Product Data Management in New Product Introduction

- A Qualitative Case Study of Ericsson, PIM RBS Kista, Sweden

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KTH Industrial Engineering and Management

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Produktdatahantering inom Industrialisering

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Sammanfattning

Dagens företagsklimat skapar ökad press på företag att minska sin tid till marknad för nya produkter, samtidigt som konstnader ska minskas och en hög produktkvalitet skall hållas. Ett resultat av detta är att tillverkningsföretag måste utveckla och producera produkter fortare, till en lägre kostnad, med ökande kvalité för att upprätthålla sin konkurrenskraft. Inom marknaden för informations- och kommunikationsteknik sker det snabba förändringar, detta göra att produktutvecklingen är allt mer viktig. Hanteringen av produktdata är en viktig aspekt av produktutvecklingen, men också en av de mest utmanande. Målet med denna forskningsuppsats är att undersöka vilka processer inom industrialisering som används för att samla och hantera produktdata. Produktdata och hanteringen av den är en viktig del av industrialiseringsprocessen samt produktutvecklingsprocessen.

PIM (Product Introduction and Maintenance) RBS (Radio Base Station) Kista är en industrialiseringssite och har valts för denna fallstudie – då de representerar en ledande del av produktutvecklingen för utsedda produkter inom Ericsson som är ett världsledande företag inom informations-och kommunikationstekniks industrin. Denna forskning har utförst i linje med det valda fokusområdet att undersöka, beskriva och analysera de viktigaste metoderna som används inom PIM RBS Kista för att samla in, lagra och använda produktdata under produktutvecklingen i industrialiseringsprocessen. Syftet med forskningen är att bidra till forskningsområdet produktdatahantering. Fokus har legat inom Operations, där nya produkter realiseras under olika aktiviteter och från vilken produktdata är det viktigaste resultatet.

De arbetsmetoder som har identifieras under fallstudien diskuteras och skapar insikt hur produktdatahantering används under förverkligandet av nya produkter – med koppling till produktionsverkstadsgolvet. Denna forskingsuppsats diskuterar även de huvudsakliga implikationera relaterat till produktdatahantering inom organisationen som är vald för denna fallstudie. Detta för att bidra med förbättringsförslag gällande nuvarande produktdatahanteringsmetod och system, samt verktyg, som finns implementerade idag.

Nyckelord: Industrialisering, Produktdata, Produtdatahantering, Produktutveckling, Design for Manufacturing (DfM), Avvikelser.

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Abstract

In today's market there is an increasing pressure on companies to reduce their time-to-market and lower their cost whilst maintaining a high quality on their products. As a result, manufacturing firms have to develop and produce products faster, at lower costs, and with increased quality in order to maintain their competiveness. The information and communications technology (ICT) market is a fast changing market, which makes the development process all the more important. The management of product data is an important aspect of the product development process, but also one of the most challenging. Product data and product data management (PDM) are important aspects of the new product introduction (NPI) process and in turn the product development process.

This research is based on a case study research conducted at PIM (Product Introduction and Maintenance) RBS (Radio Base Station) Kista. PIM RBS Kista is a lead-site responsible for NPI and product development for certain appointed products within Ericsson, a world leading multinational corporation in the ICT industry. In alignment with the research focus the main processes used within PIM RBS Kista to gather, store, and use product data during product development in the NPI process has been described and analysed – in order to contribute to the PDM research field. The focus has been within the Operations department, in which new products are realised during different activities and from which product data is the main output.

The processes identified and analysed provides insight how PDM is used during product realisation and its connection to the production shop floor. The thesis also discusses the main complications within the case organisation and suggests improvements regarding the current PDM processes and systems/tools used.

Key-words: New product introduction (NPI), Product data, Product data management (PDM), New product development (NPD), Design for Manufacturing (DfM), Deviations.

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Abbreviations

DfM – Design for manufacturing

WA – Work assignment

BOM – Bill of material

PIM – Product introduction and maintenance

RBS – Radio base station

PDM – Product data management

NPI – New product introduction

PLM – Product lifecycle management

NPD – New product development

TR – Trouble report

Organisational

PE – Production engineer

QE – Quality engineer

QC – Quality coordinator

BC – Build coordinator

PDU – Product design unit

TL – Team Leader

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1. INTRODUCTION

In this section of the report a short background to the research will be presented along with the purpose of this research combined with problem formulation, research question, and delimitations of the research.

1.1 BACKGROUND

"Global competition, emerging technologies, and ever-increasing need for superior products in shorter time frames are all contributing forces driving organisations to adopt new and innovative approaches to product innovation."

- Cormican & O'Sullivan (2003, p. 54)

Today, firms compete in a global business environment where rapid technology development drives increased competition and market uncertainty (Arnold & Floyd, 1997; Penide, et al., 2013; Saranga, 2011; Cormican & O'Sullivan, 2003). The competitive business environment, especially for manufacturing firms within high-tech industries, is therefore becoming increasingly volatile (Camarinha-Matos, et al., 2008). This volatility is a result of that the globalised market and its customers demand new products and offerings in line with the rapid technology advances (Surbier, et al., 2013). So the emerged landscape of diverse and intense customer demands creates pressure on firms to become more innovative and more efficient in developing innovative products (Williams, et al., 2007; Surbier, et al., 2013). As a result, manufacturing firms have to develop and produce products faster, at lower costs, and with increased quality in order to maintain their competiveness (Arnold & Floyd, 1997).

In response to the market pressures many multinational corporations (MNC) locate mass-production sites in low-cost countries (Penide, et al., 2013). This forces operations in industrialised countries to shift focus, from mass-production, to becoming very effective in industrialising new products (Ibid). Industrialising new products is the process of developing new products and then transferring them, for instance to an offshore mass-production site. This process of industrialising new products in manufacturing firms involves the development of new products and production processes (Cormican & O'Sullivan, 2003).

"Product Lifecycle Management (PLM) is the business activity of managing, in the most effective way, a company´s products all the way across their lifecycles."

- Stark (2011, p. 1)

In order to manage and create a streamlined global value chain many MNC adopt a product lifecycle management (PLM) approach for their operations. This since PLM is argued to support MNC in managing complex product lifecycles and to improve the efficiency of product development (Stark, 2011). The PLM is, as defined by Stark (2011), concerned with a product from the beginning of its life as a concept, through the development, introduction, growth and maturity of the product, all the way to the products end of life. Further, the PLM spectrum can be divided into two separate phases; the new product introduction (NPI) phase and the maintenance phase (Saaksvuori & Immonen, 2005).

"NPI: this is the product launch process of a new product, which starts from the product idea and ends with the arrival of the product on the market."

- Saaksvuori & Immonen (2005, p. 243)

The NPI phase in PLM involves processes that represent a MNC capability to industrialise new products in an effective way (Stark, 2011). The NPI process is an important aspect of the PLM when looking from a product management point of view (Saaksvuori & Immonen, 2005). An efficient NPI process is a vital part of the PLM approach firms adopt (Tennant & Roberts, 2003; Williams, et al., 2007). This is especially important in order to decrease time-to-market, to meet market demands, and shorter product lifecycles (Arnold & Floyd, 1997; Stark, 2011), which is seen as a critical factor for competitive advantage in highly innovative industries (Datar, et al., 1997). NPI basically involves developing new products and introducing them on the market. Within PLM and the NPI process, included operational processes are more focused on producing product data than physical products (Saaksvuori & Immonen, 2005).

""Product data" includes data related both to a product and to the processes that are used to imagine it, to design it, to produce it, to use it, to support it, and to dispose of it."

- Stark (2011, p. 115)

Within PLM and especially for manufacturing firms responsible of developing products, a vast amount of product related data and information is not only required, but also produced (Stark, 2011). This product data sets the basis for enabling efficient and effective development, production, and maintenance of a product throughout its lifecycle (Ibid). As NPI is included within the PLM spectrum, this is also the case for the NPI process (Saaksvuori & Immonen, 2005). However, the NPI process is within the development spectrum in a product lifecycle so a lot of new product data, not products, is produced in this process. This new product data is then what ensures an effective introduction of a product – as it is not a physical product per se that is transferred, but rather product data that entails information regarding how to produce a product (Saaksvuori & Immonen, 2005). Product data in this thesis includes all product related data, information, and knowledge.

"PDM systems have been developed to manage the large volume of information created in modern design environments more effectively and to meet demands for faster development of more complex products."

- Crnkovic et al. (2003, p. 17)

One of the largest challenges for firms operating with a PLM focus is how to manage product data – as product data has to be organised and maintained in an effective way in order to retain its value (Stark, 2011). This implies that without proper product data management, the product data will lose its value and therefore disable firms to reap the benefits that product data provides. This is why product data management (PDM) emerged. PDM includes systems and policies of how created product data should be managed so that involved functions in a product lifecycle can effectively make use of it (Saaksvuori & Immonen, 2005). If an effective PDM is not present to effectively manage product data – then the management of the product will be ineffective (Stark, 2011). This implies that if firms fail at managing product data – firms will be ineffective at developing, producing, and supporting products.

"Success in the future, as in the past, will surely lie in the ability to acquire and utilise knowledge and apply this to the development of new products. Uncovering how to do this remains ones of today's most pressing management problems."

- Trott (2005, p. 10)

So how product data is managed in the NPI process have consequences on how well the product data can be maintained and reused. Often a lot of time, and therefore money, is lost during product development due to insufficient management of product data (Stark, 2011). This can be connected to a quantitative research conducted by Kontoghiorghes, et al. (2005), whose research results implied that providing access of past and current experience e.g. facts and information from product development is correlated to improved product development. Further, Pentina & Strutton (2007) argued that processes connected to information gathering, usage, and storage (termed information-processing) during product development is of great importance for a streamlined NPI process. This implies that if the right individuals involved in product development can access or reuse product data, in a timely matter, and in a simple way – the product development process in NPI could be improved. In other words, effective product data management is critical for manufacturing firms in high-tech industries in order to be enabled to develop, introduce, and produce new products in a streamlined way.

Research Context

"PDM as a research field is not yet fully consistent. There are no unifying theories and the definitions are sometimes vague. This may be because the scope of the PDM is wider than that of many other research areas."

- Crnkovic et al. (2003, p. 45)

"PDM is a relatively new academic research area, and as a consequence the literature is somewhat scarce on practical solutions, including description on how data ownerships are defined, how PD are maintained, what are relevant process solutions."

- Kropsu-Vehkapera et al. (2009, p. 770)

This report will explore the PDM context in order to contribute to the research field in terms of practical and process solutions implemented related to how product data can be gathered, stored, and managed in a NPI context – in which products are developed. The effect of product related information, defined here as product data, and involved processes to gather, store, and use it in product development is something that academia welcomes research contribution of (Pentina & Strutton, 2007; Kropsu-Vehkapera, et al., 2009).

This research is conducted through a case study of a supply-site organisation with PLM responsibility for the products developed on-site. The organisation is incorporated in a world leading Swedish MNC, operating in the information and communications technology (ICT) industry. The case organisation will be introduced in [Chapter 4]. The case organisation is operating in an industrialised country and in a high-tech industry with rapid technology advances. The case organisation has gone through several changes the last decade – as reorganisations and downsizes has been executed as a result of strategic decisions on corporate level to offshore mass production to low-cost countries, which is a common tendency for MNCs (Penide, et al., 2013). This has forced the case organisation to change its focus from general production into developing and industrialising new products to offshore mass-production sites – i.e. operating in a NPI context. Therefore has the organisation faced the pressures presented in the introduction to become more efficient in developing new high-quality products, introduce them, in order to enable mass production. Within the case organisation, product data management is an important aspect of NPI activities – i.e. how product data is gathered, stored, and shared internally.

1.2 Problem Formulation

The NPI phase consists of several steps and includes cross-functional stakeholders. In order to achieve effective NPI and product development process, all product related data and information – i.e. product data – must be gathered and shared in an effective way between these stakeholders. Often the organisation connected to an NPI-process is complex and therefore the importance of effective product data management is crucial. As most product data during product development is gathered during product realisation activities often performed in a production environment, the production processes should therefore be effective and standardised so that product data can be easily gathered and stored. This is important in order to enable easy access and transfer of product data to key stakeholders, which is required to achieve a streamlined NPI process.

1.3 Objective

The objective of this master thesis is to investigate and analyse the importance and complications regarding product data management in a NPI context – connected to the processes performed by a high-tech firm in order to gather, store, and use product data during product development.

This objective is set in order to both support the case organisation and to contribute to the PDM research field in terms of providing empirical contribution of processes used to acquire and integrate product data in a NPI context.

1.4 Research Questions

- Within a NPI context, how can product data be gathered, stored, and shared during product development – i.e. what processes can be used?
- What complications can be present regarding product data management and the involved systems and/or tools used during product development?
- What product data is important to gather from the production during product development?

1.5 Delimitations

This section will present some delimitations made in the research.

1.5.1 Theoretical delimitations

The case organisation has a lean focus in its operational strategy and has implemented several lean initiatives. However, lean theory in the research has been excluded as the focus is on PDM and on empirical findings regarding ways-of-working and not the underlying concepts or methods implemented in the organisation.

Based on theory, product data in this thesis is defined as including all product and process related data, information, and knowledge (Stark, 2011; Saaksvuori & Immonen, 2005) including knowledge as well. One could argue that this would fall into the theoretical concept of knowledge management. However, the theoretical concept of knowledge management has been excluded. In certain knowledge management theory it is argued that there should be a distinct differentiation between data, information, and knowledge (Haney & Driggers, 2010; Spiegler, 2000; Zins, 2007). This distinction will not be made in this thesis. Product data is used for all product related data, information, and knowledge of a product and the processes performed to realise it. In certain cases theory from knowledge management and information management has been applied – due to the product data definition used in this thesis and the rather scarce academic research concerning PDM (Kropsu-Vehkapera, et al., 2009).

1.5.2 Empirical Delimitations

Within the case organisation the Operations department manages the production shop floor realisation of NPI products. A delimitation made in this research was to focus on product data management and involved processes within the Operations department and especially on processes related to the output from the production shop floor. This is based on that a lot of product data is produced within operations (Stark, 2011) and as operations management can be seen as controlling the transformation of input into output (Trott, 2005). The main mission within the Operations department today is to provide production feedback – termed gathering of product data in this thesis – to internal stakeholders in order to develop new products that meet customer requirements and that enables offshore mass-production. The main output from the production shop floor is therefore product data, not physical products. The product data management in this process is therefore important and will therefore be the main focus. This is founded on the argument that much of the initial and important product data related to product development and introduction is produced within the production in the product development stage (Stark, 2011).

There are additional processes connected to the product development within the case organisation. For instance, in addition to realise new products the supply chain is secured concurrently. This process of securing the supply is excluded in this thesis. Also, the research has been delimitated to focus on the main product developed on-site – radio filters – even though other products are managed within the case organisation.

