for example on the product structure and BOM. The consistency of this information in terms of logic is one of the keys for effective data practices also during the later lifecycle stages. When changes are made to a product during its lifecycle, it is extremely important that the data will also stay up to date across the whole organization.

Product data management is initiated to manage this huge mass of data. From the enormous amount of information, it is crucial for companies to understand what their master data is, and where it should be stored and managed. The master data connects the IT and the business processes and helps to avoid a multitude of challenges and unnecessary work, when of good quality. Also, the ownerships of the data must be clarified before implementing a PDM system. Figure 5 illustrates where the product data management resides in the context of company business processes.

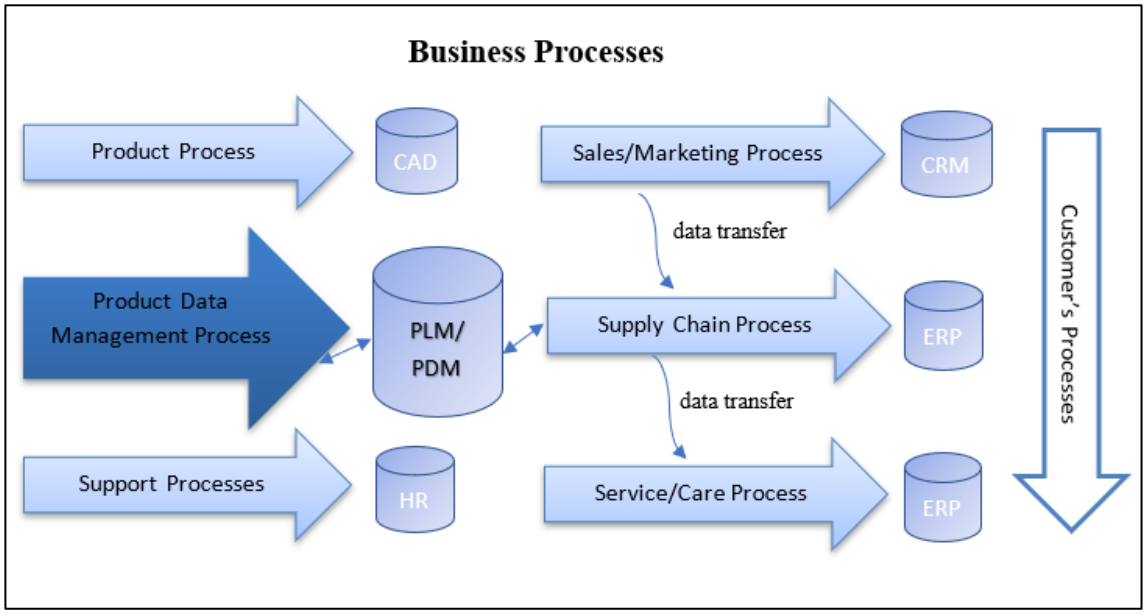

Figure 5. Product Data Management in context of Business Processes.

A product data management system is a computer system used to store and manage the data. From successful deployment of a PDM system, a company can benefit in the form

of reduced lead times, improved quality, and improved profits. The right use of a PDM system will save the employees' time by reducing the need of information-seeking, which ultimately saves companies' resources and money.

However, the implementation of a PDM system is not easy and will use lots of company's resources. For this reason, the implementation project must be planned carefully beforehand including implementation visions, objectives and strategies. The right tool with suitable functions must be found and modified to face the needs of the company.

The key issue in the deployment phase of the implementation project is to create buy-in for the users. Because they may need to change some of their daily working habits, they need to understand the importance of the new system. This change necessitates proper change management and is mostly done via proper engagement by the top management. Without the full support of the management, the entire implementation project may fail. Appropriate training at the right time is also in high importance in the successful deployment process.

3 CURRENT STATE ANALYSIS

This section of the thesis contains analysis on the current state of Haltian in terms of product data management and data flow in the business processes. Research methods are introduced first, followed by the case company introduction, materials used, and finally the analyses as well as the synthesis of the current state analyses.

3.1 Research methods

Results of research are all around us in our daily lives; one can learn about them through radio, television and newspapers. Different kinds of studies follow methods that support the wanted outcome. (Saunders et al. 2009) Research methodology is the philosophy behind all research. It examines how people know what they know and allows to understand the constraints placed upon the concept of what knowledge actually is. It also allows to understand the different ways of creating knowledge. (Adams et al. 2014)

There are two main domains of research: quantitative and qualitative (Adams et al. 2014). In quantitative research the focus is on describing, explaining and predicting, whereas qualitative research aims to understand and interpret the topic. The quantitative research is meant to predict matters, build theories based on the predictions and lastly test the theories. Qualitative research tries to form more in-depth understanding and build theories based on it. (Schindler 2019) Because of the nature and aims of this thesis, qualitative research method is used. Qualitative research methodologies have roots in variety of different disciplines, such as psychology and economics. They are designed to tell the researcher how (process) and why (meaning) things occur as they do. (Schindler 2019) Qualitative data analysis procedure allows to develop theory from qualitative data. Qualitative data refers to all non-numeric data or data that have not been quantified. It is based on meanings expressed through words. The type of data is non-standardized data requiring classification into categories and the analysis is conducted using conceptualization. (Saunders et al. 2009)

The research strategy used in this thesis is a single case study which includes different data collection techniques such as interviews, discussions and documents. This is typical for qualitative research as qualitative data can be found in many forms. Therefore, the methodology of this thesis is qualitative. There are two research approaches as well:

deductive and inductive. In deductive approach, a clear theoretical position is developed prior to the collection of data, while in inductive approach the theory is developed after the collection of data. The research approach of this thesis is inductive, as the collection of data is a base for building theories. (Saunders et al. 2009)

3.1.1 Materials used

The current state analysis is mostly based on interviews held by consultants. The consultants prepared lists of questions that helped them to understand the whole business and the information creation process of Haltian. In addition to the top management of the firm, employees and managers representing following areas were interviewed:

- Product management
- Mechanics
- Electronics
- Software
- Operations
- Sourcing
- Manufacturing/testing

For most of these interviews, there were one or two Haltian employees attending at once. Depending on the number of employees interviewed, the interviews took 1-1,5 hours each and they were held over two weeks. The interviewed employees were decided together with the consultants to cover the most crucial tasks in the order-delivery process in terms of data flow. On the request of consultants, interviews about sourcing and manufacturing were added afterwards to form more comprehensive picture of the whole data process in views of both data creators as well as the receivers. To complement gaps or shortages left from the interviews, the consultants asked a few clarifying questions via email.

Before the actual interviews, the selected interviewees were asked to answer to a short questionnaire about their working habits in terms of data management. This helped the consultants to prepare for the interviews as well as to form an understanding on the current state of data management procedures of Haltian. The answers from the questionnaire were composed into a graph that is used also in this thesis to illustrate the views of the employees about their data management process.

During the interviews, the questions as well as the answers were written down and the notes were used as a basis for the current state analysis. This is supplemented with the analysis composed by the consultants to build a comprehensive analysis with as different views as possible to consider the current state. Therefore, the analysis is supported by the views of top management and individual employees, consultants' analysis, and own observations in the company.

Additional information is gained from different kinds of meetings, informal discussions, emails, and documents to support the current state analysis. The analysis utilizes the work of consultants as a base but goes further with more in-depth observations inside the company. These are gained during the months of working in the company, attending lots of meetings and having multiple conversations with different employees about their views of product data management related issues.

The information about Teamcenter and different licenses used for suggestions are gained via materials, explanations and an offer gained from the consultants. More detailed knowledge about the functions of Teamcenter is gotten from introduction videos made by both Siemens Digital Industries Software and the consultants both representing Teamcenter Rapid Start. This knowledge is complimented with the web pages of Teamcenter.

3.1.2 Questionnaire about data processes

The consultants organized an online questionnaire before the interviews to all the attending employees. The attendees were asked questions in four categories: process, people, technology, and data. The answers were condensed into the figure 6. It shows that Haltian employees are committed to processes, systems and methods in their work and recognize the critical data. On the other hand, it is not clear to them who owns the processes and data they are working with. The biggest deficiency was in the knowledge of key performance indicators that link to the processes. The employees also seem to perceive that they are not using many systems in their work and lot of the work related to data is conducted manually instead of automatically.

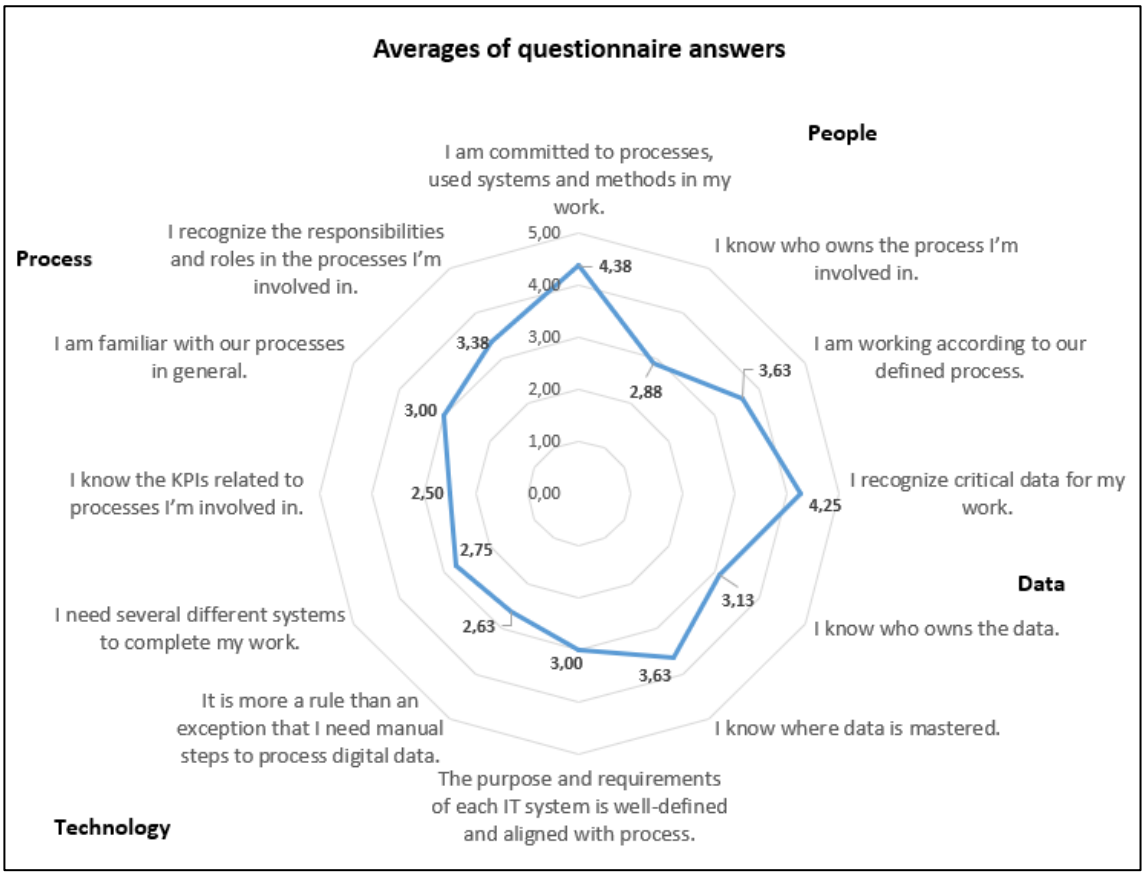

Figure 6. Averages of questionnaire answers.

3.2 Case company

The case company studied in this thesis is Haltian Oy. It is founded by former Nokia-employees in 2012 and the headquarters lie in Oulu, Finland. Haltian is operating in the industry of planning and manufacturing devices and software. It has about 75 employees of which most are working in the Oulu office. There are about 25 employees working with SW and 20 in HW. Sales and marketing team has little over 10 employees and another 10 are working in supply chain operations. In addition, there are employees working in various functions such as top management, project management, finance, and human resources.

The turnover of the year 2019 was 6,4 M€ whereas operating loss was 2,9 M€. Therefore, it can be said that Haltian is in investing phase but is trying to get the operations to profit during the coming years. In addition, Haltian is aiming for a rapid growth during next a few years, which needs scalability. To be able to achieve this, they need to have their IT systems and processes in good order, and ready for scalability.

Haltian has specialized in two different sectors: product development services (PDS) and Internet of Things (IoT). New product development services are offered to other companies who have an idea of a product. Haltian helps the companies in planning and designing the product and finding the right technology components all the way to mass production. Haltian can offer their expertise for example in mechanical and industrial designing. The most remarkable customer reference in the PDS-side is Oura with its sleep tracker and wellness rings.

On the IoT side Haltian has its own products, which offer a scalable, secure and cost-efficient IoT solution platform for businesses. The product family is known as Thingsee. The product family is based on the Thingsee solution platform which is fully built and maintained by Haltian. The product family offers devices, cloud services and end-user applications. There are three main business segments where Haltian's IoT side operates on: Smart Washrooms, Smart Facilities and Smart Factories, but in addition it delivers customized IoT solutions to any kind of businesses. The greatest customer references on the IoT side are Posti, Lindström, Tieto and Fingrid.

Thingsee Wireless devices work with Wirepas Mesh or Bluetooth LE connectivity. At the moment there are following sensors on the market: Distance, Presence, Environment, Environment Rugged, Angle and Coin-sized wireless activity tracker. To connect these sensors, Haltian offers Thingsee Gateways: Gateway LAN and Gateway Cellular. In addition, Haltian is developing new devices all the time and at this very moment it has several new sensors and one gateway under development ready to be launched in 2020 and 2021. Haltian has its own prototype-factory that produces and delivers small quantities of products to customers. Bigger volumes are manufactured by a sub-contractor in Finland. Haltian also has another manufacturer in Europe which could be used for larger scale production.

In addition to having separate PDS and IoT sides of the firm, Haltian has a few different business models for income from the IoT devices. They can sell the devices to customers and offer maintenance separately, or offer a leasing-model where Haltian charges a monthly fee which includes the rental of sensors and other services that Haltian provides. Third income from the IoT side comes from the customization-work for devices, which is charged from the customer. In the future there can be an additional business model for having the HW part of the device from a third party and combining it with Haltian's

firmware. Haltian is focusing on the sales for other companies and is not planning to go into direct consumer sales.

3.3 Analyses on the current state

3.3.1 Data flows in business processes

Because of the nature of having both PDS and IoT sides in one company, the business processes of Haltian vary. In the PDS projects as well as in the development projects of new IoT devices there are often conceptual phases needed. If new customers are ordering small amounts of IoT sensors for test usage, a starter kit is manufactured in the own production in the Haltian premises. These are certain basic models of sensors that do not need configuration or conceptual phase. The bigger amounts are usually manufactured by a sub-contractor. However, often the customer wants to have some configurations to the sensors. Then a conceptual phase is needed and the entire order-supply process takes more time and labor. All the different types of product development and manufacturing need different kinds of procedures that vary in length as well as in complexity.

No ERP systems are used in Haltian. The flow of processes and responsibilities are not crystal clear in the company either. This was visible in the interviews, as employees from different departments sometimes spoke opposite things about same tasks. Interviewees told that “strategy and consistency are missing from doing”; one interviewee even called order-delivery process as “wild west process”. This means that there are lots of processes to be improved as well as responsibilities to be clarified. In the interviews, the employees were asked questions to find out which the inputs and outputs of data in their work are and to be able to form a bigger picture of the data flows. In this section, the current state of data flows in business processes are analyzed.

The business processes of Haltian start from the sales. The company has own sales teams for both PDS and IoT sides. After being in touch with a customer, the sales introduces the customer needs to a product manager or R&D side of the firm, which includes designers from HW and SW. Usually the customer needs are documented in a PowerPoint document which is sent by the customer straight to HW via email. The role of the product manager is to form a clear product specification which includes information about the product, for example what kind of a sensor is needed, and what is the size and the color. It is an important document for HW so they can provide the right designs. The

specification is a Word file that is shared in Teams to most important project managers. This stage of the product development can be seen as a conceptual phase, where R&D examines how the customer needs could be faced via technology and then provide the customer an estimation about the financial costs.

After a conceptual phase, a kick-off meeting is held with a product manager, project manager, sales representative and HW/SW designers needed in the project. The aim of the meeting is to get everyone on the same page about the soon-starting project. After this the project team will start developing the product. The stage of development is called a productization phase and preferably it would have the same employees involved that were originally in the conceptual phase. This is however not always possible due to a possible timespan between these two phases and therefore a carefully documented conceptual phase would be a necessity to guarantee flawless data flow between the phases.

During the productization phase, HW designers are creating 2D and 3D mechanical designs in SolidWorks (CAD) as well as printed circuit board with the relative components in Altium (E-CAD). Both mechanical and electronical BOMs are created based on these designs. Updating the BOMs later are found laborious because all the changing and checking work must be conducted manually.

Whereas HW designers get the customer needs from product specification, SW gets their information from task management program Jira. It is used to identify the tasks and requirements of customer orders in the IoT products. When the product gets to supply chain and manufacturing phase after productization, the last process phases on that side are definition, variant creation, manufacturing, testing and delivery. These tasks have their own designated employees that are responsible for conducting the phase. In addition to Jira, they get the needed information through meetings and emails. They do not have access to projects' network drives. After the delivery, last phase of the whole supply chain process is invoicing that is composed from the work hours and purchasing bills of the project.

The summary of data flows in business processes is illustrated in the figure 7. It simplifies how the product data flows through three main business processes of Haltian and in which formats. It shows where the data is stored as well. It must be noted that this is the big picture and often the information may be stored in different locations, such as the personal computer of an individual designer. Therefore, in the current system of Haltian, one

cannot ever be sure if the information needed is truly in the locations assigned in this figure.