1.5.3 Research Delimitations

In industrial management there are three different levels to consider; the individual, the functional, and the industrial level (Blomkvist & Uppvall, 2012). These are all interlinked and it is important to understand the connection between these levels when analysing industrial management issues. These three levels has been connected to innovation and product development theory, *see figure 1*.

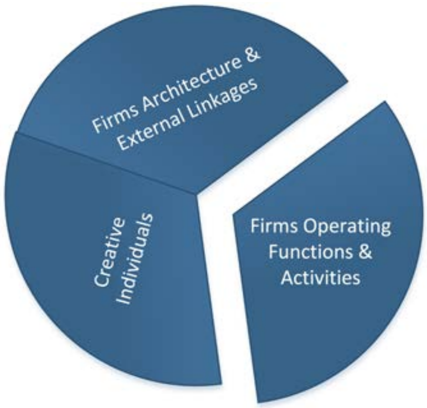

Figure 1: The three levels of innovation, as adopted from Trott (2005, p. 10).

The individual level in innovation theory constitutes of creative individuals who provide inputs as a result of technological development. The functional level is connected to the firms operating functions and activities, as firms develop knowledge, processes, and products by operating on a daily basis. The last level, industrial level, is connected to firms coping with external pressures, demands, and opportunities emerged from social- and market changes that affect the firm's architecture. In this report the focus has been on the 'Firms Operating Functions & Activities" – i.e. the functional level (Blomkvist & Uppvall, 2012). In this thesis primary data will mainly be discussed in relation to this level, in order to analyse processes connected to product data management. However, the individual and industrial levels will mostly be covered by secondary sources – i.e. theoretical literature.

2. METHODOLOGY

In this section the methodology for the research will be presented. Including a description of the methods used to gather primary data from the case company.

The case study research methodology has been used to conduct research of the presented phenomena. This case study was conducted in an interpretivistic way that induces a mind-set to investigate social reality within a specific context, through a process that is affected by the researcher (Collins & Hussey, 2009). This methodology was chosen as a more open research strategy was more suitable – to enable development and adaption of the process during the course of conducted research. This has also been argued to be a preferable research approach when conducting a case study (Verschuren, 2003) especially of interpretivistic nature (Yin, 2003).

In general a case study can involve one or many cases and can combine several different data collection methods, both qualitative and quantitative in order to find answers (Eisenhardt, 1989; Verschuren, 2003; Yin, 2003). In accordance to the interpretivism paradigm (on a technical level) and the case study methodology, the process of gathering empirical data in this research is primarily based on qualitative methods (Collins & Hussey, 2009). The actual research strategy and process will be discussed in more detail in the following sub-sections.

2.1 CASE STUDY

The methodology case study is often defined as an investigation focused on exploring one single phenomenon and the complexity of a certain case in a natural setting (Collins & Hussey, 2009; Stake, 1995; Eisenhardt, 1989). Connected to interpretivism a case study approach should be open-ended (Verschuren, 2003) and not only explore a certain phenomenon, but also serve as a tool to understand it in its specific context (Yin, 2003). Basically, a case study is a research strategy that consists of several different methods, techniques, and procedures to collect and analyse primary data and also accounts for how the researcher interprets reality and designs the research (Verschuren, 2003). The objective of this master thesis is to explore, understand, and describe a certain phenomenon within a specific context from which new knowledge can be created. Therefore, a case study methodology with an interprevistic focus been chosen. In this research a case study will be defined as:

"A case study is a research strategy that can be qualified as holistic in nature, following an iterative-parallel way of preceding, looking at only a few strategically cases, observed in their natural context in an open-ended way, explicitly avoiding (all variants of) tunnel vision, making use of analytical comparison of cases or sub-cases, and aimed at description and explanation of complex and entangled group attributes, patterns, structures, or processes."

- Verschuren (2003, p. 137)

This definition sets the foundation of how this case study research was conducted. As mentioned, in order to conduct a case study the phenomena and its context must be not only be explored but also understood. This is why a holistic focus is important (Verschuren, 2003). A holistic approach is beneficial from an iterative-parallel strategy. This implies that the research is conducted with little constraints at the beginning and that the research can develop throughout the research process (Verschuren, 2003). For instance, initial research questions can be change during the course of the research – by being adapted to the primary data findings. This has been performed in this research.

In this case study the research has been divided into three different levels, the individual level, the functional level, and the industrial level – or the three industrial management levels. The focus has been on the functional level, as mentioned in delimitations. Most of the primary data was collected regarding processes that the case organisation performs. However, attention to individual and industrial level has been acknowledged. This is aligned with the case study definition previously defined. It is important to not overlook cause-and-effect relations in case studies, nor to miss that research objects are part of something bigger and that the holistic picture must be taken into consideration (Verschuren, 2003). So the case organisation on the functional level was set as the research unit, using the definition:

"Research unit is an object about which the researcher wants to produce knowledge."

- Verschuren (2003, p. 125)

Also, to conduct research with focus at a group level (e.g. characteristics, culture), rather than on an individual level (e.g. individual traits) is preferred in an iterative-parallel research strategy (Verschuren, 2003). The open-ended research the iterative-parallel strategy represents should leave room for research adaption to findings and research adoption – of new knowledge, which should guide the researcher and allow the research approach to develop.

This research started with performing a current-state analysis where the case organisation was investigated through appropriate methods. The delimitations at the beginning were vague and open-ended. This was performed in alignment with trying to explore, understand, and describe the phenomena and its context. Then the research was narrowed down by identifying focus points in which the richest primary data could be found. This was to highlight areas from which most knowledge could be retrieved from. This has also included an iterative process of defining research questions and interview conscripts throughout the research.

There has been criticism to case studies according to Verschuren (2003), mainly regarding the research quality, validity, and due to the rather researcher-dependent nature of it. However, case studies conducted by the definition given earlier eliminate the criticism of case study quality (Ibid). This is valid as long as the case study is conducted in a holistic way and aims to understand and describe a complex research unit and its context. According to Verschuren (2003) a case study should start by answering two prerequisite questions; what is investigated? And how is it investigated? In other words, a unit of analysis must be set and appropriate research methods to be used. The two questions will be answered in the following sub-sections.

2.2 UNIT OF ANALYSIS

"The unit of analysis is the phenomenon under study, about which data are collected and analysed."

- Collins & Hussey (2009, p. 115)

Answering the – 'what is investigated?' question is important in order to avoid tunnel vision. Tunnel vision is the risk of looking at a unit of analysis at; one single point in time; detached from its context; neglecting relationships with other objects included in the case; and neglecting the functions it performs for the case it is part of (Verschuren, 2003). The same author argues that researchers must understand the phenomena and its context before conclusions can be drawn, also that focus should be on observations of structures, mechanisms, patterns instead of variables, and to focus on processes, dynamics, and developments to avoid time constraints. Therefore, this research has had focus on observations and interviews on organisational processes by using an iterative-parallel research strategy. The unit of analysis for this research is the case organisation, which will be presented and discussed later in the report. The main focus has however evolved to focus on the operations function within the case organisation – and the identified functional processes to gather, store, share, and use product data.

2.3 DATA COLLECTION

Answering the second question – 'how is it investigated?' is important as to determine how data should be collected. This research will be based on both primary data – *"data collected from an original source"* (Collins & Hussey, 2009, p. 23) and secondary data – *"data collected from an existing source"* (Collins & Hussey, 2009, p. 23). Primary data has mainly been collected through qualitative methods. Qualitative methods are preferred to produce holistic observations and to have an open-ended research approach – to secure that the case study investigates the research unit in its natural context (Verschuren, 2003).

Data collection methods can help to reduce tunnel vision further. Methodological triangulation – using several methods for explaining and understanding a phenomenon (Collins & Hussey, 2009) is important as it reduces tunnel vision (Verschuren, 2003). According to the same author, observation states behaviour, but not the motive behind it, whereas interviews may describe the motive for behaviour but not the behaviour itself. Triangulation is also an effective method to increase reliability and validity of primary data findings (Collins & Hussey, 2009).

The main methods used in this case study to collect primary data were interviews and observations, which both are qualitative methods that foster a more holistic understanding than quantitative (Verschuren, 2003). This is aligned with the case study strategy used in this research. These two methods served as the foundation to develop a deeper understanding of the research context – i.e. the case organisation and its functional processes. Secondary data was gathered from the case organisation's intranet from which internal information can be attained. The secondary data has been primarily used to describe existing processes and the context in which the case organisation operates in.

2.3.1 Interviews

The method that will be the primary method when gathering primary data is interviews. The interviews are a vital method when gathering information regarding the case organisation and the processes that is being conducted at a daily bases (Collins & Hussey, 2009). Most interviews were conducted on-site at the case organisation and was conducted face-to-face with interviewees. Also, many of the interviews were conducted by two interviewers – one in charge of the interview and one taking notes during the interview. This was executed in order to get as much information down immediately, but also to have a wider spectrum to analyse answers directly and follow up findings with open-ended questions (Collins & Hussey, 2009).

In order to receive as much valuable information as possible semi-structured interviews were conducted (Collins & Hussey, 2009). By applying the semi-structure with open-ended questions the interview can be kept on the right subject and guided the way that is intended but also at the same time allow for the interviewee to share the information he/she thinks is vital (Moyle, 2002). Semi-structured interviews are also preferable in an interpretivistic case study research (Collins & Hussey, 2009). Open-ended questions are also in line with the research strategy chosen, as otherwise a reductionist approach can be adopted that reduces the quality of the case study results (Verschuren, 2003). Open-ended questions allowed a more holistic research agenda as interesting and new issues could be pursued; also more in-depth information could be obtained (Collins & Hussey, 2009).

In accordance to the defined case study strategy, an iterative-strategic sampling, such as snowball sampling is preferable and should be included in an iterative-parallel research design (Verschuren, 2003). Snowball sampling is also connected to research conducted in the interpretivism paradigm (Collins & Hussey, 2009). Snowball sampling was used during interviews in order to find suitable interviewees involved as stakeholders in different processes. A Stakeholder in this research is based on the definition: *"any group or individual who can affect or is affected by the achievement of an organizations purpose"* (Freeman, 1984, p. 46). This was important as to find cause-and-effect relations and to get a holistic understanding of the processes performed in the unit of analysis (Verschuren, 2003).

Interview Cycle 1

The first interview cycle was founded on information gained from three different managers within Operations. Their recommendations of involved roles and functions in processes set the initial interview cycle. Then the first interview cycle was expanded by using the snowball sampling method to identify new interviewees. These were identified and recommended either as new stakeholders or as individuals that possessed specific information or knowledge suitable for the research. The first cycle of interviews was conducted with the aim of identifying involved stakeholders, but also to create a holistic understanding of the processes and context. This process is also in alignment with the case study methodology. The result was a current-state analysis that was used to identify and describe both the case organisation and its processes related to product data – that will be presented later in the report.

Even though snowball sampling is appropriate it could become personal biased, as it could become dependent on employees individual contact network within the organisation. As a result, the primary data could become to describe a process that is only valid in certain inter-personal networks. Therefore, if applicable, when a new recommended interviewee was contacted a colleague of he/she was also contacted. This was done to expand the snowball sampling and select multiple interviews based on role or function, rather than on personal recommendation of a single individual.

Interview Cycle 2

The second interview cycle was executed in order to gather more in-depth primary data regarding identified focus points from interview cycle one. This was part of the research strategy as it was open-ended. Certain key stakeholders were chosen to be interviewed again and interviews were performed in order to gather in-depth information. During this time, observations were also performed and questions in relation to observations were also asked. As the research was conducted on-site at the case organisation – access to key individuals and stakeholders was high and continuous. This interview cycle also had focus on the current state analysis, but was based on the interview cycle 1 findings. In this interview cycle issues present in the organisation related to work processes was identified. The stakeholders of the outbound product data from operations were in focus in this cycle – i.e. other internal functions related to product development. Due to the diverse sample, the interviews required some adaptation of the questions asked to different interviewees.

Interview Cycle 3

The interviews in cycle 3 focused on gathering additional in-depth primary data regarding processes used to gather and store product data. In this interview cycle the focus of the questions were on what information the interviewee required or lacked in identified processes. Also additional issues regarding the processes were identified – with more focus on PDM systems interaction in the organisation. These identified issues was analysed as improvement factors of the current processes and how the processes identified could be improved. The questions in this interview cycle was still open-ended but had a more specific nature as well as adaption to the involvement of the interviewee in different processes. This was a natural step as the research developed throughout the process and as stakeholders in different processes had been identified.

2.3.2 Observations

This master thesis was mainly conducted at the location of the case organisation, which enabled great opportunity for observations. The observation method that will be used is more of a participant observation, where the information will be gathered by interaction, rather than non-participant observation (Collins & Hussey, 2009). Observations should also preferably be performed in connection to processes – in order to minimize the time aspect in tunnel-vision e.g. synchronic focus (Verschuren, 2003). Therefore, the continuous observations have been conducted to gather primary data at different times connected to the same process.

Case-relative observation methods have been based on the fact that the authors have had direct access to the production floor and the office landscape, in which the organisation performs their day-to-day work. Attendance at certain meetings has also been possible. In this case investigation especially one meeting has been of special interest – morning meetings at the production floor. This enabled access to observe issues that occurred in real-time and to talk to involved individuals. For instance, if an issue emerged in the case organisation questions related to that issue and the process could be asked straight away – resulting in direct primary data gathered connected to special issues.

However, none of these observations have been recorded, neither has the questions asked been compiled. There could also be some effects of preferable behaviour from the observed individuals within the case organisation – as observations could affect the behaviour of the observed (Collins & Hussey, 2009). This could lead to misguided behaviour and therefore reduce the quality of the research. It is stated that preferable behaviour effects from observations could be minimised by stating a different research focus than the actual one conducted (Collins & Hussey, 2009), however due to ethical issues this has not been done.

The morning meeting observed is a meeting where information is shared between operations and other functions. A recap of production progress (for production runs) of the previous day and present day is presented by team leaders to attenders. This is presented at a set of visual boards in order to simplify information sharing. Different management and functional roles are present. The main reason of the observations at these meetings was that production issues were highlighted and the meeting represented a forum where information regarding production progress and performance was shared. From these observations issues and primary data regarding processes could be attained.

2.3.3 Secondary Data

Access to data, both primary and secondary, can be an issue in research (Collins & Hussey, 2009, p. 114). In this research, access to the case company's intranet was granted from which internal data could be gathered regarding production processes, documents, reports etc. The secondary data in this research is mainly used to support primary data – i.e. describing processes and the organisation. To some extent, secondary data has been used to compare with primary data findings – i.e. differences between gathered primary data and secondary data regarding a process.