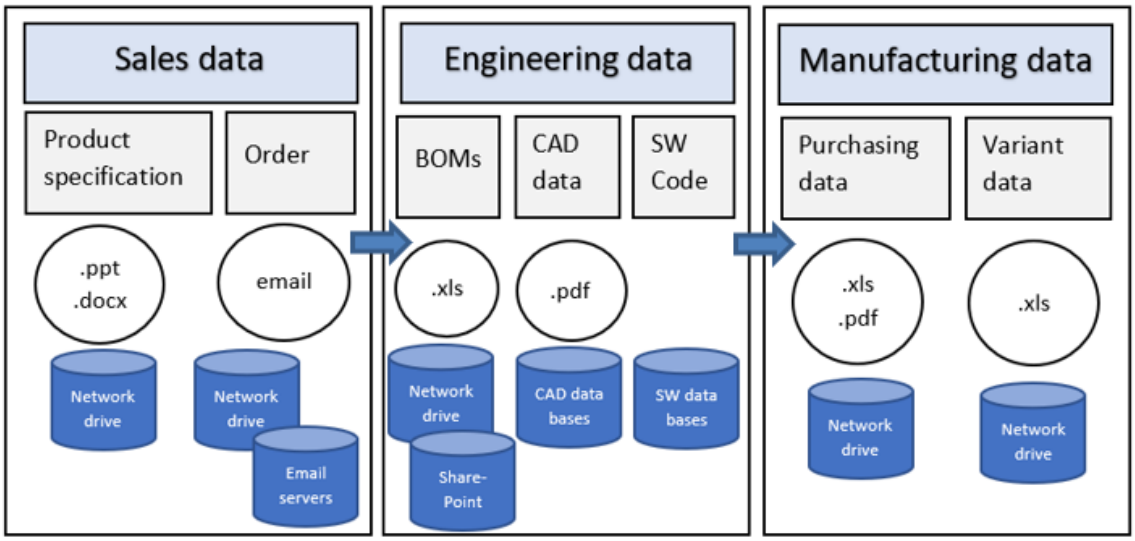

Figure 7. Data flows in business processes of Haltian.

3.3.2 Product master data

In the interviews, all the employees were asked about the inputs of data they need in their work. From the answers can be combined an idea of what is the product master data in Haltian. The flow of PMD starts from the sales data: the customer order comes via email or as a form of a Jira task. Based on the order, the customer requirements are usually described in the product specification, which is an important input for example HW designers that create the product structure. Both mechanics and electronics designers bring valuable information for sourcing about the components and materials to be ordered.

From the engineering work different EBOMs are created and further combined to one MBOM that include all the components and product structure levels all the way to the sales package. Those combined with 2D and 3D design pictures as well as printed circuit board layout information form a product structure, which is crucial information to manufacturing. The physical product structure is complemented with SW code created in the SW environments. Based on the customer requirements got from the Jira task, the product's variant data is usually created before manufacturing. The product ID is formed during the production. Those are needed in the delivery process, where the information

about customer deliveries are created for invoicing. In table 1 is composed the PMD that different stakeholders need in their work in Haltian.

Table 1. Product master data for different stakeholders in Haltian.

Role of a stakeholder	Product master data
Product management	-Customer order & requirements
Electrical engineering	-Specification
Mechanical engineering	-Customer requirements -Specification
SW design	-Customer requirements -Specification
Sourcing	-EBOM -CAD designs
Operations	-Customer order - EBOM
Manufacturing/testing	-Customer order -MBOM -Variant data

3.3.3 Manual data entry, storage & management

Haltian does not currently have any company wide PDM systems in use but they are performing all product data entry, storing and management manually. In addition to the lack of comprehensive product data management tool, Haltian does not have any systems for version control either. The company has one PDM which is integrated from a designing tool, but it is only used for storing the 2D- and 3D-designs generated from the tool, and other data related to the products are stored elsewhere. The product data stored

in this existing PDM is not widely managed there and the system is lacking version control dimensions as well.

Currently a big part of product data is being created and stored in Excel sheets. For example, all the BOMs are in Excels which are stored, changed, and distributed manually. This manual way of data management is not only time consuming but extremely risky as well. It would only take one oblivion or sloppiness of one person and the data would disappear or be incorrect. This would leave someone uninformed or with outdated information. In this current manual way of working there is too much room and possibilities for mistakes. The interviewees seem to be surprised about the fact that they have not yet faced any massive troubles caused by this lack of automated processes and clear structures for data management.

Introducing a PDM system has been discussed at Haltian for a few years now. Some interviewees say that they should have taken a PDM system in use already some years ago. Most of them seem to think that it is hard to know when the right time for implementation is, but now would be a good time before the numbers of products and active devices become too big. People seem to be fed up with the amount of work that manual data management and continuous information seeking is currently causing. They acknowledge that for example “manual coding of components holds risks”. Considering all this, the employees of Haltian are ready for the new system, and ready to face the changes it will necessitate in the daily working habits.

3.3.4 Incoherent data requirements

In addition to manual data management, processes around the product data are not currently in their best shape. There are no clear enough guidelines, for example for what needs to be taken into consideration when creating new data. The ways of documenting new data vary a lot between designers. Therefore, there may be big variation in the forms and amounts of data; the designers may enter data in diverse ways as well as to different places. Some may write down the properties extremely precisely whereas others enter as little information as possible. This makes it harder for other stakeholders or designers in later phases to find and make use of the data.

Currently there is a profile card in the current design tool for every product where the mechanical designer should fill in the relative information, such as product code.

However, filling in this data is not necessary and therefore not every designer does that. The interviewees felt that a clear requirements and rules for data creation would be needed to form a coherent way of documentation which would further ensure better data accuracy and attainability.

According to the interviews, not all designers are on the map with regards to all the processes and capabilities of current systems, when it comes to managing the created data. For example, in the case of mechanical BOM, it is mainly being built manually by designers even if it could be exported straight from the system. This is also due to the lack of filling in the profile cards in the first place. Therefore, the usage of current systems seems to be versatile and more clear guidelines and requirements for data creation are needed.

3.3.5 Fragmented data

Haltian uses multiple different locations for storing and sharing their product data, which leads to the product data being fragmented. The data is stored for example in SharePoint, Teams, design tools, process management tools, network drives, emails, and individual employees' personal computers. In addition to enormous number of different storing locations, the data is in multiple forms as well, for example Excel, PDF, PowerPoint, and Word documents.

All product development projects are distributed to own project files in one design tool's own PDM system. However, even in this PDM there is only a tiny part of the project's information stored, which basically means the 2D and 3D designs created in that tool relate to a certain project. Other documents related to the same project, such as PDF files and PowerPoint presentations, including product specifications and other designs are stored in the projects' network drive. The interviewees, however, did not reveal why this kind of a method of having multiple different data storing locations has been selected. People outside the project team do not have access to the PDM system nor the network drive to see the project data. The network drive is meant to be the main storing location for project data, but only the employees in that project have the rights to view the data, which leads other stakeholders such as manufacturing being left without access to the relevant information.

The fragmentation of data leads to many issues. Almost every interviewed employee said that they need to use a big part of their working time for seeking information; they estimated it to take about 10-20 per cent of their daily working hours. One employee told that "1-1,5 hours is used daily just for searching the information". This is mainly because the data is stored in multiple different locations, which weakens the traceability of data. It takes excessive amount of time to search through multiple different tools, files and emails compared to a PDM system where all the data would be available in one location. The current situation is caused by not only the lack of access to project's network drive, but also the fact that for example product designs and BOMs are stored in different locations.

Sometimes the employee seeking for information does not even know where the data should be found, or most likely they do not have the rights to view the data even if they knew where to find it. Then it takes extra time to first query, who is responsible of the data and second, find out where to find the data, or get someone to provide the data. This wastes the time of not only for the information-seeker, but also the designer who has to respond to inquiries and share the data. This kind of information-seeking is pure waste of time for both stakeholders.

In addition to the difficulty of searching the data, the fragmentation makes it hard to combine the data into entireties of product data. There is no single place where all the data about certain product could be found. It is also excessively difficult to combine the data from different locations as one employee seldom has the rights to even view all the data. Also, the naming of different documents may have been so different that it is not possible to trace which codes or file names equates to which products. This leaves a big hole of perceiving wholes of data, which could be used for many business purposes.

3.3.6 Managing changes

If an employee that needs certain data knows where to find it, there are still more issues to come. In addition to manual data entry, any changes are also conducted manually. If something is needed to be changed for example in mechanical design, the data is exported from one tool, changed manually and then sent to related stakeholders via email. After this it needs to be remembered to update the version numbers in Excel sheets in project's network drive so it would match to the revised design version in the tool.

When changes are made to any data related to products, for example to the structure, it is in the responsibility of project manager or even individual designer to remember to update the information in right locations where data is being stored. Because of lacking proper change management procedures, one can never know if the data found is the latest version and up to date. Someone may have simply forgot to enter or update the latest information in some location. This leads to the possibility of having different or wrong information which may even further lead to big mistakes, for example in production.

Theoretically the information about changes in a project should reach all stakeholders well. In the reality, there may be some knowledge that has been lost between HW and SW. For example, a component may have gone to end-of-life stage and this requires changes in printed circuit board as well the software. This data is only stored in the project's own files and the ones outside the project need to ask for the information from someone linked to the project. The product manager does not necessarily even know where the right information about substituting components should be found.

According to one interviewee, "maintaining data takes a lot of time". All the interviewees agree that this kind of a manual change management procedure is not working at its best at the moment, but most importantly will not be efficient when there are more people, products and projects in the future. Therefore, in addition to the coming PDM system being a place to gather all the product data, it also needs to be a tool to manage the engineering change procedures.

3.3.7 Time lost in meetings

Many of the interviewees told that so far Haltian has succeeded to manage their product data and related processes surprisingly well considering all the flaws they have. Surviving without big mistakes requires everyone to be on the same page as well as the information being up to date. The personnel of Haltian feels that everyone is kept informed mostly due to great number of held meetings. The employees see this as a positive thing; the meetings are considered as a good way of information sharing.

There are weekly meetings held with a sub-contractor manufacturer for example about the components, which are available and which going to end-of-life. The supply chain operations team is having a monthly meeting about product versions. All the changes that have been conducted to all the IoT products during the previous month are gone through

in that meeting. These kinds of meetings are currently essential to keep on track of the changes.

Haltian's own production team is having a weekly meeting every Monday to plan the manufacturing activities for the coming week. Because of the nature of customer orders sometimes being ad-hoc, even this weekly plan does not always work and needs to be changed during the week. More meetings are needed to understand all the customer requirements as well as production instructions.

The above introduced only a few examples of meetings held at Haltian. In addition, there are lots of meetings that are considered necessary. These include, for example project meetings as well as daily, weekly, and monthly meetings with different stakeholders. The meetings are held to keep everyone informed about the ongoing projects, product requirements, and development processes.

3.3.8 Product data ownership through product lifecycle

A big part of Haltian's competence is created through the ability to configurate products according to needs of customers. This is something that causes not only advantages but also challenges: in the interviews it was described as "ad-hoc based doing". One clear benefit is that it makes Haltian able to go to variety of different markets and also have big variety of different customers. On the other hand, high amount of configuration means longer and more complex product development projects and therefore bigger amount of product data to manage. This is one aspect that makes it essential to have structured PDM procedures in place.

Haltian has a product manager who should be in responsible of the whole product portfolio of Haltian. The role is relatively recent and therefore there are difficulties in the formation of the procedures related to product management. Sometimes the product manager is being bypassed if the salesperson with a customer inquiry goes straight to R&D to ask what should be done and at what price instead of contacting the product manager first. The role of product manager should be about planning the coming and recent products and how they fit in the vision of the company's future. The product manager would like to be the interface between potential market demands, sales, and product development. He should be the one to find new potential markets and to come up with recommendations on new products.

According to the interviews, the role of a product manager is not working as it should be. They would like to see a clear focus of how to develop the products in the future. Haltian is currently creating new products mainly based on the customer requests coming from sales. Many interviewees think that sales should concentrate more on selling the devices that already exist. In addition, a question considering sales' technical knowhow about Haltian's own products was brought up.

To control the product portfolio, there are weekly meetings about HW roadmap. The meetings are held to evaluate new needs, to start new IoT projects, to follow current IoT projects, and to do the end-of-life decisions. In addition to product manager, there are relevant people from other teams attending. There is one employee from SW side also attending the meeting but otherwise the product manager does not have any control over the software dimensions of the products. The SW team has their own meetings about the functionalities of products. The SW designers feel that their side is not taken into consideration well enough in the product lifecycle management.

An issue that arose from many of the interviews was unclear product data ownership in Haltian's own IoT products. Especially at the end of the product lifecycle the ownership of products and data related to them are unclear. Some interviewees told that the issue comes from the lack of release manager from the SW side that would own all new products releases. There are changes made to product's SW every six months and currently no one is on map which versions has been sent to which customers and when. Many of the devices sold to customers are also maintained by Haltian. This is another part of the late product lifecycle in which product management is not involved.

For every new product, there is a project team and manager assigned. The project manager is often from the mechanics side of the company and is therefore mostly along in the development phase of the product lifecycle. When the product is introduced to markets, usually the mechanical work is already done. However, during next years there are usually still lots of work done on the SW side. Because the project leader, who is basically the product owner, was from the HW, they are not properly along in these later phases. Because of this the changes made are not managed and documented well enough. Furthermore, the later phases are not taken into consideration for example in terms of value creation. In addition, in the very end of product lifecycle the end-of-life decisions, procedures and responsibilities are found to be unclear as well as the announcements of

ending of the projects. When the conclusions are unclear, also the lessons learned from the projects are left undocumented and will not be utilized in the future.

3.3.9 Financial losses due to inadequate product data management

The interviewed employees estimated to use 10-20% of their daily working hours for searching product data. Haltian has about 55 employees in HW, SW and supply chain and operations who need to use product data in their daily work. By calculating with approximately 15% of daily work time used for searching with 60€/hour rate the cost for fragmented data is 846,450 € per year. This is the price of wasting valuable time that could be used for engineering work and is therefore lost from progressive and billable working hours.

The true costs of lacking systematic product data management procedures are impossible to be comprehensively calculated but the estimation of the costs derived from searching data gives an idea what the actual costs could be. There are also other financial costs generated from poor product data management, for example all the work hours used for manually conducted work that could be automatized. Whole another issue is the possible costs of risks that can realize to errors because of the manually conducted work as well as the lack of monitoring and traceability.

3.4 Synthesis of the current state analysis

Haltian has a lot of improvements to be made in terms of product data management to be able to fulfill their big targets of growth. The systems used for data creation and management are currently almost nonexistent and the work is conducted mainly manually. This is time-consuming and will therefore affect Haltian’s efficiency. It also exposes the whole product development and manufacturing processes and poses great risks. With just one oblivion, the inaccuracy of data may lead to failures in any phase of the processes, which often affects the end products.

The information availability is seen to be a problem in the company, leading to the need of searching and asking about the needed information. This is found to be very time-consuming and inefficient. Most of the interviewed employees told that they need to use 10-20% of their daily working hours to find information related to the product they are working with.

Haltian is in the business to business sales and therefore the lifecycles of products are long. During the lifecycle of a product there will be many changes, which necessitate proper processes for managing engineering changes and variants. Rapidly growing number of different devices with multiple variants need to be managed in a good manner to avoid failures and to work efficiently. The PDM system is expected to bring help in creating structured processes for managing product data. In addition, the creation of new product data needs clearer requirements and frames to make the data more coherent and attainable.

Yet another big issue in Haltian is the ownership of the product data through the whole product lifecycle. This is noticed especially in the later phases of the lifecycle when HW part of the device is ready, but there are still many SW updates to come. This issue is more about the lack of process structures and affects also the management of product data.

There are many issues that need to be addressed related to business processes and data management in Haltian. Fortunately, top management as well as the employees seem to be well engaged in the PDM system's implementation project. Table 2 summarizes the key improvement areas that implementation of a PDM system is hoped to resolve at Haltian. The recommendations of this thesis will not go into all of these in detail but focuses more on the flow of product data in the business processes. As one interviewee said: "All culminates to that where all documents are stored and how revisions are handled".

Table 2. Key improvement requirements for PDM system at Haltian.

Improvement area	Challenges
Product data creation process	-No clear structures -Inadequate requirements
Product data ownership	-Unclear data ownerships -No ownership in the end of product lifecycle
Information detection	-Fragmented data -Time wasted for detection -No access to view necessary data -No proof of validity
Change management	-No clear process for product data changes -Changes conducted manually -Changes documented manually
Variant management	-No automatic procedures for creation -No documentation connected to orders

4 RECOMMENDATIONS

Some of the challenges of product data management at Haltian are related to the lack of structured processes and requirements in the whole product order-delivery process, but most of them can be fixed by the deployment of a PDM system. This section of the thesis includes recommendations for actions to take related to the product data management and implementation of a PDM system.

4.1 Development proposals

To overcome the challenges Haltian is currently having in their product data management, they need to implement a PDM system. Haltian has already evaluated a system called Teamcenter created by Siemens Digital Industries Software. During the evaluation, the system was discovered to be suitable for Haltian and therefore it would be a logical continuance to implement it. Teamcenter can offer all the needed functions for Haltian to easily and cost-efficiently conduct their PDM. From Teamcenter user interface, people across the organization can easily take part in the product development process.

4.1.1 Creation of data flows in business processes

To get rid of the "wild west process" Haltian needs structured business processes and clarified models of the data flows in the processes. This section describes the suggestions for future data flows in business processes of Haltian. It all starts from the sales, which receives the customer's inquiry about a product or engineering service they would like to buy. The sales should always first contact the product manager to see if the order would fit into firm's product portfolio or production plans. After this, the sales and product manager together with R&D should make plans of how the customer needs could be fulfilled during the conceptual phase. The needs as well as product specification must be imported to the PDM system for easy access. This will ensure that even after a long time or with different employees all the information from the conceptual phase will be documented and can be used in the productization phase.

When the customer has decided to continue with ordering the product, the customer order is created by the sales. It must be created by filling a template which have all the essential information about the order. This will also be imported to the PDM system. A

productization phase can start and engineers will create 2D and 3D designs which can be imported straight from SolidWorks and Altium to the PDM system. During the design work, the engineers must fill in the profile cards, which ensures the traceability between components, parts and documents. Both EBOM and MBOM are composed and updated automatically by the PDM system.