2.4 Ethical Issues

All of the interviewees were asked if the interviews could be recorded and all participants accepted this request. However, some wanted the recordings to be deleted after the analysis of the interview was conducted. This promise was kept and not all interviews are available.

Ethical issues, concerning the research methods were presented for the interviewees at initial stages before conducting them. Information regarding the secrecy of the participant was given and everyone was asked for permission to present primary data findings, but with the participant's work-role as description. This is ethical issues that need to be in place when performing research (Collins & Hussey, 2009). Also, when required, information regarding the non-disclosure agreement signed by the researchers was given to the participant – so that the interviewee could share information in a comfortable way.

Also, all primary data and secondary data have been checked by case company supervisors in order to retain a level of confidentiality and anonymity corresponding to the case organisations requirements. This has also to some extent reduced the level of detail in certain aspects, but overall the presented primary data and findings are sufficient to present a valid picture of the case study and research topic.

2.5 Case Study Research Map

To illustrate the development of the research in connection to the chosen methodology a research map was constructed, *see figure 2*. The map represents how the research problem has been approached, it also represents how the research has been conducted and evolved. This is the result of analysing the case organisation and primary data gathered from conducted interviews and observations. The research conducted has had a iterative nature and evolved through findings from primary data. The literary review has been adapted along the way, and the next section will present the theory and theoretical areas that has been the final framework when analysing findings.

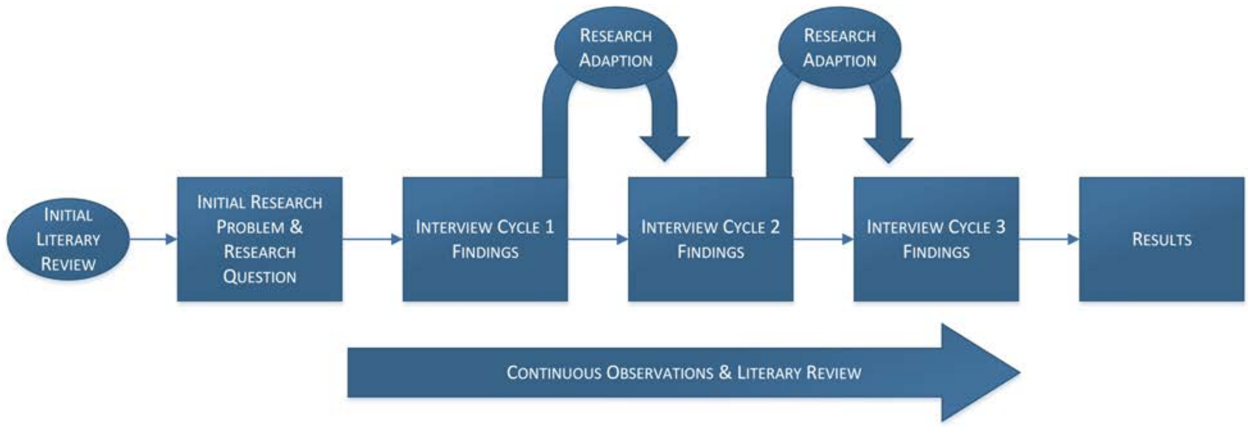

Figure 2: Illustration of the case study research map and its iterative nature.

3. THEORETICAL FRAMEWORK

In this section the theoretical framework of this thesis will be presented. The purpose of this section is to grant basic understanding of the theory related to the conducted research, and the context in which the case organisation and therefore the research are conducted in.

An overall view of the theoretical framework and its connection to the conducted case study can be seen below, *see figure 3*. The initial theoretical framework was primarily identified before the research was conducted. The adapted theoretical framework is the part of the literary review that has evolved throughout the research in connection to empirical findings.

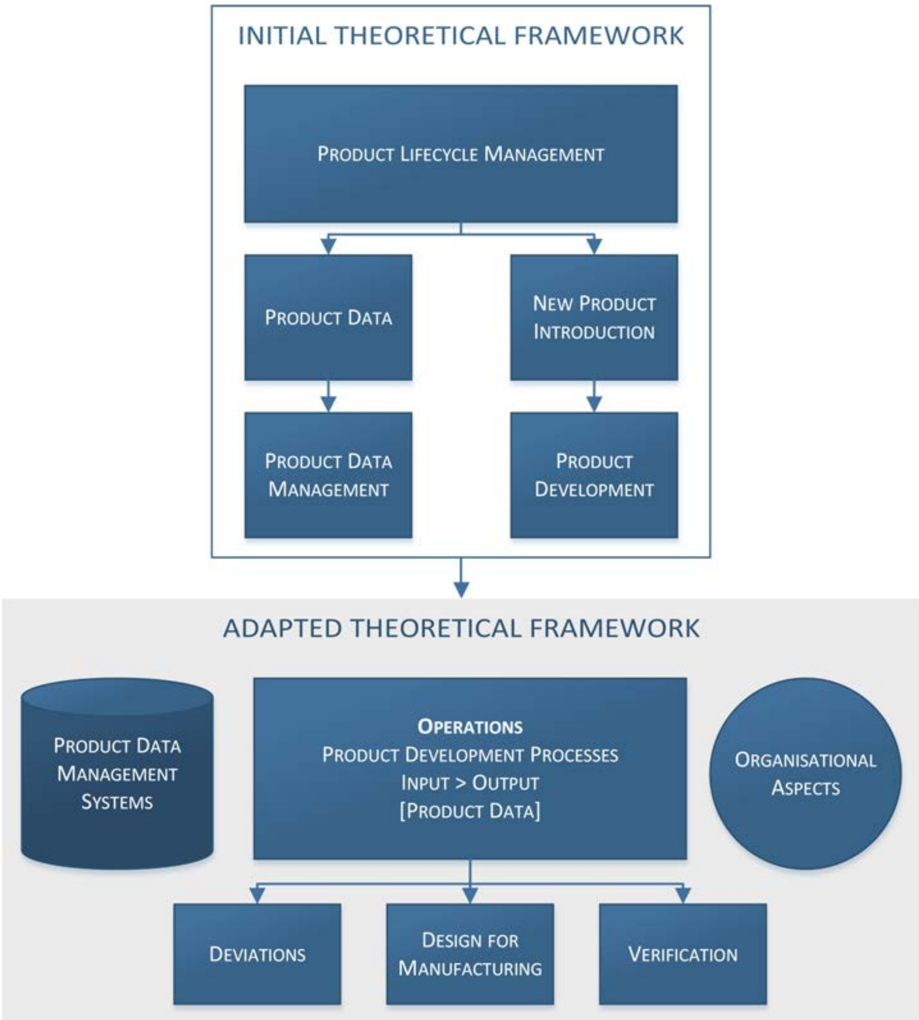

Figure 3: Overview of the theoretical framework.

3.1 PRODUCT LIFECYCLE MANAGEMENT

Product lifecycle management (PLM) can mainly be described as a corporate approach that focus on product management (Saaksvuori & Immonen, 2005), *see figure 4*. PLM consists of activities that enable effective product management, from a product's emerging stage as an idea through its lifecycle until it is removed from the market – i.e. throughout the product lifecycle (Stark, 2011). The PLM spectrum can be divided into two different phases; the NPI phase and the maintenance phase (Saaksvuori & Immonen, 2005). When a new product concept emerges it starts in the NPI process and continues onward until the product is introduced on the market. When the product is introduced to the market the maintenance phase starts. This stage involves product management in terms of maintenance and product changes of the introduced product until it is removed from the market (Saaksvuori & Immonen, 2005). PLM includes a lot of activities and the main ones are presented below, *see table 1*.

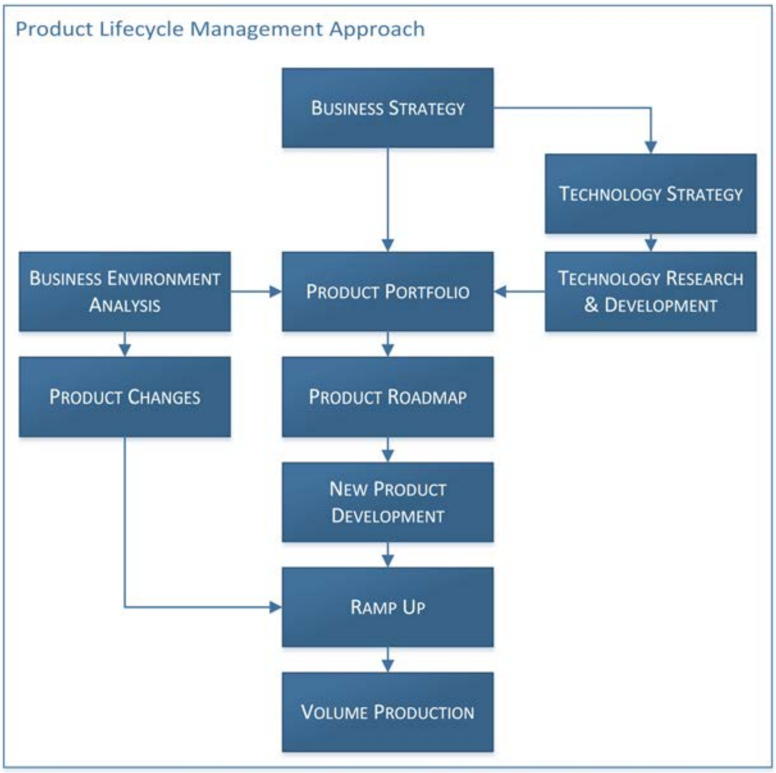

Figure 4: Illustration of the product focus in PLM (Saaksvuori & Immonen, 2005, p. 202).

Product Lifecycle Management Activities:
• Manage the product portfolio
• Maximising financial return from product portfolio
• Provide control and visibility over products throughout its lifecycle
• Manage products throughout its lifecycle
• Manage product development, support, and disposal projects effectively
• Manage feedback about products from customers, market, etc.
• Enable collaborative work with design, supply chain partners, and customers
• Manage product-related processes to ensure coherent, effective, and lean ways of working

Table 1: Main product lifecycle management activities (Stark, 2011, p. 2).

3.1.1 Product Lifecycle

The product-life cycle model has been used as a tool for firms to follow a product through different stages in its market, basically from its birth to death, in order to support product planning and strategic decisions (Cannon, 1978). This definition is however connected to marketing theory and market-based stages (Stark, 2011). Saaksvuori & Immonen (2005) use the following phases in PLM to describe a product lifecycle; planning, introduction, growth, maturity, decline, and retirement and connects these to the two PLM phases new product introduction (NPI) and maintenance, *see figure 5*. The planning and introduction phase includes conceptual realisation of new products, its manufacturing process, and its introduction to the market. The growth phase involves securing volume production without quality loss. In the maturity phase the product and market matures and the main focus is on attracting new demand by incremental product changes. The decline phase involves activities to start phase-out of a product – i.e. removing it from the market. The last phase, retirement includes to eliminate the product from the market and in internal processes and systems.

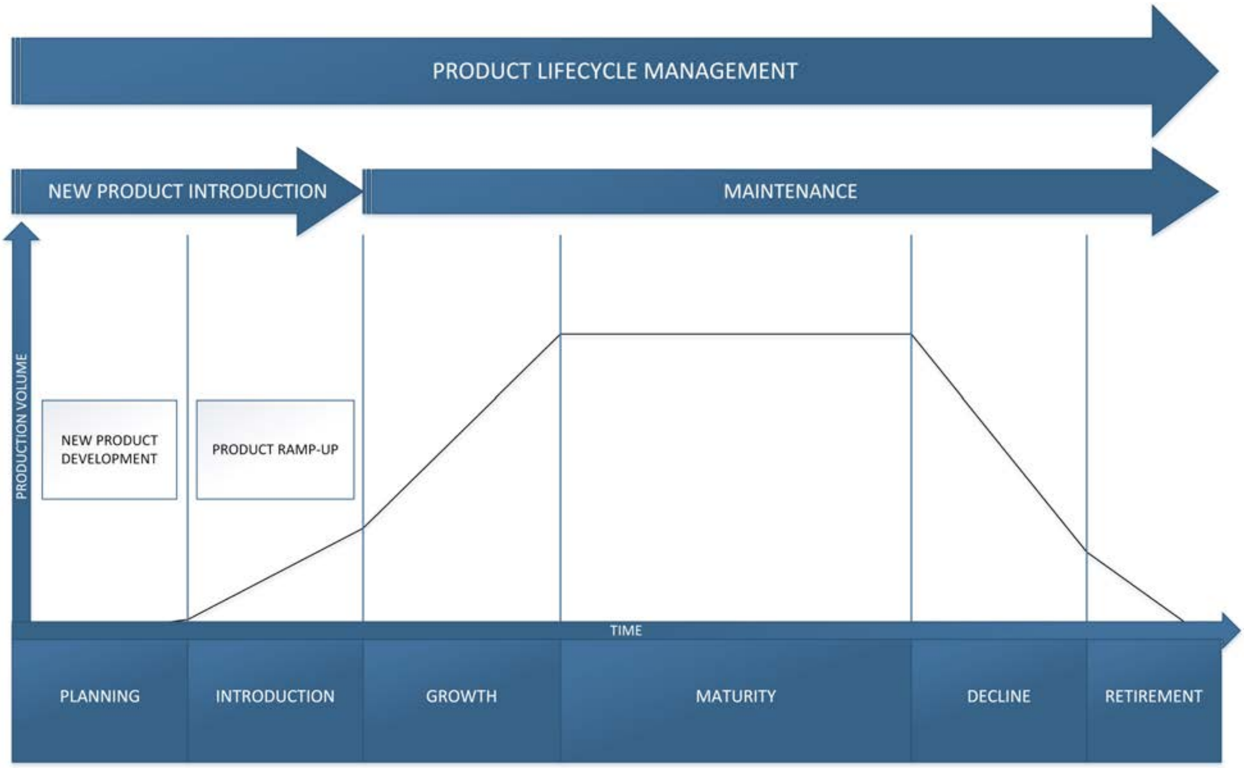

Figure 5: Illustration of the connection between product lifecycle stages and PLM phases.

3.2 NEW PRODUCT INTRODUCTION

The different stages within NPI starts with the development of a new product and ends when a product is matured enough for volume production. A global NPI process can be divided into three different stages, *see figure 6,* as adapted from H.-H. JK Li et al. (2013). These stages involves to realise a new concept into a complete physical product according to customer and firm criteria (e.g. in terms of cost, quality, functionality, manufacturability, etc.) and to ensure its capability to be mass-produced. When the product is matured enough and meets customer and firm criteria it is transferred into the maintenance phase. In the first stage new products are innovated, designed, and developed, often through prototyping in order to successfully introduce and start production of a new product. The second phase often consists of transferring the developed product & process to an offshore mass-production site. The third stage involves ramp up. Production ramp-up is the phase between product introduction and the start of mass production of a new product (Terwiesch & Bohn, 2001) – i.e. the process to reach production volume required by demand. When the new product has gone through ramp-up, it is ready for volume production at a mass-production site. Thereby is the total NPI process to an end and the product enters the PLM maintenance phase that involves volume production and incremental improvement of the product.