After the productization phase, the supply chain and manufacturing unit will create a Jira item. They can export the customer order from PDM system and attach it to task management program Jira as well. Therefore, all the stakeholders working with the order can easily see the customer requirements that they need to fulfill in the producing and development work of the product.

The summary of the recommended data flows in business processes is illustrated in the figure 8. It shows how the product data should flow through three main business processes of Haltian and in which formats. All the data should be stored in the coming PDM system. However, because this is only the high-level review some of the data will most likely be stored and used in other locations as well, for example Jira. It is reasonable to export the product data from the PDM system and to use it in different systems but the baseline must be that all the master data is always located and managed in the PDM system and will be up to date there.

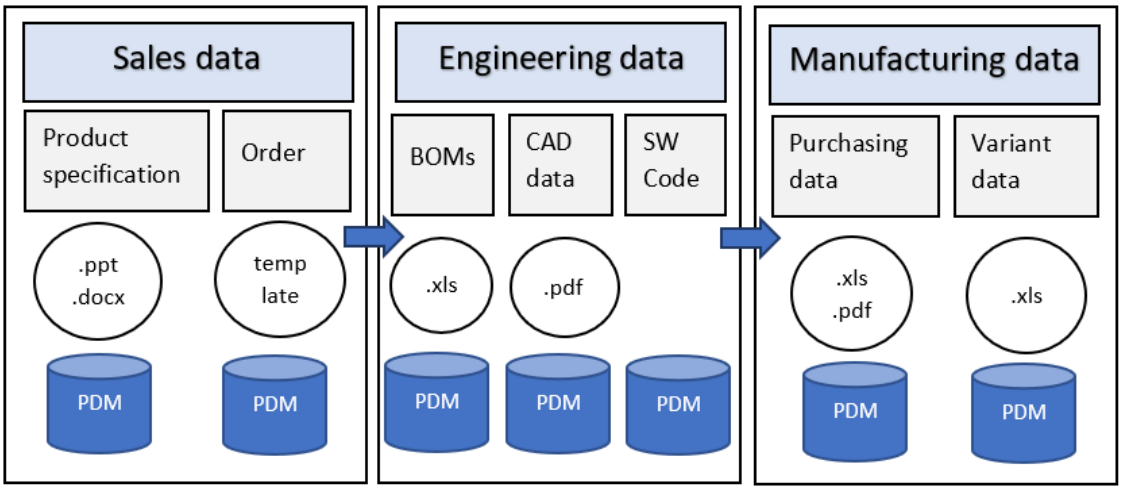

Figure 8. Recommendation for data flows in business processes of Haltian.

4.1.2 Product master data in one place

To efficiently take care of product master data at Haltian, Teamcenter should be implemented and deployed. Teamcenter is a PDM system that takes control of product data including crucial product master data, which includes 2D and 3D designs, electronics, software, documentation and BOM. In addition to all the product master data being in one place, Teamcenter enables an easy access to the data and the usage of it across the organization. By features of requirements and change management for data, the deployment of Teamcenter ensures that quality and accuracy of the PMD will be in place.

When about to deploy the PDM system, it is important to make sure that all the current product master data will be migrated to the new system. In the deployment, Teamcenter will also be integrated to Microsoft Office. This ensures that all the important product related documentation such as product specifications can be created and worked on familiar Office applications just like before. The difference is that all the documents will be stored and managed in Teamcenter instead of earlier multiple different locations like network drives or SharePoint.

4.1.3 Automatic data entry, storage & management

A PDM system will help Haltian to improve their product data entry, storage and management in many ways. Currently a lot of data is created in the Excel and is stored for example in network drives, emails or SharePoint. After the deployment of the PDM system, remarkable part of the data can be created, stored and managed automatically. This will save employees' time and decrease the possibility of errors.

A good example of the automatization of work are BOMs. Mechanical, electronical and software information can all be found in the Teamcenter BOM. It will be automatically generated from all the design data and different ways of viewing the BOM can be selected. All the documents related to the BOM can be viewed in the system as well. The product structure can also be visualized even without an access to the original designing tool. A crucial benefit for the PDM system is the visibility to the usage of each item. This becomes especially important when conducting changes to the products.

In addition to automatically created documents, all the other needed product related documentation can be created and managed in Teamcenter as well. Microsoft Office can be Integrated to Teamcenter and therefore used from desktop applications just like before. In the Microsoft Office applications, there will be a Teamcenter menu where users can check out, check in, review, and edit product related documents while managing the files in Teamcenter.

To ensure the full usage of the PDM system, monitoring the usage after the implementation is in place. It must be assured that employees are not going to slip back to their old manual ways of working. If the employees have their own documents that are excluded from the PDM system, the system is not fully utilized, and the risk of errors caused by inaccurate data will exist. The rate of right usage of the system can be monitored via questionnaires and conversations with data creators as well as users, and by monitoring the data that flow through the order-delivery process. It must be ensured that the system completely fulfills the needs of the process. The system is recommended to be bought as Teamcenter Rapid Start, which enables fast and easy start and implementation. However, it is very generalized version of the Teamcenter and therefore it must be later examined if some altering must be done to make the system work better for Haltian.

4.1.4 Coherent data requirements

One issue that brings difficulties in the order-delivery process in the company is the lack of structured requirements for customer orders. Many times, the customer is not fully on map what they actually need or want, but it should be the responsibility of sales, product manager and R&D to cooperate and form clear requirements and specifications based on the customer's wish list. All the dimensions including variant information and delivery address should be in place and documented before sending the order to the following stakeholders in the order-delivery process. This would be realized easiest by creating a clear template that is to be always filled when entering a customer order.

Having a clear template to fill could save a lot of time for example in manufacturing and supply chain if they would not need to ask for the basic information in every case of a new customer order. The customer order in the form of a filled template by the sales should be visible in the coming PDM system for every stakeholder in the order-delivery process. They should be able to effortlessly check the dimensions of the product that they

need in their work. Currently Haltian is using Jira as a task manager, and the customer order documentation should be visible there as well.

The interviews raised an issue that in addition to sales, the engineering designers have much variation in their ways of entering data as well. In the mechanical designing in SolidWorks there is a profile card for every product where the designer should fill in the related information. Currently the profile card is not widely used, which further leads to problems in the automatic creation of BOM. There should be clear guidelines that profile cards are necessary to be filled and clear instructions for the information input are needed as well. Filling in the profile cards may take some time for the designers, but it would also save their time later when the BOM can be created and exported automatically without manual work. Clearer and more structured form of data would also lead to better data accuracy and attainability and save time of other stakeholders when searching the information that the designers have created.

4.1.5 Combined data

The fragmented data leads to many difficulties not only on the R&D side but also in the whole order-delivery process of the firm. With more combined product data, the company will be able to make faster R&D, decrease their lead times and better serve their customers. The work conducted for example in the conceptual phases will be accessed easier without examinations of employees that were involved. The implementation of a PDM system will also ensure that the product master data will not disappear even if employees are changing during the projects or will leave the company for good.

In addition to the time wasted in seeking for information, the fragmentation of data exposes the company to errors. Getting all the product data into one PDM system will help reduce the errors by easy access and data validation. With the usage of a PDM system, the employee in need of information can be sure that the data they found is accurate and up to date. The PDM system will also help to manage and combine the data which will provide many possibilities for the business. The possibilities are introduced in the following paragraphs.

Currently the data fragmentation leaves a big hole into the possibilities of perceiving of data as a whole, which could be used for many business purposes. It would be extremely useful for Haltian to have coherent data about which products and variants they have sent

to which customers and when. This would for example allow them to perform order follow ups to the same customers a lot faster without unnecessary investigation about the content of the earlier orders.

Furthermore, perceiving whole product data entities would improve the company's ability to faster additional sales, and increase the competitiveness on the markets. The company could also improve their marketing capabilities in the form of after sales activities. This would be enabled due the concrete and precise knowledge about earlier deliveries customer specifically, providing valuable information that could be used for many purposes. There are for example software updates released every six months, and it could be beneficial for Haltian to reach out the customers to inquire if they would like to have newer versions of their existing devices, or even order brand new sensors with other functionalities.

Teamcenter offers a PDM system that has all the important product master data in one place. After the implementation of Teamcenter, a lot of valuable time of the engineers will be saved from searching and inquiring about data. Teamcenter will also link the data so that, for example, when viewing a product, there will be all the related information available with ease, including product structure, BOM and other documentation.

The PDM system will help Haltian to shift from fragmented product data to systematic and efficient data management. Figure 9 shows how the designing tools used in Haltian will be integrated to the PDM system to ensure the consistency of data. All the designs from SolidWorks, Altium and Software applications will be stored and managed in the coming PDM system, from where the product data can be manually exported to other systems, such as Jira.