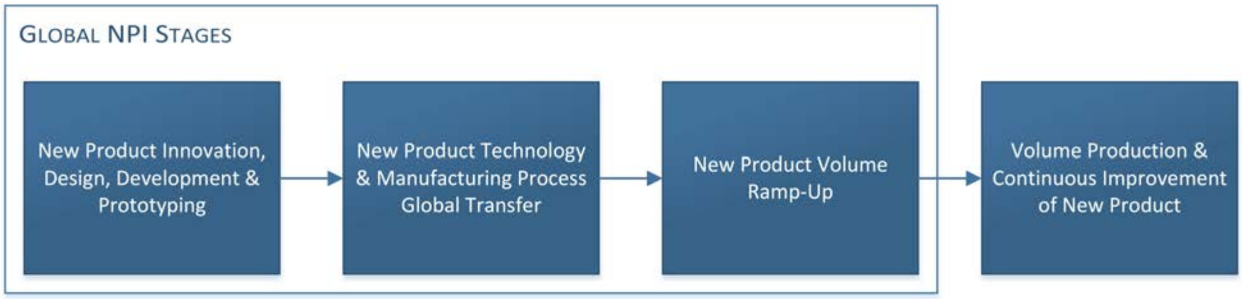

Figure 6: NPI stages and included activities, as adapted from H.-H. JK Li et al. (2013).

3.2.1 New Product Development

New product development (NPD) is the process in which a product is transformed from an idea and conceptualised into a physical product (Cannon, 1978). NPD involves the management of every function or disciple included in the process of developing new products, which makes NPD a complex process to manage (Trott, 2005). NPD can be connected to the first stage of NPI, as presented in *figure 6*, in which a new product is developed from concept to a fully functional physical product. The different functions or disciples that theoretically are included in NPD is presented below, *see figure 7,* and the research scope in this thesis is highlighted.

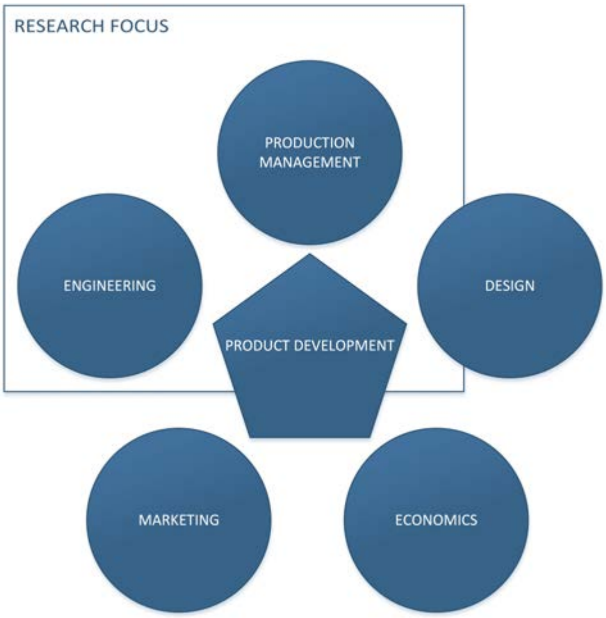

Figure 7: Common disciples involved in product development (Trott, 2005, p. 384).

The NPD process can be described in a step-by-step process, *see figure 8*, (O'Connor, 2005). The process basically starts with securing strategic alignment of the new product. The 'Front End' of NPD includes activities to search and analyse ones business-, industry-, and market environment for interesting markets, segments, technology, products etc.; analyse the internal capabilities of pursuing identified new products; then generate and analyse the feasibility of new concepts developed. The

'Front End' stages can thereby be mainly connected to the marketing, economics, and design disciples, as presented in *figure 7*. After the 'Front End' stages, the product development stage in NPD is performed. In this stage a new product often goes through a phase-gate system, where the product is developed and conceptualised in a step-by-step and iterative process into launch (O'Connor, 2005), often through prototyping (Silverstein, et al., 2009). The last stage, and research focus, often includes the disciples production, engineering, and design (Saaksvuori & Immonen, 2005) as highlighted in *figure 7* above.

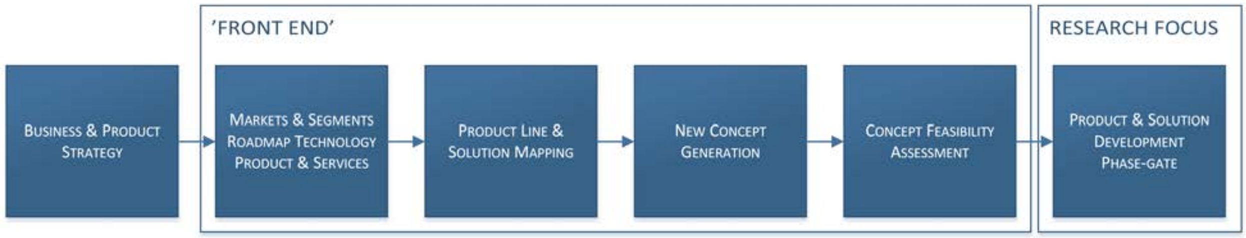

Figure 8: Overview of NPD stages, as adapted from O'Connor (2005, p. 60).

Prototyping consists of developing iterative versions of a new product to check its functionality, robustness in terms of quality and design, determine the best production process, and suitable production equipment, tools, and fixtures – i.e. develop and verify a product & process in steps in order to ensure a fully functional product that can be mass-produced in a cost-effective way (Silverstein, et al., 2009; Cooper, 2008). Prototyping can also include overlapping development steps, where different components included in a final product are developed concurrently that reduce development time (Terwiesch & Loch, 1999). The phase-gate system includes decision gates that specify certain requirements and in prototyping these decisions determine whether a product can continue in the development process – based on testing and verifications to ensure requirement fulfilment (Cooper, 2008).

3.2.2 Product Platform Development

Closely related to product development is product platform development. Product platform development consists of developing new products based on a standard platform that new products stem from. Product platform development enables firms to derive new products or product families by modifying a product platform by changing one or many modules that the product platform consists of, which results in development benefits in terms of cost, lead-time, product differentiation (Simpson, 2004), and manufacturing flexibility and responsiveness (Robertson & Ulrich, 1998). A product platform can be defined as:

"…a set of common components, modules, or parts from which a stream of derivative products can be efficiently developed and launched."

- Meyer & Lehnerd (1997, p. 7)

Information reuse and supporting information management systems are especially important for product platform development, as it includes developing derivatives of products that are similar (Simpson, 2004; Alizon, et al., 2006). Designers of product & process can benefit from reusing experience connected to previous process developments connected to new products, especially for platform based products (Alizon, et al., 2006). This also includes process design, production line layout, and equipment (e.g. tools, assisting technology, fixtures, etc.) (Ibid).

3.2.3 Design for Manufacturability

When discussing the development of new products the process of design for manufacturability is a key aspect (Selvaraj, et al., 2009). Manufacturability or producibility is terminology used to describe the ease of which a product or component can be manufactured (Elgh & Cederfeldt, 2007). The main purpose of design for manufacturability is to develop and design a product & process that improves manufacturability (or producibility) without decreased product functionality or performance (Venkatachalam, et al., 1993). Design for manufacturability stems from concurrent engineering (CE) that emerged in product development in order to be enabled to concurrently design new products & processes in product development (Lehto, et al., 2011) and are stated to be one the most important techniques in CE (Swift & Brown, 2003). Methods and tools implemented in product development in order increase a product's producibility is termed design for manufacture (DfM), and related to product design for simplified assembly is termed design for assembly (DfA) (Elgh & Cederfeldt, 2007).

Design for Assembly

Design for assembly (DfA) is often implemented in product development to minimise part variation and to simplify the assembly process, in order to increase quality and reduce assembly issues (Selvaraj, et al., 2009). DfA includes design rules to standardise production processes as much as possible, as well as develop component commonality for products. DfA has also been stated to lower product defects by 80%, and assembly lines are often hampered due to product defects, e.g. defect components or workmanship related mistakes (Booker, et al., 2005).

Design for Manufacturing

Design for manufacturing (DfM) is also often performed in the product design phase – i.e. in product development to increase its producibility in terms of product- and process design (Elgh & Cederfeldt, 2007). DfM can be seen as a strategic approach when developing new products, as it focus on increasing a product's manufacturability through design alternations concerning assembly, testing, and manufacturing (Dröge, et al., 2000; Ferrer, et al., 2010). DfM is often used to minimise production tools and fixture variety, in a product & process design perspective, and also to identify and eliminate manufacturing issues during the product design phases (Selvaraj, et al., 2009). The DfM design process is knowledge intensive – as a lot of product & process insight is required from the responsible product & process designer (Elgh & Cederfeldt, 2007).

Applying DfM in early product development stages can severely minimise downstream delays and therefore development costs due to late design changes (O´Driscoll, 2002; Dröge, et al., 2000). Often DfM includes the use of continuous verifications, including testing of components or products (Dröge, et al., 2000), for instance in prototyping development (Silverstein, et al., 2009). These design verifications often include interactions with product design teams (Dröge, et al., 2000) in order to eliminate product issues. The product related information – i.e. product data, often connected to design specifications produced in these interactions is a vital part of the DfM process (Giachetti, 1999).

Guardiani, et al. (2005) discusses two main strategies when preforming DfM analysis; proactive-, and reactive DfM. The proactive DfM strategy is focused on defining the variables in production with the help of design rules, these design variables should in the end guarantee high product manufacturability. By embedding these rules in the standard design flow and make continuous verifications in collaboration with design will help to optimise the yield of the product, this without having to do additional verifications after the DfM process is finished. The reactive DfM strategy on the other hand is when the design modifications is not conducted and verified continuously through-out the design process, but handled in the end of the design process.

O´Driscoll (2002) describes a process during the DfM process which he refers to as "checkpoints" that the product needs to go through. It is within these phases between the checkpoints that the product data is gathered. The checkpoints are placed in the development process that involves the verification of the product. In order to pass these checkpoints there are documents in forms of questionnaires that needs to be completed in order to gather product data regarding the new product. This gathered product data will help the DfM team to avoid pitfalls that might occur in manufacturing, this before the product is being mass produced. The product data that is gathered during the verifications are important to use in later stages of the development process in order to highlight problems that were not found during development.

3.2.4 Product Verification

Strongly connected to product development is the use of product verifications. Verifications are primarily used in product development to verify engineering and design solutions in terms of quality, functionality, and performance requirements of new products (Peggs, et al., 2009; Maropoulos & Ceglarek, 2010; Harkonen, et al., 2009). For instance, verifications are used in prototyping in product development – as different prototypes of a new product is developed and verified in order to find issues and problems with new products before it is finalised and launched. Further, it has been previously stated that DfM and DfA processes includes product verifications as well – as new products are changed and verified during its development also in terms of producibility aspects. The product verification process is an important process, as it determines if a product or component is consistent with the established specification for the process or product (Oberkampf & Trucano, 2002). The verification process includes analysis based on logical argument, simulation analysis, inspection, test, or demonstration (Bahill & Henderson, 2004). Also, in PLM, product verifications are also performed in the maintenance phase – as this involves to incrementally changing products to current industrial requirements or to improve the product (Maropoulos & Ceglarek, 2010; Saaksvuori & Immonen, 2005).

Maropoulos & Ceglarek (2010) also argues that the verification process also is an important process for preserving information and knowledge. In the business sectors such as aerospace manufacturing and ship manufacturing the companies have a strong requirement to conserve and reuse information and knowledge that is gathered in the verification process. The authors go on stating that the early stages in the design process are especially important for capturing technical and lifecycle requirements, the verification process is therefore an important source of product data in the early stages of the product lifecycle – i.e. within product development.

3.2.5 Product Deviation

New product development includes a lot of uncertainty – as concepts to be realised are often based on an idea consisting of vague definitions regarding design and technology. Therefore are product deviations present during product development – representing issues or problems that cannot be foreseen. Eliminating deviations, e.g. component defects, workmanship mistakes, etc. in manufacturing is impossible – as deviations will always emerge when variability is present, both in used components and assembly processes (Booker, et al., 2005). Therefore is the management of deviations an important aspect in product development (Munthe, et al., 2014). Deviations in product development related to products have been classified into four different types, which are;

component deviations; interface deviations; concept deviations; and scope deviations. These are presented below, *see table 2*, as taken from the original source (Munthe, et al., 2014, p. 210).

	Component	Interface	Concept	Scope
Cause	Technical component problem	Technical interface problem	False assumption of technical functionality	
Effect	Component redesign	Interface redesign	Retake of concept development	Requirement spec. change

Table 2: Presentation of different deviation types in product development.

A product deviation is in this thesis defined as by Munthe et al. (2014), presented below:

"A deviation in product development is in this paper defined as something that is not going as planned: a technical component does not function as expected; a developed solution does not solve the problem as intended; an action taken does not have the expected effects, or the project is affected by an external disturbance."

- Munthe et al. (2014, p. 204)

Worth mentioning is that the authors had a time constraint in this definition – if a problem were solved within a specific time-line without affecting other activities it was not defined as a deviation. This time constraint is not adopted in this thesis when defining a deviation.

In this thesis product deviations are termed to be a source of product data. As deviations is a part of product development and represents unforeseen product issues or defects that have to be fixed in order to realise a fully functional product. That is: deviations that emerge entail product changes and therefore produces new or changes in product data.

3.3 Product Data Definition

Product data in this thesis is defined to include all product related data, information, and knowledge produced in the processes performed to imagine, design, produce, use, support and dispose of a product (Stark, 2011; Saaksvuori & Immonen, 2005). Product data is stated to be produced and used throughout its lifecycle (Crnkovic, et al., 2003). Product data represents a strategic resource in PLM and effective product data management is therefore a critical matter (Stark, 2011). This will be further discussed in [3.4] describing product data management (PDM). Examples of product data are; bill of material (BOM), CAD-documents, verification reports, test results, engineering blueprints, etc. (Stark, 2011; Seokbae, et al., 2011), more examples are stated below, *see table 3*.

Product Data:				
Examples of…	Concepts	Product specification	Test data/results	Shop floor instructions
	Proposals	Process specification	Analysis data/results	BOMs
	Requirements	Design specification	CAD geometry	Failure reports
	Cost estimates	Packaging specification	Photographs	Assembly drawings
	Prototypes	Functional specification	Manufacturing data	Engineering drawings

Table 3: Presentation of product data examples (Stark, 2011, p. 116).