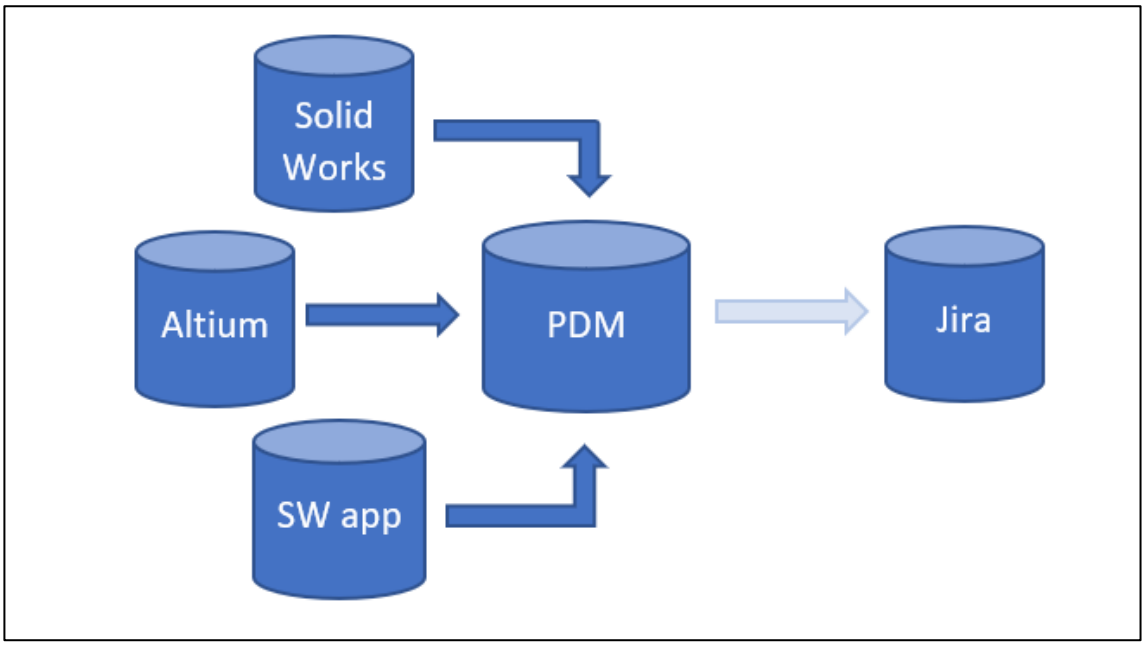

Figure 9. Product data flows in system applications.

4.1.6 Managing changes systematically

Currently at Haltian, the project manager has unnecessarily big responsibilities in managing and documenting all the engineering changes conducted within a product structure. There is a need for automated system for conducting the changes in the product structure and moving it forward to all the concerned stakeholders. The new PDM system must create a solid path for managing the changes, and to ensure the information will reach everyone and data will always be up to date.

The same issue exists with the component changes. If a change is made, the system should automatically change it to every location where that piece of product data is being used or stored. For example, if one component is changed in a product, changing it would automatically replace the old one in BOMs. That would ensure that anything is not accidently designed or manufactured with old versions. Simultaneously the history information is easily available. If the changed component is known to be going to end-of-life, the change should be automatically made to every product containing the component. The system should also notify about which products and data the change concerned.

Teamcenter provides this much needed traceability between documents and parts. The user can effortlessly see the parts related to the document and likewise the documents

related to the part. This is especially useful when conducting changes to the data. The users can ensure they update all the necessary parts and documents related to the changing data. This is a feature that Haltian is in a desperate need of to ensure the validity of data. It will also be an enormous step towards the scalability that Haltian is in need in terms of product data management. In addition, Teamcenter will include automated PDM processes. For example, engineering change and the whole engineering workflow process including change request and change order components can me managed in Teamcenter.

The system can provide a significant help for managing changes, but new ways of working must be built around the system to ensure that all the benefits of the new system will be utilized, and the change-process is as efficient as possible. To ensure the traceability, all changes must be conducted in the PDM system, or applications integrated to it, and then distributed to other external systems if needed. In addition, the responsibilities of engineering changes must be carefully planned and executed. For example, it must be considered who can carry out changes to product structures, and who's responsibility it is to accept the changes. The whole process of conducting changes should be examined and adjusted with the help provided by the new system.

4.1.7 Only necessary meetings

A PDM system should keep everyone on the same page about the changes conducted to a product. Therefore, at least some of the meetings held now daily, weekly or monthly could be held more seldom or even stop having them completely. One example is the meeting about product versions, which is currently held once a month. Due the changes being automatically updated to all the products this meeting will not be necessary in the future after the deployment of a PDM system. All the currently held meetings should be individually reviewed and re-evaluated to understand whether the implementation of the system will reduce the need for those specific meetings.

Before implementing a PDM system, Haltian should create clear requirements and template for customer orders. Therefore, meetings considering new orders like kick-off meeting for a new project could be held more efficiently without time lost for presenting the guidelines that all the employees in the project can check easily from the PDM system. The time saved from attending in the meetings could be used for engineering and other real value-adding work.

4.1.8 Product data ownership through product lifecycle

Haltian needs to have some significant changes in their product data ownership through the whole product lifecycle. Product manager's responsibilities must be clarified and coordinated better with sales and R&D. Haltian also needs to set a clear vision for its future products, product development and sales. Having these three aspects in line will help in having consistent and more cost-efficient products and product management.

Currently the project managers of product development projects are from mechanics. However, the products of Haltian are mostly complex and distinct because of their SW, and for that reason it would be essential to have product manager also to look after the software side. There should be an alignment that product manager will take care of the products as a whole in a high level including both HW and SW. Software department should also be more involved in the conceptual phase of the product development, as they have the knowledge and could better demonstrate what can actually be done with Haltian's software and furthermore with its products.

To avoid the current situation with product and product data ownership being unclear after launching the product, the ownership could be shifted after the launch. Haltian has been planning to have a separate release manager for all the new software releases it is having every six months for their products. The release manager could also be the product owner and take care of all the product data. Therefore, the product release could be the point where the product ownership shifts from the HW project manager to release manager who will take care of the product as long as the SW releases are made. After this, in the very ending of the product lifecycle, it should be the product manager's responsibility with the support of the release manager to make an end-of-life call to products.

4.2 Carrying out the proposed changes

The implementation of a PDM system would be a start to reach efficient product data management at Haltian. Many of the recommendations are proposed to be fixed by the implementation of the system and for this reason most of them cannot be realized into action before implementing the PDM system first. However, to be able to fully utilize the coming system, the processes around data management should be addressed before the deployment of the system. This means for example determining clear structures for data

creation. Nevertheless, getting these recommendations through will necessitate usage of the ways and tools for successful change management represented in the section 2.4.3.

To develop the data flows in the order-delivery process as suggested, the changes should be examined in a detailed level in the organization. In addition to coordinating the bigger picture, every business unit should have their own investigation about how the recommendations could be conducted. In this thesis the data flows are examined at the higher level, but to guarantee the real, efficient utilization of these recommendations, the examination must be carried out in a more detailed level as well. After the throughout examinations, the suggestions should be implemented into the practice. The greatest differences possibly relate only to changing the everyday processes and ways of working. The examinations as well as the implementation work should be deepened into the level of individual employee to ensure that everyone is on the same page and knows how these new processes and systems are working and what they need to change in their daily work routines. With careful implementation work, the new ways of working are better deployed among the employees who are supposed to take them into usage.

4.2.1 The implementation project

The Kotter's Eight-Stage Process for change management starts from establishing the sense of urgency. The urgency has already been identified by the company itself. From the interviews and other discussions with both managers and employees there seems to be a common understanding that the current data management processes are not working as they should be, and because of the firm's ambitious growth goals in near future there is the necessity of getting the procedures right before the amount of product data is too big to handle. Employees also seem to understand that the current processes and ways of working are not optimal, and they are using work time for activities that should be done automatically or be otherwise easier.

The guiding coalition including the most relevant stakeholders has been developed to get the whole implementation project executed in the first place. A vision has been set by the company, and it has been communicated well throughout the process to the employees that the changes will affect the most. The empowering of employees to take action is an important part and will be conducted mostly simultaneously with the actual deployment of the PDM system. It will be conducted in the form of training about how to use the system, but also one by one conversations with the employees using the system to make

sure that they are motivated, understand why the system is deployed, and also to hear their thoughts about the use of the system in their daily work.

As described in the Kotter's Eight-Stage Process, during the change it is important to generate short-term wins. It enables the monitoring of the progress as well as motivates the employees by not showing the change as an endless pile of work. There should however not be too many changes at one time. Therefore, the timeline for implementing a PDM system and fixing the processes around product data management is recommended to be performed in stages as illustrated in the figure 10.