3.4 Product Data Management & Systems

Product data management (PDM) concerns the management of product data related to developed products throughout their lifecycle. PDM can be defined as:

"PDM is mainly a set of tools and methods aimed at efficiently managing product data"

- Saaksvuori & Immonen (2005, p. VI)

However, to organise and maintaining product data is one of the biggest challenges within the PLM (Stark, 2011). PDM has the purpose of assisting and improving the product management by providing structure and support for the included activities (Crnkovic, et al., 2003). As previously stated this is a main issue in PLM, as ineffective management of product data results in ineffective product management (Stark, 2011). Despite being a big challenge for firms, PDM contributes with PLM support through enabling exchange and sharing of product data, often through PDM-systems (Gielingh, 2008; Saaksvuori & Immonen, 2005). By enabling effective PDM, the product data management enables firms to improve the usage, quality, and processing of product data which could lead to improved lead-times, development costs, and therefore improve the firm's competitiveness, market share, and revenues (Stark, 2011). Effective PDM is stated to be very important in product development and engineering activities – as this phase creates and handles a lot of product data and represents a valuable asset for re-usage when developing new products (Saaksvuori & Immonen, 2005).

The main purpose of a PDM-system is to enable effective gathering, storing, retrieving (Otto, 2011), and sharing (Peltonen, et al., 1996; Philpotts, 1996) of product data. This especially connected to product development (Stark, 2011) between engineering, design, and manufacturing (Saaksvuori & Immonen, 2005). A successfully implemented PDM-system allows firms to store and control important documents and files containing product data, such as BOMs, manufacturing instructions, etc. and shall enable organisations to quickly access the product data for reuse and management, this while minimising the risk of using incorrect product data (Saaksvuori & Immonen, 2005; Peltonen, et al., 1996).

One of the most important aspects of PDM is the structuring of product data. When using a PDM-system it is usually by integrating certain separate applications containing information, this in order to create an informational platform (Crnkovic, et al., 2003). It is important that the product data is structured in such a way that it is easily accessible by the employees that are in need of certain product data (Philpotts, 1996; Crnkovic, et al., 2003). Further, PDM-systems should ensure that product data available at the right time, in the right format, to diverse stakeholders involved in PLM activities and included processes (Demoly, et al., 2012). The access and availability of existing product data, containing information and experience, from previously developed products are very important in order to develop new high quality products (Saaksvuori & Immonen, 2005).

There are of course complications related to PDM-systems. Some of these complications are; a lack of management support, insufficient user acceptance, and the cost factor (Siddiqui, et al., 2004). Further, there is still a lack of associability between different products in terms of similarities in PDM-systems that act as a barrier for effective product design (Demoly, et al., 2012). In order to control the complication of user acceptance and to improve the usage of the PDM systems a reward system may assist, also knowledge, attitude, and commitment of the users of the PDM-systems are highly important (Wognum & Kerssens-van Drongelen, 2005).

4. EMPIRICAL INFORMATION

This section will introduce the case organization, PIM RBS Kista, which is the research unit in this case study. The section will mainly describe the operating context of PIM RBS Kista with a focus on the Operations department. The purpose of this section is to provide general knowledge in order to create an understanding of the organisation and its context, which is important for the research strategy chosen and in alignment with the scope of the conducted research. The information presented here is mainly based on secondary data found in company documents.

4.1 PIM RBS KISTA

Ericsson is a Swedish Multinational corporation (MNC) founded 1876 and is a world-leading provider of information and communication technology (ICT) and related services to mobile and fixed network operators globally. The offerings include services, software, and infrastructure within ICT for telecom operators and other industries. Today, over 1,000 networks in more than 175 countries utilize their network equipment and 40 percent of all mobile calls are made through Ericsson's systems. Ericsson has more than 110,000 employees in more than 180 countries and headquartered in Stockholm, Sweden. Ericsson is listed on NASDAQ OMX, Stockholm and NASDAQ, New York stock exchanges. (Ericsson AB, 2013)

PIM (Product Introduction and Maintenance) RBS (Radio Base Station) is an organisation within Ericsson. PIM RBS Kista has new product introduction (NPI) and maintenance responsibility for certain appointed products into the supply chain. PIM RBS Kista is accountable for the full product lifecycle management (PLM) for appointed products. The PLM responsibility includes enabling efficient and effective processes regarding product introductions and test solutions, industrialisation of new products, supply chain development and facilitation, all with a customer-value focus. The main PLM responsibilities of PIM RBS Kista are listed below, *see table 4*.

Main PIM RBS Kista Product Lifecycle Management Responsibilities:	
Full service supply	• Pre-development, design, prototyping, and industrialisation of appointed products
Act as supply lead	• Responsibilities to globally industrialise and supply radio filter products
Lead administration	• Responsibilities for complaint and change management, analysis, and global capability regarding cost, quality and lead-time for appointed products

Table 4: Presentation of main PLM responsibilities appointed for PIM RBS Kista.

In Ericsson there is a corporate PLM process termed 'Streamlined Development'. The concept is aimed to enable cooperation and collaboration between development units and product management that shall ensure an efficient process and customer focus throughout a products lifecycle. The PLM process at Ericsson consists of 8 phases, *see figure 9*. The different phases and the PLM process are based on a phase-gate process. Between each phase, there is a decision gate that represents an assessment whether a product should proceed in the lifecycle process. The purpose of the PLM phase-gate process is to increase the development flexibility and efficiency.

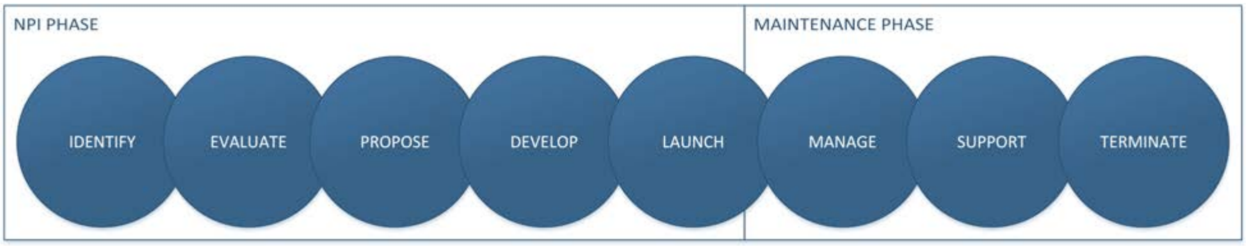

Figure 9: Overview of the PLM phases at Ericsson.

The three first NPI phases, identify, evaluate, and propose includes activities that are performed by collaboration with external departments, e.g. marketing, R&D, design as connected to product development theory, as previously presented in *figure 5,* (Trott, 2005). The PLM stages identify, evaluate, propose, and develop included in the NPI phase can also be connected to generic NPD stages. As the first four NPI phases includes NPD – to identify new business opportunities, evaluate these, propose a product concept, and to develop this concept into an physical product that meet customer demand, as previously presented in *figure 6,* (O'Connor, 2005). Launch it on the market can be connected to ramp-up (Terwiesch & Bohn, 2001). Manage and support a product on the market, and finally terminated it – i.e. remove it from the market lies within the maintenance phase (Stark, 2011; Saaksvuori & Immonen, 2005).

The develop and launch phase represents the main focus of the Operations department – as these two phases represents the development of new products & processes, as well as the industrialisation of products to offshore mass-production sites in low-cost countries – i.e. global transfer of the new product technology and manufacturing process and ensuring new product production ramp-up (Li, et al., 2013), as presented in *figure 6*. In Ericsson the purpose of the develop phase is to realise new product concepts by implementing specifications into a product, implement the product, and test its performance. The purpose of the launch phase is to secure a smooth introduction, fast growth, and high performance operations – i.e. ramp-up (Terwiesch & Bohn, 2001) that include implementing processes, tools, and training at an offshore mass-production site.

The main focus in this thesis is as stated within the NPI phase and especially within the included develop phase. This is where product data is gathered within Operations during product development in order to enable mass-production – i.e. to ensure the launch phase. The product development scope for PIM RBS Kista includes; new product platforms – new core technology that create competitiveness; derivatives of existing products – updating existing platform products; and incremental improvements – modification of existing products (e.g. small design changes, improvements for lower costs, etc.) (Trott, 2005).

4.2 PIM RBS KISTA ORGANISATION

The organisation at PIM RBS Kista is illustrated below, *see figure 10*. The PIM RBS Kista management includes management positions that constitute overall responsibility of the site in Kista. The organisation is thereafter divided into three departments with product management responsibility, divided after appointed products, one of which is the filter product management department. The organisation is then further divided into four sub-departments; Project Office, Test Development, Engineering, and Operations. These four departments are all involved in the NPI process and product development process.

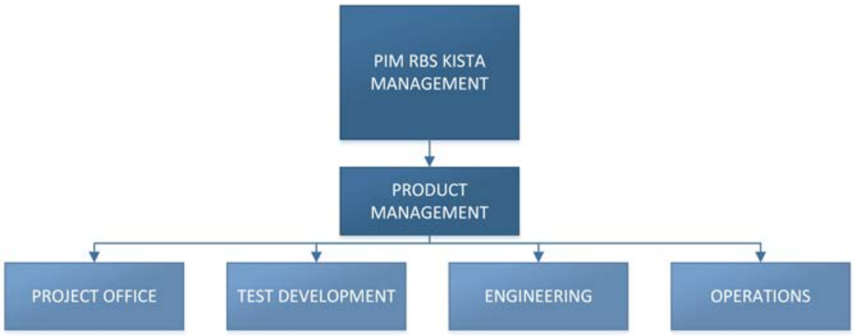

Figure 10: Overview of organisation at PIM RBS Kista.

4.2.1 Project Office

The project office consists of project managers that manage all product related projects at PIM RBS Kista. NPI projects are assigned from the product design unit (PDU) in order to realise a new concept and industrialise it. The responsibility for NPI projects is to ensure that a new product meets cost, delivery, and quality criteria set. A project manager is also responsible to assess in collaboration with PDU whether a new product, in a NPI project, has met pre-set requirements and criteria in order to be handed over to the maintenance phase.

4.2.2 Engineering

"Our mission is to drive production solutions that enables short time-to-market, high quality, and cost efficient production of PIM RBS Kista's products on a global scale."

- Mission of the Engineering function

The Engineering organisation is responsible for the development and support of product-unique production processes that enable supply of existing and new products. The department is also responsible for providing resources and competence to ensure product quality and producibility when introducing new products into the supply chain. The Engineering organisation consists of functional management and is then divided into three sub-departments; Production Engineering; Analysis; and Quality, *see figure 11*.

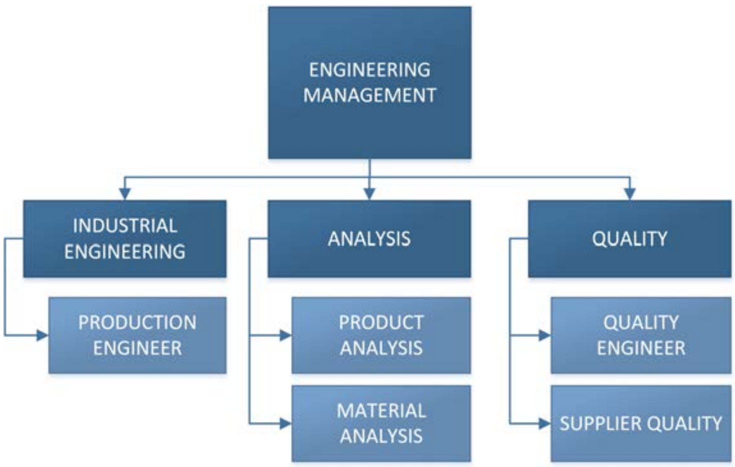

Figure 11: Organisational overview of the Engineering function.

Industrial Engineering

The main responsibilities of industrial engineering are to continuously develop, improve, and support existing and new production processes. This responsibility is global and includes activities such as; production preparation activities; specify and implement production layouts; product producibility analysis (e.g. design for manufacture (DfM)).

Production engineers (PE) is one of the main stakeholders of product data, as much of the product & process related information is gathered in DfM-analysis reports that PEs are responsible of. PE's main task is to prepare the production process in a mechanical aspect, which includes developing and specifying assembly instructions and tools that are needed to manufacture a product. PE's are included throughout NPI-projects, all the way from the concept feasibility of PDU product designs until the product is matured enough to be handed over to maintenance.

Analysis

The analysis function includes two different functions; material analysis or material quality assurance (MQA); and product analysis. MQA & material analysis includes activities such as metric measurements (e.g. length, shape, gradient, roughness, etc.) and material and reliability analysis. Product analysis performs troubleshooting and technical analysis of products and proposes design changes depending on analysis results. These functions are often involved in NPI as to conduct deviation analysis and in-depth troubleshooting.

Quality

The Quality function is also divided into two sub-groups, quality engineering (QE) and supplier quality assurance (SQA). The scope of SQA includes being responsible for global supplier quality on purchased components, including suppliers production process throughout a products lifecycle. All issues or product deviations related to supplier compliance failures falls under the SQA function to analyse.

The scope of QE includes to secure the quality of the production process by performing quality analysis, deliver quality plans and reports to projects, monitor quality KPI's (e.g. yields), support with product quality analysis competence, verify production process and/or product quality for high-volume production, and support the organisation with quality management knowledge. A QE is involved throughout a NPI project at PIM RBS Kista.

4.2.3 Test Development

The main responsibility of the test development function is to secure production test for filter products. This includes development of filter test systems aimed for high volume production and test fixtures. The function has global responsibility for filter test platforms and 2^{nd} line support of test systems & fixtures. Test development can also assign test-related verifications to the engineering function that is performed in the production. This involves an ordinary product change process to verify that a new test system, upgrade, or fixture is working as intended for the aimed filter product.

4.2.4 FRAG

There is also a task force called FRAG (fault rate analysis group) within PIM RBS Kista. FRAG consists of a cross-functional team that have a global responsibility to analyse and conduct root-cause troubleshooting of product deviations. If a deviation occurs, a problem escalation process is initiated for troubleshooting and deviation analysis. FRAG is basically the final escalation point for a deviation. A deviation that cannot be solved or requires in-depth analysis is managed by this cross-functional task force consisting of several functions from the Engineering- and Operations department that together tries to solve deviations. FRAG is mainly involved in the NPI process.

4.3 Operations at PIM RBS Kista

Throughout the research it was identified that it is within the Operations department and especially in the production shop floor that product data is gathered during product development. Product data – i.e. product related data, information, and knowledge is gathered and shared to internal stakeholders within PIM RBS Kista organisation that compile this product data into different reports and the main end recipient is the product design unit (PDU) – responsible for design implementation decisions. The product data gathered within the Operations department is therefore the main source for suggesting product changes by the Engineering and Test Development departments to the PDU.

The main responsibility for Operations within PIM RBS Kista is NPI production of filter products. This includes planning, manufacturing, and delivery of prototypes, as well as production qualification for new suppliers, components, and test solutions. The scope of the Operations department include; planning; material management; production; first line support; customer returns; and services. The different functional areas are presented below, *see table 5*.

Functional Area:	Main Responsibilities:
Planning	• Planning of production runs (prototypes, early deliveries, verifications, claims etc.) • Logistics of WIP and stock of finished goods • Outbound planning
Material Mgmt.	• Received goods, internal logistics, outbound packaging and shipping • Inventory management • Inbound material inspection
Production	• NPI production (prototypes, pre-series, etc.) • Provide new product development feedback • Support pre-development with product, process, test, etc. feedback • Analysis of product changes through verifications
First Line Support	• Product and production performance & quality • Production preparation • Purchasing of production consumables • In-house equipment maintenance
Customer Returns	• Handling, analysing, and repair of claims (customer returns)
Services	• Introduce products & processes at offshore production sites (e.g. training)

Table 5: Presentation of functional areas included for PIM RBS Operations department.

4.3.1 The Operations Department Organisation

The operations function includes several functional areas and roles, *see figure 12*. NPI production includes two managers that share responsibility for the operators in the production line as well as the material handling personnel, which handles material preparation for the production line, goods receiving & shipping, storage, etc. Inbound & logistics includes build coordinators, planners, and purchasers who handle production planning, production coordination, and purchasing of inbound material. First line support mainly acts as production support in order to handle production problems that occur – e.g. deviation escalation and production maintenance.

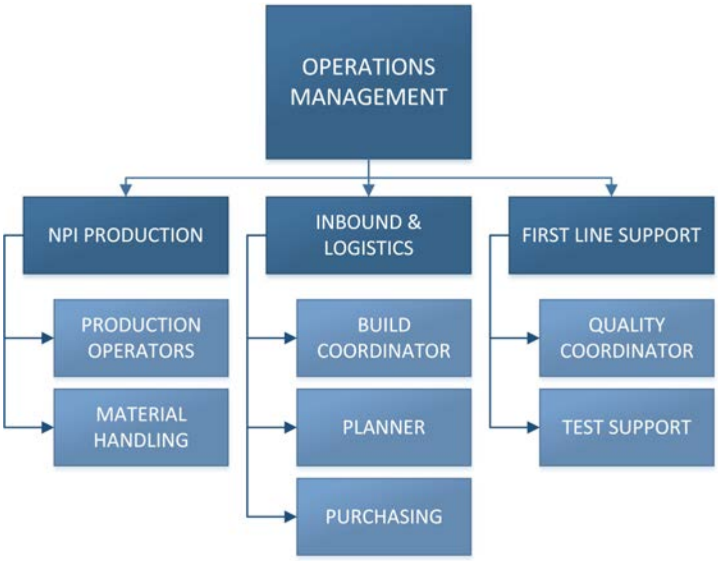

Figure 12: Overview of the Operations department organisation and included roles (some excluded).

There are more roles included in the Operations department, but these are excluded in this thesis. Some of the roles within Operations will be described as to create an understanding of these contextually important responsibilities.

Planner

A Planner's main responsibility is to plan the production schedule, ensure availability of material for the production line, allocate resources for NPI projects, and issue material orders to material handling personnel that prepare material for production runs. A planner basically plan when a product is to be built, that the material for that built is secured, and that the material is prepared in time when the product build is to be performed. Planners are involved in NPI projects.

Build Coordinator

Build coordinators (BC) work in close collaboration with the production line. The main responsibility of a BC is to coordinate all production runs. A BC is the main contact between the production and other functional areas within PIM RBS Kista. A BC is involved in NPI projects and mainly communicates the progress within the production line and provides production reports – containing product data.

Quality Coordinator

A quality coordinators (QC) main responsibility is to support the production operators with first line support. This includes analysing product & process deviations or problems that occur in the production line, which operators require support with. The QC is mainly responsible for product quality deviations and are strongly involved in the deviation management process, in which a QC escalate problems internally if a deviation cannot be solved by them.

Test Support

Test support has similar responsibilities as a QC but provides support for test related deviations or problems that are included in the responsibility of the Test Development function. Test support is the first instance to handle and analyse test related problems – i.e. deviations and escalate them to the Test Development function if a solution cannot be provided for further analysis.

4.4 THE PRODUCT – RADIO FILTER

The product in this research is a signal processing filter which is a module in radio base stations (RBS). A RBS receives and transmits wireless communication signals and data. The filter unit in a RBS process wireless signals and assort them within certain bandwidths to ensure a high quality signal and to remove signal distortions – i.e. unwanted frequencies. Filters are highly sensitive products as deviations can strongly affect the filters ability to process signals. The quality and performance of filters depends on, for instance, the design (e.g. shape, geometry), included components, and interfaces between components. Further, the interaction between the filter and test fixtures, software, and production tools also represents complex interfaces.

4.5 THE FILTER PRODUCTION

At PIM RBS Kista there is production for filter products and surface mount assembly (SMA) products. The SMA production line produces is an automated PCB (Printed Circuit Board) assembly line that produces PBA (Printed Board Assembly) boards. These PBA boards are either used in filters as a component or for other customer orders. However, the main product at PIM RBS Kista is filter and therefore the focus in this thesis. The main filter production line, *see figure 13*, constitutes of an assembly line, tuning stations, and test stations.

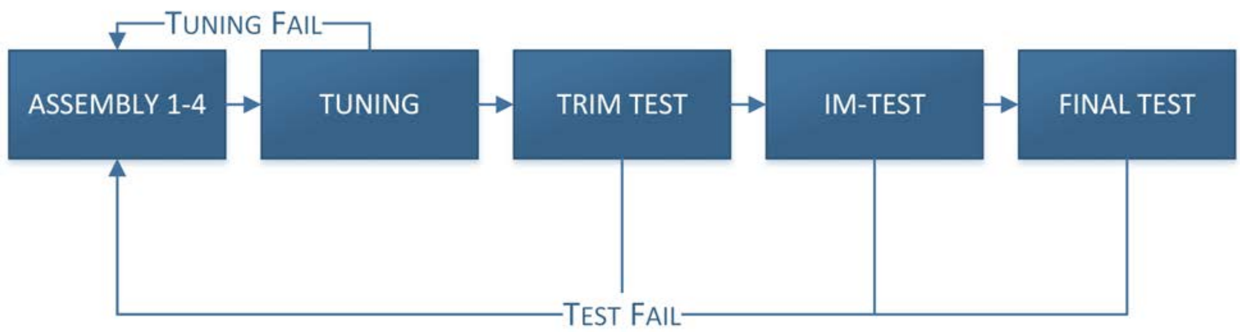

Figure 13: Simplified overview of the main filter production line.

The assembly line consists of four assembly stations. The next step is the tuning, in which filters and modules are tuned to ensure that the filter process the right kind of signal with high quality. After tuning there are three different tests, tune test, IM-test, and final test. These tests are performed in order to ensure the filter product quality and performance. Yield measurements take place at tuning and at the test stations – to measure the number of failed assembled filters compared to the total number of filters assembled. If a filter fails to be tuned the filter will go back to the assembly line for a control, and if a filter fails to be tuned several times a repair proceeding is performed by assembly operators. This is also the case if a product fails test – failing several times will initiate a repair action. The first repair action includes visual analysis of the filter in order to find deviations that could cause tuning or test failure. The second repair action involves a more thorough troubleshooting – removing and cleaning components, and visually analyse the filter for problems. If the deviation cannot be identified and solved by operators the deviation management process called problem escalation process will be initiated. Thereafter the deviation, depending on its severance and nature, will be escalated to internal functions to do an in-depth analysis in order to solve the deviation.

There are also smaller filter production lines, which is used to perform certain prototype builds or 'plock-checks'. A plock-check is a test production of a small amount of filters products where initial analysis is performed in order to check if the product and product data is properly prepared and complete enough in order to be built in the main production line – to minimise disruptions in the main production line. Plock-checks are always performed for new products, or NPI products, at PIM RBS Kista.

4.6 Product Data Management at PIM RBS Kista

"Product Data Management, PDM, consists of methods and tools those supports an organization to handle the product life cycle. The supports starts from early design stages to final product phase out. PDM handles all information, including business rules, during this life cycle."

- Ericsson PDM definition

Within Ericsson PDM is implemented to support individual processes, such as the design process, by keeping track of all valid information, documents, drawing, etc. throughout a products lifecycle. PDM is also stated to act as glue between different business processes, such as design and manufacturing. In alignment with theory (Stark, 2011) that effective management of product data in PLM is important, is a shared concept within Ericsson. Storing up-to-date and accurate product data is stated to be important as otherwise the product data will become worthless. This is also stated to be important as to reduce lead times – by enabling effective sharing of product data between different units involved in enabling final production of products.

There is a main system interface used within PIM RBS Kista to access different PDM systems. This is a windows application that is used in order to access and change product data stored in different PDM-systems within Ericsson. The PDM-systems that the system interface is connected to are a product database, a data warehouse, and a local document system. Due to the connection of systems, the system interface enables users to search and fetch product data from all of the connected PDM systems. The two main PDM systems that the system interface ties together are the product database and the data warehouse. The product database serves the main purpose of supporting the Ericsson organization to keep track of products and stated is that: *"if a product isn't registered in the product database, it doesn't exist"*. The data warehouse is the central archive to store all information, text documents, drawings, software components, etc. – i.e. all product data. Whenever product data is changed in the data warehouse it is automatically updated in the product database.

There is also a wide range of other PDM applications used within PIM RBS Kista. For representation of what kind of product data some of these systems provide, *see table 6*, below.

PDM-System:	Type of Product Data:
Product Database	Product information
Data Warehouse	Product documents
Local Document System	Department documents (e.g. product, project, process, related documentation)
Test Data System	Production test data, Statistics, Repair actions, Reference data
Deviation System	Troubleshoots and repair actions – test deviations in production
Trouble Report System	Trouble Report management, Solution management, Analysis & Measurement

Table 6: Presentation of PDM-systems used within PIM RBS Kista.

5. CURRENT-STATE ANALYSIS

This section will present the main findings concerning the processes identified throughout the research at PIM RBS Kista that produces product data. The processes will be described and certain issues found in relation to the processes will be presented as well. This section will serve as a foundation for the discussion part of the thesis in the next chapter.

Throughout the research certain processes were identified to gather product data that is of value during product development in the NPI process. Firstly, a production feedback process is performed within the Operations department and it is in the production shop floor that most of the product data are gathered that are used by internal stakeholders. Secondly, a design for manufacturing (DfM) process is used during the product development process to verify the product design and production process, in order to ensure a high level of producibility of new products. Secondly, within product development a lot of deviations related to product quality, performance, functionality, etc. are present that has to be managed. Any deviation that emerges has to be handled in order to ensure that a product can be finalised, as often deviations end up as a recommendation of design changes – this process therefore produces a lot of product data. In addition, a verification process used for product changes in the maintenance phase is included. This is based on the argument that the verification process performed within the Operations department is very similar to the production feedback process and includes gathering of product data. All of these processes will be described and included issues found related to product data management (PDM), regarding gathering, storage, sharing, and re-usage of product data will be presented in this chapter.

However, the NPI process and involved activities will be described in more detail first, connected to theory, as to create foundational understanding of why product data is gathered and create a context in relation to how product data is gathered.

5.1 NPI AT PIM RBS KISTA

All new product introduction (NPI) assignments – new product concepts – originate from a product design unit (PDU), which can be generally termed as a design department. Within PIM RBS Kista a new NPI assignment, or new product concept, is assigned to a project manager within the Project Office. The project manager then sets up a cross-functional team, consisting of representatives from different departments and functions within PIM RBS Kista, e.g. Engineering, Operations, and Test Development. This project team is then responsible for the NPI product throughout its development in the NPI phase until the product is matured enough to be introduced at an offshore mass-production site and launched on the market. Then the NPI project is concluded and the product is handed over to the maintenance organisation.

The NPI process at PIM RBS Kista includes activities of creating and introducing new products in either an existing or new supply chain. The NPI project is divided into six different stages that are divided by milestones that represent requirements that the new product must fulfil in order to proceed. This is a normal process within product development – where new products go through a phase-gate system including step-by-step development (O'Connor, 2005). If a product does not meet the set requirements for the different milestones – the new product will not proceed to the next stage in the NPI process but rather loop back to the previous stage in order to be refined to meet set requirements. In a simplified overview, a NPI project is divided in to different stages and is connected to different NPI activities within PIM RBS Kista, *see figure 14*.

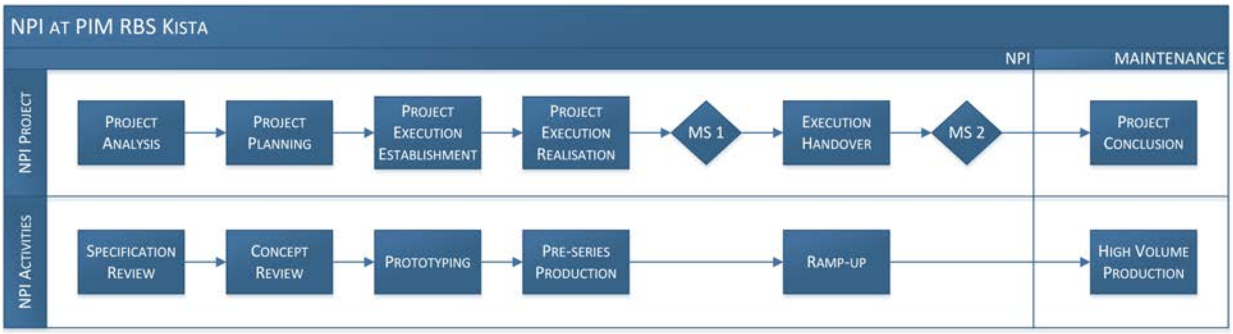

Figure 14: Simple overview of the NPI process within PIM RBS Kista.

5.1.1 Project Analysis – Specification Review

The specification review is performed within the NPI project organisation in order to assess the specifications given from PDU. It is in this stage that requirements concerning a new product are reviewed and set regarding quality, functionality, performance, and costs. New product concepts must fulfil these requirements in the development phase in order to become a finalised product that can be introduced at an offshore mass-production site for ramp-up and be moved into the maintenance phase.

5.1.2 Project Planning – Concept Review

In this stage the project is planned and the milestone 1 (MS1) and milestone 2 (MS2) goals are set for NPI projects. The concept review includes an initial screening of the product design. This activity often includes a production engineer (PE) that reviews initial product drawings and CAD files from PDU to find incompatible design solutions in terms of producibility before the first physical realisation of the product concept is produced. This activity includes both design for manufacturing (DfM) – and design for assembly (DfA) based producibility review – termed DfM within PIM RBS Kista. This is done in order to find bad design solutions as early as possible in the new product concept in order to increase the producibility of the product. Using DfM in early design stages is stated to be advantageous (Elgh & Cederfeldt, 2007) and important in product development to develop an efficient production process, increase the product quality, decrease product defects (Venkatachalam, et al., 1993; Booker, et al., 2005; Selvaraj, et al., 2009).