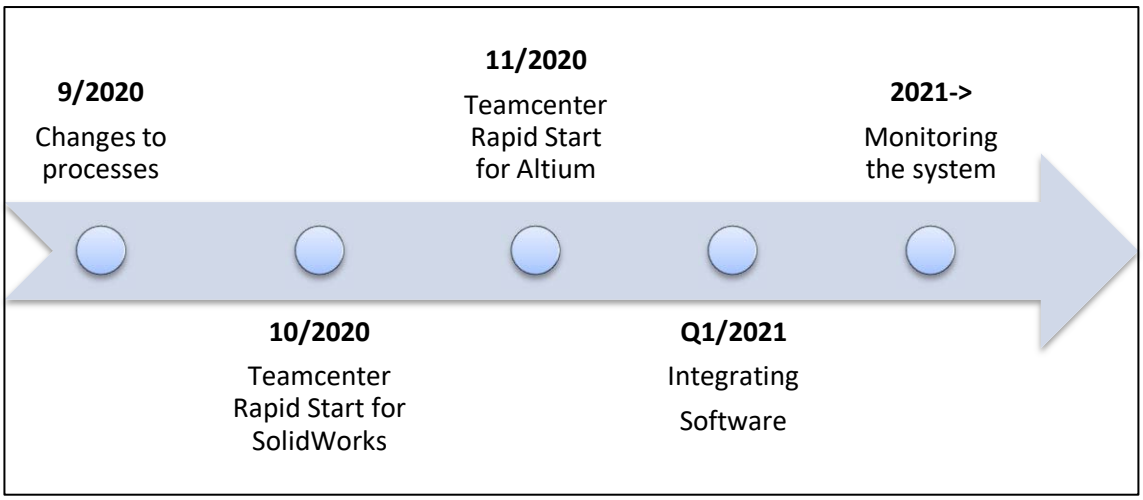

Figure 10. Timeline for implementing a PDM system to Haltian.

The last two stages of the Kotter's Eight-Stage Process will be possible to perform only after the deployment of the PDM system and therefore they will not be conducted before this thesis is finished. They should however be used to make sure the new system is fully deployed. After the implementation work is done and the system is in the use, the gains should be consolidated. It is similarly important to anchor the new approaches to ensure that people will not start to forget the new ways of working and go back to their old habits. This can be ensured thorough rightly timed training, and by highlighting the importance and benefits that the systematic usage of the system can provide. The PDM system can help Haltian to work efficiently and prepare for the future growth. However, the system will only work as it is supposed to if all the employees are committed to using it. All in all, the work with the system will not end after the implementation, but the new ways of working and the effects of the system must be monitored.

4.3 Financial savings enabled by a PDM system

Implementation of a PDM system is a big investment and therefore the budget must be carefully thought through. Licenses for using the system have direct costs when buying them and additional annual costs from the maintenance provided by the system supplier. There are different kinds of licenses for different user requirements and the types as well as amounts of the selected licenses affect significantly to the final cost of the system. In addition to the license costs, the integration work of the company's current design tools to the coming PDM system is charged by the system supplier. Altogether the financial cost of the system implementation could be in the vicinity of 50,000€. The annual costs from the licenses could be around 10,000-20,000€ depending on the types and amounts of the licenses bought.

The sum of 50,000€ and additional annual costs may first sound to as a lot of money but comparing it to the rate of current financial losses (over 800,000€/year) puts it right into the perspective. Even though estimating the actual losses is almost impossible, some estimated range can be perceived. The calculations show that investing 50,000€ to the system now can pay itself back multiple times even in a short period of one year.

4.4 Reflection on the proposed solutions

Haltian is suggested to implement a PDM system called Teamcenter created by Siemens Digital Industries Software. The system can face the requirements that Haltian has for a PDM system and helps to fix the issues Haltian is currently having in its product data management. Teamcenter is the solution to gather all the product data to one location where it can be viewed, changed and managed easily. It links the product to the related documentation to ensure traceability, which is especially useful when conducting changes. It ensures that the changes will be executed to every document, component and product concerned. By using Teamcenter and integrating it into daily business processes, Haltian can be sure that its product data is always accurate and up to date.

All the crucial designing systems including mechanics, electronics and software tools as well as Microsoft Office will be integrated into Teamcenter to guarantee smooth data transfer and effortless user experience. The implementation project is suggested to be conducted in phases to ensure fluent and efficient deployment. It is important also to

monitor the usage of the system to ensure that it is working properly, and the maximum benefits are gained.

In addition to recommending the implementation of a PDM system, some adjustments to order-delivery process are suggested to be made before the actual implementation. The changes include for example clear templates and profile cards to the product data creation process as well as release manager, product ownership changes and end-of-life calls for more advanced product data ownership. The recommended changes will help Haltian to fully utilize the new system as well as make the whole order-delivery process work faster and easier by more systematic procedures.

Carefully conducted implementation of the PDM system with proper change management, and the recommended process changes can help Haltian to manage their product data more efficiently and therefore utilize it more effectively. Table 3 summarizes the solutions that are suggested to fix the challenges of product data management at Haltian.

Table 3. Proposed solutions to product data management challenges.

Improvement area	Challenges	Solutions
Product data creation process	-No clear structures -Inadequate requirements	-Clear template for customer orders -Profile card that must be filled by designers
Product data ownership	-Unclear data ownerships -No ownership in the end of product lifecycle	-Release manager -Shift in product ownership from project manager to release manager after the launch -End-of-life calls
Information detection	-Fragmented data -Time wasted for detection -No access to view necessary data -No proof of validity	-Teamcenter: ➢ to gather the data ➢ for easy access to the data ➢ for data traceability
Change management	-No clear process for product data changes -Changes conducted manually -Changes documented manually	-Teamcenter to conduct, manage, and detect changes
Variant management	-No automatic procedures for creation -No documentation connected to orders	-All orders' product data containing variant information to Teamcenter

5 DISCUSSION

Products play a central part in businesses: without products there would not be companies. Companies may have thousands of products with thousands of variants. This leads to an enormous amount of product data that must be managed and used in a good manner. Product master data is created at the beginning of the product lifecycle and usually contains information about product's definitions, structures, classifications, change data, lifecycle status and configuration rules. Product master data should be stored in a product data management system and transferred to other systems afterwards.

Product data management has a main goal to manage all information needed throughout a product's lifecycle making correct data accessible to all people and systems that need to use it. PDM integrates and manages processes, applications and information related to products. It helps to make products profitable by efficient development, fabrication and distribution. With proper implementation, the usage of product data management should result in faster work, fewer errors, less redundancy, and smoother workflow.

A PDM system is a computer system with a primary purpose to manage product data. The main task is to provide conditions for connecting information systems, processes and automation islets. The system should provide value to companies by seamlessly integrating information from organization-wide processes. PDM system is a structure in which all types of information used for defining, manufacturing and supporting product are stored, managed and controlled. It ensures that users always get and share most up to date information and the information is available whenever, wherever and whoever in need. In addition to product data, PDM system also manages product development process by controlling for example product information, states, approval processes and authorizations.

Implementing a PDM system brings multiple benefits for organizations in terms of productivity and competitiveness. It for example helps reduce lead times and costs as well as improve quality. For users it brings effectiveness for work and improves collaboration as well as change management. PDM systems also collect information on the daily operations of a company that can be used as a support for decision-making.

PDM systems also bring financial savings but the benefits are difficult to convert directly to euros because there are many factors that contribute to the cost of PDM. The costs come from inaccurate data and an organization's inability to know what impact the PDM system will have. However, most of the companies that have implemented a PDM system considered that the system provided good returns on investment. The savings come from the operations and increased earnings possibilities of the business. The calculatable savings basically come from the decrease in expenses and working capital, because without a PDM system engineers typically use 24% of their working hours for information sharing and retrieval, 21% for work that has already been done earlier and 14% for meetings to share information. Reducing those numbers saves the working hours to more efficient work.

Implementing a PDM system is a process that has two phases: tool is first evaluated and then deployed. Because once implemented tool is seldom replaced, the implementation project is extremely important. The implementation is not an easy task, since the system is cross-functional and may face issues with people, project team, process, organizational structure, funding, information, installation, everyday use, and the system itself. The business objectives and vision for the system as well as implementation project should be clarified before the project.

Change management plays a crucial part in the implementation project. The key to successful deployment is to make sure the engagement of management. The buy-in for the users must be obtained before they start to use the new system and training must be delivered at the right time. Change management is mostly about changing people's mindsets. This thesis utilizes an eight-stage process for change management introduced by Kotter (1996).

The current state of product data management is important to be analyzed before the implementation. In this thesis it is performed mostly via interviews, which gave a wide perspective on the current processes and documentation related to product data. All the interviewed employees agreed that there is a need for a PDM system at Haltian. In conclusion of the analysis, there are issues to be addressed in product data creation process, product data ownership, information detection, change management and variant management. Most of the work related to managing product data is conducted manually and therefore carries a huge risk of errors. The current ways of working are not only

frustrating for employees but also waste their valuable time and cause financial losses to the company.

The recommendations of this thesis try to solve the challenges found by the current state analysis. They are composed from the whole created by the literature review and the current state analysis, which is complemented with own observations and ideas gained while working for the company. The recommendations are given to all the main issues found currently as challenging in terms of product data management at Haltian.

Haltian is suggested to implement a PDM system called Teamcenter. It has been evaluated to face the needs that the company has and based on this thesis it can solve the challenges Haltian is currently facing with its product data management. Because the biggest issues are caused by the fragmentation of product data, the most remarkable improvement is that after deploying the PDM system all the product master data will be in one location. The easy access to needed data will help the Haltian employees to work more efficiently. Also, the change management procedures will be more advanced and has traceability due the new system, which will reduce the risk of errors.

In addition to the implementation of the PDM system, some adjustments to current processes around data management are suggested to be made. These are for example clearer requirements for entering data to product orders as well as profile cards of mechanical product parts. The recommendations for order-delivery process aim to improve the data flows throughout the process as well as make it work more fluently and faster.