5.1.3 Project Execution Establishment – Prototyping

This is the main stage in the product development process. In this stage several versions of a new product concept (prototypes) is developed and realised in an iterative process – to ensure that it fulfils requirements through testing and verifications (Cooper, 2008). Verifications are primarily used in product development to analyse engineering and design solutions – to ensure that a product fulfils quality, functionality, and performance requirements (Peggs, et al., 2009; Maropoulos & Ceglarek, 2010; Harkonen, et al., 2009). This basically constitutes a step-by-step development process in order to ensure that the product and process meet set requirements to enable mass-production in a cost-effective way (Silverstein, et al., 2009; Cooper, 2008). The iterative process of prototyping at PIM RBS Kista is represented below in a simplified way, *see figure 15*.

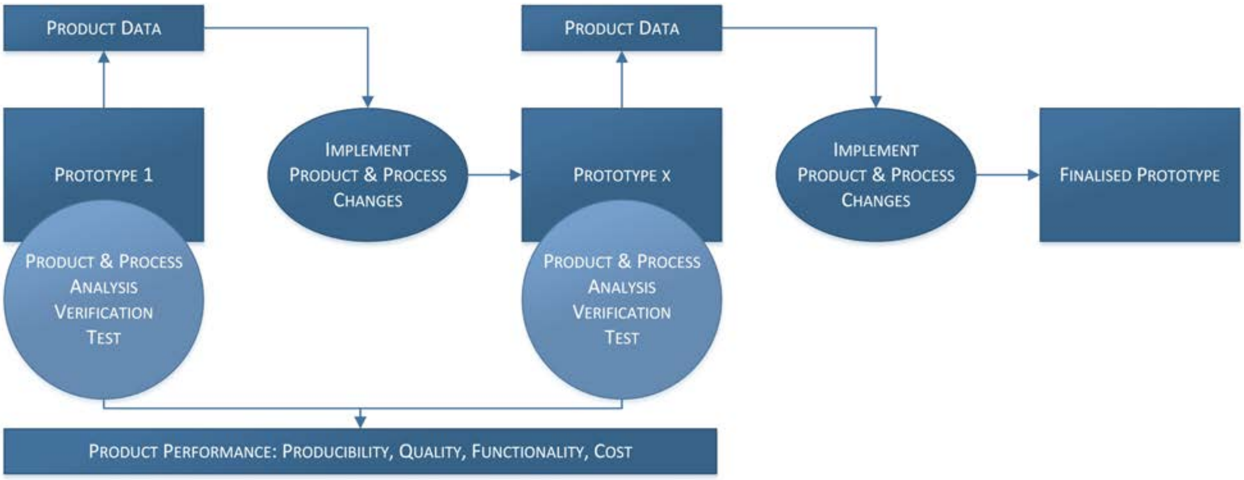

Figure 15: Prototyping overview.

The prototyping process at PIM RBS includes feedback loops of product data that are gathered by operators every time a new prototype is developed. This product data is managed and compiled by the responsible BC. It also includes several different product data management (PDM) tools, PDM-systems, and in different processes – as to be presented later. This product data primarily contains design, quality, and producibility issues found, including deviations concerning the existing product data (e.g. manufacturing instruction, BOM). All prototypes functionality is tested and the product performance is measured by the yield – based on product test data. The end product for each prototype is a report that is compiled by a QE that communicate prototype findings to the NPI project and the PDU.

5.1.4 Project Execution Realisation – Pre-series

When a prototype finally meets requirements set by the NPI project, the product is ready for pre-series production. In the pre-series production further analysis is performed, the main focus here is on the production process. This is more of a production process verification that the product can be produced in an efficient way with high quality and performance, and that related product data is accurate (e.g. BOM, manufacturing instructions, etc.). This is performed in order to ensure that the product is ready for introduction to an offshore mass-production site. Concurrently to the pre-series run the supply chain of a new product is verified (excluded in this thesis as stated). If the filter product is approved in this process, the MS1 status code is set.

5.1.5 MS1 Status Code

MS1 is the status code that determines that the product is basically fully realised – i.e. the product, its supply, and design is fully developed and therefore ready to be industrialised to an offshore mass-production site for ramp-up. The MS1 status code is decided by the project manager in collaboration with the responsible PDU project leader.

5.1.6 Execution Handover – Ramp-up

At this stage the NPI product that has been developed is transferred to an offshore mass-production site in order to implement the product and its manufacturing process (Li, et al., 2013) and train operators on that site. This is performed in order to enable ramp-up of the product at the offshore site – so that it can reach the required production volume (Terwiesch & Bohn, 2001).

5.1.7 MS2 Status Code

The next status code is MS2, which represents that the product is handed over to the maintenance organisation and the end of the NPI phase within PIM RBS Kista. However, a product can be declined MS2 status and therefore enters the NPI process again – to be further developed often because of that the product yields are not adequate. When a new product has been successfully introduced, the NPI project is concluded and the product is handed over to the maintenance organisation. Thereby is the NPI process at PIM RBS Kista finalised.

5.2 NPI WITHIN THE OPERATIONS DEPARTMENT

A new product concept (e.g. NPI) assignment from PDU enters the Operations department through the NPI project often, but not always, as a build assignment specification (BAS). The BAS include information regarding the new product and a product tree, showing all included sub-modules and components that constitute the whole filter unit. The two most involved roles within Operations are build coordinators (BC) and planners. BCs are responsible for all production runs performed in the production in order to develop a NPI product. BCs attend NPI project meetings to communicate progress and issues related to the production process of a NPI product and are also responsible for the product data that is gathered within the production. Planners are responsible for scheduling NPI production runs, allocate resources, and secure material preparation for these runs.

5.2.1 Product Development Process within Production

In the conducted research there was certain steps identified in the product development phase, *see figure 16*. For each prototype developed there is three different production builds or runs involved; a 'First build', a plock-check, and a prototype run.

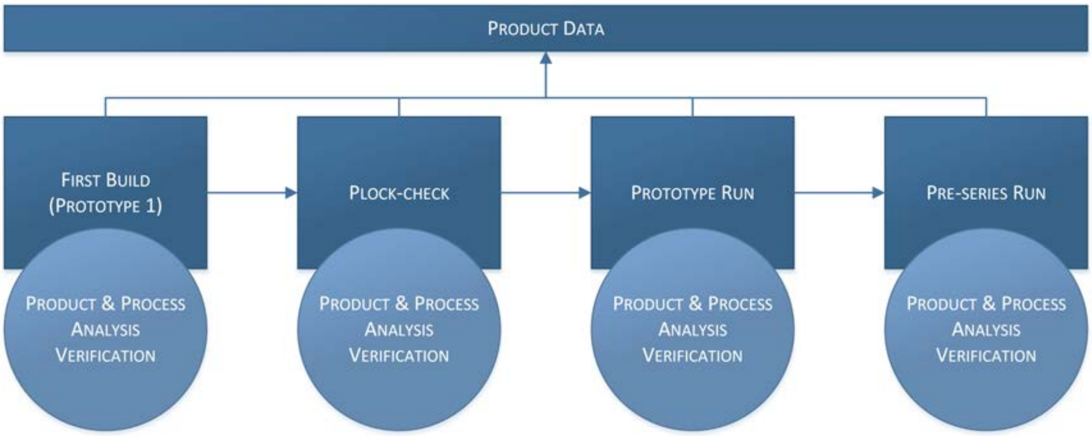

Figure 16: Illustration of product development stages.

First build

The first prototype is termed 'First Build'. This is the first build of a new product concept – i.e. the first time a concept is realised into a physical prototype. This process involves an operator, a production engineer (PE), and sometimes a representative from the product design unit (PDU). This is where the first analysis and verification of a product is conducted. This includes the ordinary manufacturing process of assembly, tuning, and test of a new filter product. It also includes verifying that the initial product data related to product design, bill of material (BOM), manufacturing instruction, etc. is correct. This is the first stage in which product data is gathered in the production shop floor and shared to internal stakeholders. This is the first process within Operations that could result in product design changes implemented by the PDU.

Plock-check

The second step is a plock-check, which includes a small amount of builds of the adequate prototype. This is performed either in a prototype production line – a smaller version of the main production line or in the main production line. A plock-check is executed in order to find product & process deviations that could cause problems in the production line. The main purpose of this is to ensure that an efficient production process can be performed in the main production line, to eliminate disruptions that involve more operators. This step often involves some of the most experienced production operators. It has been stated by operators and the production team leader that plock-checks are very important and often including findings of product deviations that is required to be fixed before the prototype is prepared in the main production line.

Prototype run

This involves running a prototype in the main production line to ensure that the prototype meet requirements set in terms of producibility and process quality – i.e. meet set test and yield requirements to be prepared for a pre-series run. Product analysis and verification is performed in this step by operators and any findings are put into the WA (work assignment) feedback tool.

Pre-series

The pre-series run involves analysing the product. However, the main focus in this stage is to ensure that the new product is actually matured enough to be introduced at an offshore mass-production site.

5.3 OUTBOUND PRODUCT WORKFLOW OVERVIEW

A product workflow includes the *"activities that create and/or use product data"* (Stark, 2011, p.161). It is within the Operations department and mainly in the production shop floor that product data is gathered at PIM RBS Kista. Production findings based on analysing, verifying, and testing filter prototypes and production runs, e.g. pre-series runs all involve a feedback loop of product data that goes through internal stakeholders, the NPI project, and finally to the PDU who takes decisions on implementing product design changes. An overview of this feedback loop of product data – or product workflow – is represented below, *see figure 17*. In this feedback loop several PDM tools and systems are used, as can be seen, and it constitutes a very complex product workflow – of product data.

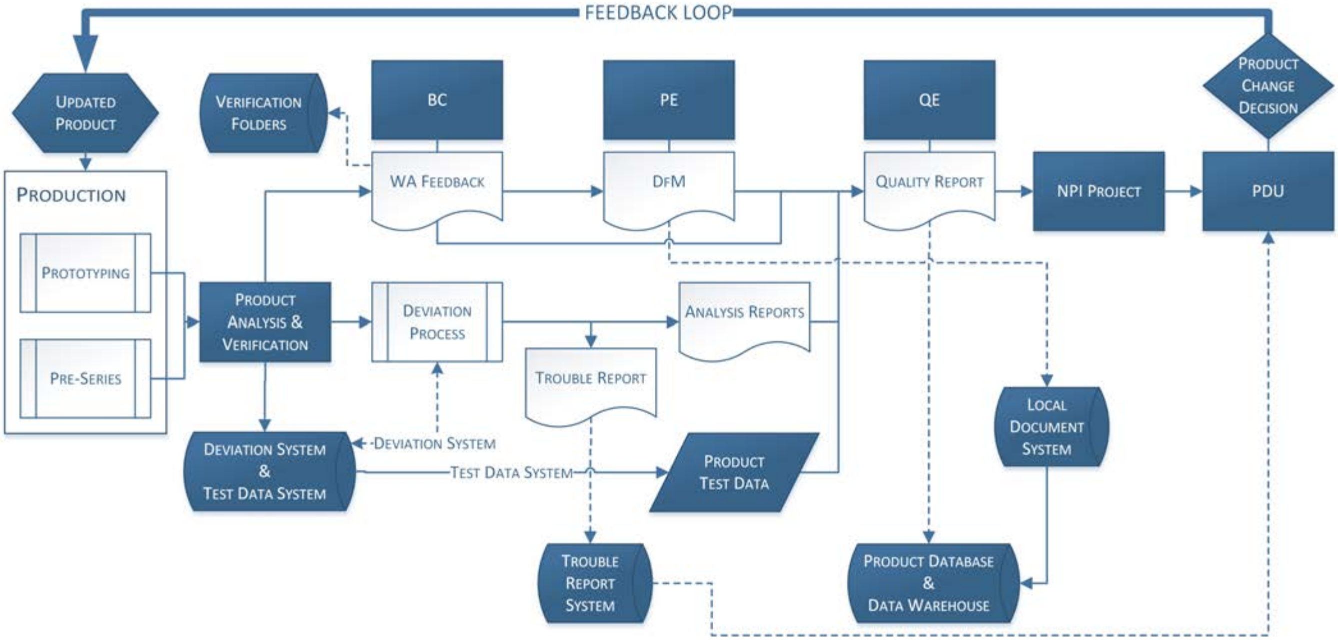

Figure 17: Overview of the outbound product workflow from the Operations department.

Product data gathered in the production shop floor are stored in a WA feedback tool (word document) that BCs are responsible of. Then the BC input all of the producibility related issues in the WA feedback tool into a DfM tool (Excel document) and sends it to a PE. The BC also sends the WA feedback tool to QE. Production test data is registered at the test stations within the production line in the test data system. Deviations that occur in the production line is input to the WA feedback document, but the ones that cannot be solved by the operators through repair actions or causes production stops are reported through a deviation system and a deviation process – a problem escalation process – is initiated. The deviation process is ad hoc and can involve several internal functions within first line support and Engineering to analyse the deviation in order to find a solution. If the Analysis function within Engineering conducts in-depth troubleshooting of a deviation, the result is an analysis report, which is also sent to the responsible QE. At the end of the outbound product workflow – QE compiles product data from the WA feedback tool, DfM tool, analysis reports, and product test data from the test data system into a quality report – including the main and most critical findings and references to the compiled documents containing all findings. This quality report is then delivered to the NPI project and presented to PDU – in order to suggest product & process changes. As PDU is responsible for all changes made to a product – the decision to implement changes is taken by the responsible PDU representative. In addition, deviations found – that are identified to require a design change by the PDU should be sent as a trouble teport (TR) through the trouble report system.

5.4 PRODUCTION FEEDBACK PROCESS

Throughout the conducted research especially one process within Operations at PIM RBS Kista was identified to gather product data, in this thesis termed – the production feedback process. This process is rather standardised within the production as the included product data gathering tool, or PDM tool, is used for all prototype builds (included in prototyping) and production runs in NPI, as well as for product change verification runs for maintenance products. The product data gathered in this process is used as production feedback in order to develop a product and its production process. The gathered product data is then used by internal stakeholders within Engineering to provide feedback to the PDU – i.e. to suggest design improvements so that PDU can implement design changes. This in performed in order to ensure a products performance in terms of quality, cost, functionality, and producibility. In order words, the product data gathered in the production shop floor through product analysis & verifications are used to suggest product improvements, which ensure that a product and its process meet pre-set requirements and specifications.