5.1 Key results

The aim of this study was to examine what needs to be taken into consideration when implementing a PDM system, and to find the right procedures and methods on which to follow in the implementation project. This part of the summary presents the key results to the research problem. The results answer the three research questions set for the thesis. The answers are combined from the earlier parts of this thesis and therefore more in-depth results can be found in other parts of the thesis. From the whole formed by this thesis, the answers to each research questions are developed and answered separately.

PDM system is a tool that links different applications together and makes sure they support the overall process. In addition to integrating applications, it also manages processes and information that define the products across the applications. A PDM system keeps track of product data that is used for example to design, manufacture and build products and provides a structure in which all types of product data are stored, managed and controlled. In addition to product data management, a PDM system has multiple other features to create comprehensive support to processes around product data. These are for example product structure management and maintenance, change management, information retrieval, task management and document management. PDM systems usually contain a wide range of information related to products. Product data is mainly from engineering perspective and excludes for example price information. The product data stored and managed in a PDM system is for example user manuals, part definitions, specification, CAD drawings, software components, documents, project plans, maintenance info, patent reports, label information, customer requirements and product configurations. The data is generated by different applications such as designing tools and can be stored in varying formats in the PDM system.

Haltian is in the business to business sales and therefore the lifecycles of products are long. During the long lifecycle, many changes may arise which necessitate efficient processes for managing engineering changes. The products of Haltian also have multiple variants that must be managed in a good manner. From this great amount of product data, master data is the part that should be cared most precisely. The product master data of Haltian includes for example customer orders and requirements, product specifications, engineering design pictures, BOMs and variant data. The creation and management of this PMD must be structured, organized and combined to ensure efficient data flows through order-delivery process. The users of product data are mostly internal stakeholders who need it in their daily work but include also for example a sub-contracting manufacturer. The amount of product data is increasing all the time as more products are developed and customer orders delivered, which leads to the need of an organized way to manage the product data. Haltian does not currently have any company-wide systems for product data management. Data is mainly created, changed and managed manually, which is found to be time-consuming and exposes the company to errors with product data. In addition to manual work, maybe the biggest challenge is currently the fragmentation of product data. The data is stored in multiple different locations and no one can keep track of where the data is located. This leads to difficulties in finding and accessing the data as

well as ensuring the data is up to date and accurate. Currently the requirements for creating product data are not clear and structured enough, which leads to unclear customer orders and inadequate parts information. This further affects to efficiency of working hours, as time must be used to investigations and manual work. The changes to product data are conducted manually, and it is in the responsibility of project manager to remember to update the changes, which holds huge risk of errors. All of the challenges introduced above result in the need of having great number of different kinds of meetings, which are currently found to be the best way to keep every stakeholder on the same page about the products and projects related to them. In addition, the product data ownership through product lifecycle is unclear and needs to be clarified.

Change management is created to focus on why and how organizations change. The change always involves changing the routines of the organization and therefore the implementation plan of a PDM project must match with the organization's ability to change. There are different models and tools created for change management and this thesis follows Kotter's (1996) eight-stage process. The deployment of a new tool necessities changing working practices, which needs the change in people's mindsets. In leading change, it is crucial to make the rationales for change initiatives seem like a common sense to the stakeholders in the organization. The one operating the change must be in touch with the key stakeholders to constantly assess their perceptions. A big issue with change management is the involvement of senior management, because having them on board will reduce the resistance to change by users as well. The management must understand all the implications of the rollout as well as the impact it will have on the design teams. The senior management should show their support by communicating their view about the coming system as well as being personally involved in the implementation project. Buy-in for users will play a critical role in the implementation project and it must be earned before they start to use the new system. This can be supported by user-friendly system and at the right time delivered training. It is also important to have someone in the implementation project team who can sell the system to users and relates to the people in the business. Understanding the needs of the users necessitate technical ability. The greater the genuine buy-in and motivation towards the change, the better are the chances for successful and sustainable change. According to the interviews, the top management as well as the employees of Haltian are already in a relatively good level in their buy-in of a coming PDM system. They have been suffering from inefficient product data management and procedures for a long time and therefore are waiting for a change. The

difficulties come when the system must fulfill their wishes and expectations. Therefore, the features of the coming system as well as deployment timeline must be carefully planned. The implementation is planned to be performed in phases as illustrated in the figure 10. In addition, it must be ensured that the new ways of working will be anchored to the working culture of Haltian.

5.2 Scientific implications

The novelty of this research lies in providing some insights on the early stages of an implementation process of a PDM system in a case company. Some related product data management challenges prior to the implementation are also revealed. The findings are in line with earlier literature (Stark 2015, 2016, Philpotts 1996) and therefore do not provide new scientific information as such, but combine the information about implementing a PDM system and describe a case example about the difficulties in product data management before the system implementation. The results of this study show that without a PDM system, employees must use a significant part of their working hours to information seeking and retrieval, which eventually becomes expensive to the organization. This is supported by previous literature (Saaksvuori & Immonen 2008, Olson 2003, Stark 2015, 2019). The findings about current PDM challenges are well in line with the traditional product data management issues presented in earlier research (Stark 2015).

5.3 Managerial implications

This thesis composes information about the implementation of a PDM system, and therefore any organization planning on implementing a PDM system, or is otherwise having issues with their PDM can benefit of this study to some extent. The literature review contains a combined package of general knowledge about the implementation and what must be taken into consideration when planning it. The information can be used before the implementation project to illustrate how the project will be like and what is needed to successfully deploy the system. This would be especially informative if the company and the project team were not familiar with PDM systems or their implementation. The current state analysis can help to understand how the current state of a company can be examined, and to notice if there are similar issues in other companies.

The proposals can provide a top-level guideline on how to conduct the implementation project and the related process changes.

5.4 Assessing the results

The results of this thesis are assessed by using criteria created by Lincoln and Guba (1985). According to them, qualitative research can be assessed through four criteria: credibility, transferability, dependability and confirmability.

What is comes to credibility, there is a limited amount of academic literature available about product data management and especially implementing a PDM system. Therefore, additional references about PLM needed to be used and generalized to PDM. This was possible due the fact that PDM and PLM are closely related and therefore same rules apply. The results of this thesis are based mainly on interviewing employees, which ensures the credibility but on the other hand means that the interviewee can only know what the employees of each function are telling. Therefore, the opinions of one or two people may affect to some of the end results. In addition, there is always a possibility that some crucial stakeholder was left without an interview, for example sales was not interviewed. However, the fact that many issues arise from multiple interviews support that the findings are accurate. In addition, I did my own observations in the company that have further deepen the understanding of the current state and therefore I have been able to see the challenges in the reality and how they appear in daily work.

In terms of transferability the results are only valid for this case study and company and therefore there are some limitations in the generalization. The companies may have their own aspects with special products and different ways of working which generate different results. Especially the recommendations for order-delivery process are precisely for Haltian and their current, unique situation. However, the results can be generalized to some extent to other technology companies of the same size because most of the issues found were something the PDM system is especially meant to resolve and therefore the challenges before implementation can be similar. For example, data fragmentation may be an issue that every company planning for implementation of a PDM system is likely to have.

Despite trying to describe the research process as precisely as possible, the dependability of this study is limited. The interviews were arranged with consultants and therefore the questions cannot be presented. However, from the questionnaire of data processes as well as the whole current state analysis can be perceived what kind of questions the interviews included. Therefore, the research can be replicated at some level by reading the same literature references and conducting interviews of top management and employees to form a current state analysis and recommendations of needed actions. In addition, the overall process for implementing a PDM system is generally presented in the literature review and contains information that is useful for every company planning to implement a new PDM system.

To ensure the confirmability, the findings of the interviews were introduced to all the employees that attended the interviews. The results were represented, and future suggestions given in a final presentation of the pre-evaluation. The employees were encouraged to comment and discuss about the results, which were found to be realistic and accurate. The key findings were also communicated to the top management, which recognized the issues found from the interviews. Additional confirmability is given from the fact that the company and especially its processes were not familiar to the researcher in advance, which ensured an open mind and neutral approach towards the research and its results.

5.5 Limitations and future research

The implementation project of the PDM system will be starting while this thesis is finished and therefore the implementation phase cannot be taken into the scope of the thesis. Also, the other recommendations such as process improvements will be conducted simultaneously or after the research process of this thesis and therefore will be left unvalidated in the real life. For the same reason, the benefits of deploying the PDM system cannot be evaluated in this thesis either.

Because the actual deployment phase of the implementation project could not be taken into the scope of this thesis, the impacts of the PDM system could be a topic for later studies. The benefits derived from the deployment of the system as well as the possible challenges or disadvantages from it could be examined. In addition, the possible faults in the implementation project could be evaluated and lessons learned documented.

From the interviews, there were many aspects arising that has a room for improvement in the current order-delivery process of Haltian. Many of the issues could be further researched, such as variant creation. Despite that the PDM system will most likely help to detect the variant information, it could be beneficial for Haltian to create more structured ways of creating and managing the variants.

After the implementation and successful deployment of a PDM system, the next step in the digitalization and automatization of organization's processes would be deploying ERP. The current state should be analyzed, tool vendors evaluated, and implementation plan created and executed. This all could be founded by the analyze about the actual need and possibilities of the deployment of ERP.

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