5.4.1 Production Feedback Tool

The PDM tool in this process is a Word based document called WA feedback. The WA feedback document is managed by build coordinators (BCs). The WA feedback tool is a standardised document used for all production runs, or build assignments, in NPI projects. For maintenance product verifications an adapted WA feedback document is created by a BC – that specifies what the production operators should focus on for that particular product. This WA feedback document is in that case based on a WA that BC receives from quality engineering (QE) – that specifies what should be analysed. Maintenance product verifications will be discussed more in 5.4.

All product data – i.e. product & process deviations, improvements, issues, etc. regarding quality, producibility, performance, and design solutions should be gathered in the WA feedback document. This includes findings from all the production line steps – assembly, tuning, and test. Production operators are the ones who perform the product- and production process analysis & verification and therefore also the ones who provide the product data in the WA feedback.

In the WA feedback document all product data, or product and process analysis findings, should be defined by a description of the problem, a suggested solution to the problem, the responsible function or individual to produce a solution, and (if applicable) a picture to provide a more detailed description of the problem found. The WA feedback document can differ between different runs – as it can involve analysis & verification of different components or sub-modules that constitute a filter product, or the whole filter product. However, the input points previously stated are the same weather it is maintenance verification or a NPI project.

5.4.2 Process Description

A simplified outbound product workflow of the WA feedback document is presented below, *see figure 18*. This represents the general flow when a product analysis & verification is performed in the main production line, including plock-checks (performed in the main production line), prototype runs, pre-series runs, and also maintenance product change verifications. The WA feedback document is shared through the 'Verification Folders'. Verification Folders is a storage consisting of network shared Windows folders – in which all WA feedback documents concerning historically performed production runs are stored, shared, and managed. QE, BC, and operators have access to these folders and are enabled to store, retrieve, and update the WA feedback documents. QE has the main responsibility for the Verification Folders.

Operators then access the WA feedback tool through the Verification Folders in the production line and use it while performing product analysis & verification to input findings – i.e. gather product data. When a prototype build or production run is completed and product data has been gathered in the WA feedback tool – the production team leader saves and stores it again, so that the responsible BC can retrieve it. The BC reviews the WA feedback and its product data content, finalises it, and store the updated version. The responsible BC then delivers the finalised WA feedback document to internal stakeholders – the main stakeholders are QEs and PEs (production engineers).

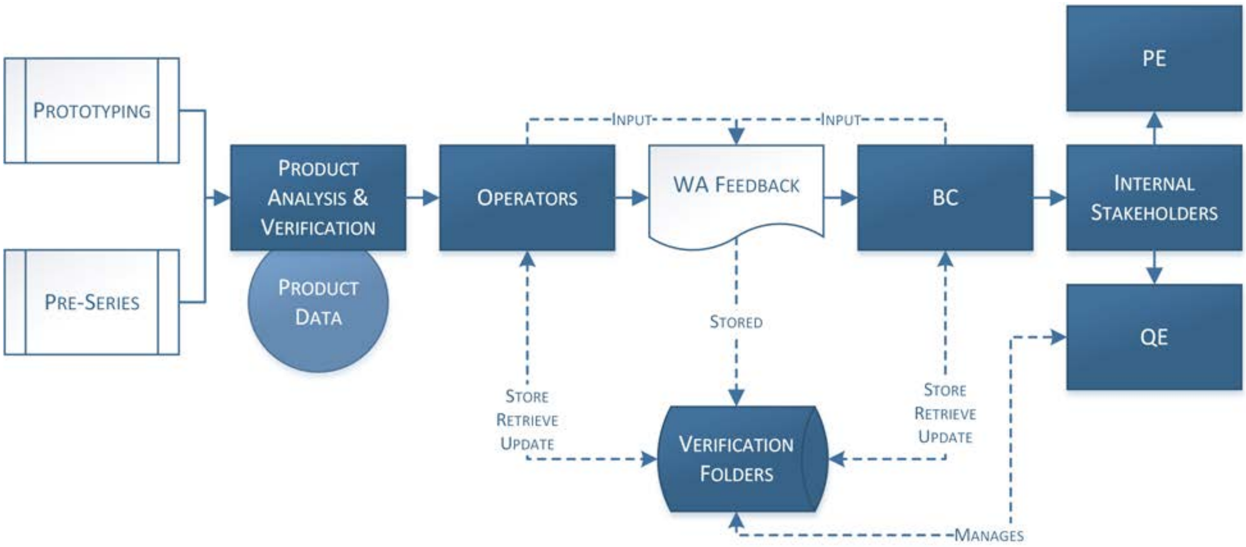

Figure 18: Overview of the WA feedback product workflow.

As stated, when a production run has been performed the WA Feedback product data content is reviewed and finalised by a BC. This is in order to ensure that the product data gathered is sufficiently presented for internal stakeholders, e.g. within Engineering or the NPI project organisation. Product data gathered in the WA feedback tool is also used to provide producibility feedback. Certain product data in the WA feedback document becomes input to a producibility report – in most cases a DfM document – which a PE compiles. This will be discussed separately, later in the report where the DfM process is described.

As mentioned in [5.2.1], when a new product concept is realised for the first time into a physical product (prototype 1) through a first build, an experienced operator builds this prototype together with a PE. This is often performed outside the main production line. At this stage in the product development process, product data input is written in collaboration between the operator and the PE in the WA feedback tool. Also, the WA feedback tool is used for plock-checks that also sometimes are performed outside the main production line. Therefore are these two activities not represented by the overview in *figure 18*.

According to interviewed stakeholders of the product data gathered in the WA feedback document, the quality of the product data gathered is not an issue. As a production engineer expressed himself:

"findings in the WA feedback document are good and of great value … it has improved … the operators are almost getting too picky regarding the production feedback provided"

- Production Engineer

A QE also stated in an interview that the outbound product data from Operations compiled in the WA feedback tool is very good and adequate in order to provide sufficient information to PDU and the NPI project in terms to suggest product changes implementations and evaluate the development progress of the product.

5.4.3 Production Feedback Process Issues

There are some present issues with the WA feedback document, or PDM tool. Firstly, the access to the document is restricted to one user at a time. During an interview with an operator it was stated that this caused problems in the production – as if an operator found a deviation, sometimes it could not be written directly as someone else was working in the document. This could cause product data losses – as an operator might not be enabled to report a deviation directly and could simply forget the finding. Also, the WA feedback document format is only compatible with the computers used at the assembly stations. This adds further access restriction to the WA feedback document that adds to the issue of availability that could result in product data loss. The viewpoint that the document restriction did to some extent hamper the analysis process was shared with BCs – it could become more efficient if this restriction was reduced. However, it was also stated that this access restriction did foster involvement and communication between operators – as it basically forced operators to engage in open communication and discussions regarding analysis & verification findings. If an operator found a deviation but did not have access to the WA Feedback document – the operator had to engage in collaboration with the person currently handling the WA Feedback document. According to interviewed operators it was stated that this actually improved the quality of product data gathered and also contributed to increased involvement of operators in the product analysis. This might also be connected to a statement from interviewed operators that certain operators rather get involved in oral discussions, rather than write down production findings.

Another issue that the interviewed operators also stated was that sometimes people forgot to close the document, which means that no one else could access it. This resulted in that someone had to check all computers in the production to close down the document. For instance, if the document is open within the production line – a BC cannot access the document and finalise the review of the gathered product data.

Additionally, the WA Feedback document is not shared or stored in a PDM-system today. The document, or tool, is shared through network folders that internal functions have access to. The responsibility for the maintenance of these folders lies on the QEs. A QE implied in an interview that it would beneficial to store these documents in some type of database – as these contain a lot of product data today.

"There are a lot of WA Feedback documents stored from the production, each WA Feedback document must be opened and every finding has to be analysed, so there is no systematic database to use – one has to click through a lot of information in order to find things."

- Quality Engineer

If a QE wants to find product data stored in a WA feedback document – he/she has to click through a lot of folders in order to find a certain WA feedback document. This implies that in order to find certain product data related to a certain product – one has to know very specifically what to look for. Today, there is a lot of product data stored in these network shared verification folders that have re-usable value for internal stakeholders – as these WA feedback documents contain deviations found and also suggested solutions to these deviations that could be applicable for other similar products. However, the storage used for this product data is not sufficient and involves a time-consuming process of finding relevant product data. Further, as the WA feedback tool is a document restricts the ability to be enabled to simply find product data within the document – as a PDM system or application could provide functions that would allow the user access to product data concerning several products in a simple way (Stark, 2011).

The production feedback process and the product data gathered in the WA feedback tool is the main source for gathering product data in the production. However, this product data is then used by internal stakeholders that utilise this product data to compile other documents that are used to implement design changes and evaluate the product development progress.

5.5 DESIGN FOR MANUFACTURING PROCESS

The DfM process is an important part of the product development process (Selvaraj et al., 2009), and represents a main part of the NPI process at PIM RBS. The DfM process is connected to the Industrial Engineering department and production engineers (PE) is responsible for the DfM review. This is one of the processes identified in the NPI process for gathering product data. The DfM review is a producibility review that should be performed for all filter product designs and the included production documents. This includes producibility deviations regarding the manufacturing instruction used by the assembly, mechanical design deviations, tools & equipment related deviations. The purpose of the DfM reviews is to enable PEs to find design deviations in early development stages and report them to the PDU. This is stated to ensure a safe, high-quality, and cost-effective production process and to shorten lead-times – supported by theory (Dröge et al., 2000).

The DfM process should be present in all NPI projects executed at PIM RBS Kista. Producibility reviews are performed several times during product development in order to find issues or deviations as early as possible to enable design alterations. This is supported by theory and by performing DfM reviews, or producibility reviews, problems or design deviations can be identified early and minimise deviations later in the development process that induces higher costs (O´Driscoll, 2002; Dröge et al., 2000). In PIM RBS Kista, the DfM process includes the use of continuous verifications, including testing of components or products (Dröge et al., 2000), which is especially important in prototyping development (Silverstein et al., 2009). The product related information – i.e. product data, often connected to design specifications alterations produced in these interactions with product design units is seen in theory as a vital part of the DfM process (Giachetti, 1999).

This process is highly inter-linked with the production feedback process described earlier. As the DfM producibility review and the included DfM document is mainly filled with product data from the WA feedback tool. In other words, the PDM-tool WA feedback used within Operations contain product data that represents input to the DfM document, which can be seen a PDM tool as it is used for gathering and storing of product data (Otto, 2011). Because of this, PEs was identified as one of the main stakeholders of product data from Operations. However, the DfM document can also include input directly from PE through communication with PDU.

Throughout the DfM process product data is gathered at PIM RBS Kista, and O'Driscoll (2002) states that it is important to gather product data continuously within a DfM process in order to avoid issues related to producibility in later development stages. In order to describe the DfM process an overview of the process in connection to production activities and the NPI project phases are presented below, *see figure 19*.

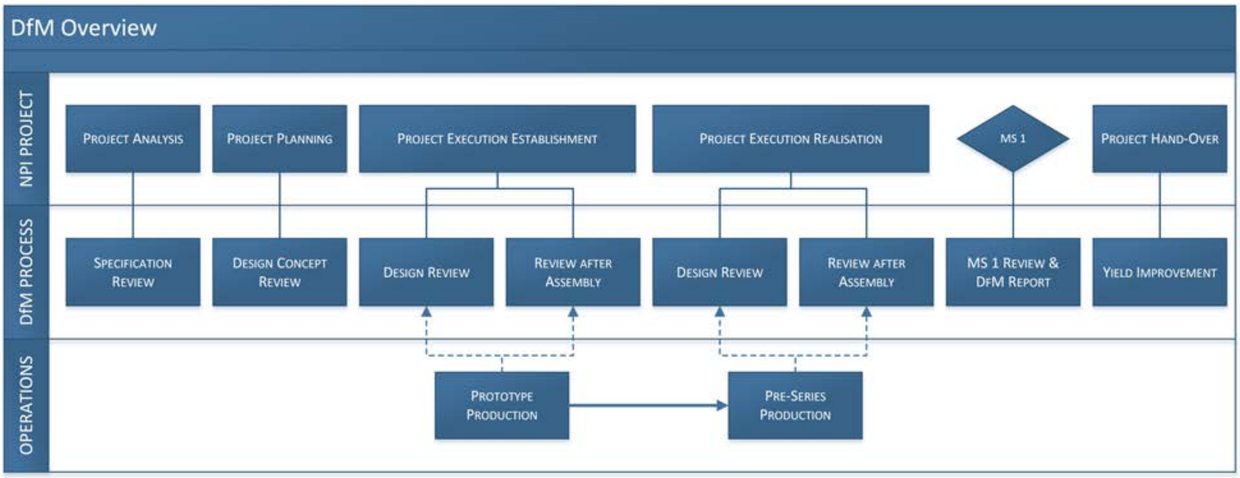

Figure 19: Overview of the DfM Process and its connection to NPI Project phases and the Operations department.

5.5.1 Project Analysis & Project Planning

The most important phases are essentially the project analysis and project planning phases, in which the initial DfM producibility reviews of the specifications and design from PDU is performed. This is also where the specification and design of the first prototype is set, as well as its production cost. The collaboration and communication with the PDU is stated to be very important during these phases – to ensure that a sound process of recommendations and product evaluations are established to the PDU, which is also supported by Guardiani, et al. (2005) who stresses the importance of continuous collaboration with responsible product designer.

The activities in the project analysis and planning phases includes; pre-study meetings – where previous experience from production, producibility, and testability issues from previous products are gathered and used as a foundation for design evaluation. Often this is performed through lessons learned workshops. These phases also include several reviews of design proposals, for instance building practice, test solution, review of components, etc.

Design concept review

Before the DfM analysis starts on an actual physical realised product, an analysis of the product requirements and design is conducted by a production engineer (PE). This often involves the most experienced operator from the filter production. So Operations within PIM RBS Kista is involved in this early stage. The bill of material (BOM) (Stark, 2011) – that constitutes the mechanical parts of a filter is also analysed in this step. This is performed in order to secure that the right components are listed – so that operators will have the correct BOM in the production (product data verification). The manufacturing instruction is also created in this step, together with the experienced operator to ensure a production process with high producibility – i.e. a simple and efficient production process (Elgh & Cederfeldt, 2007). This step therefore includes the creation of product data that enables an effective production process – i.e. how to assembly the product and the included components.

This activity includes providing feedback to the responsible designer and CAD drawer at PDU to find issues as early as possible regarding the product. The responsible PE for the DfM SMA process stated that 95 percent of the design issues are identified in this initial analysis. A PE responsible for filter products also stated that this stage identifies most of the issues – however physical verifications are required as to gather all deviations, i.e. product data. These initial issues are registered into the

DfM tool, but serve more as a foundation of aspects to consider when later DfM reviews is performed.

5.5.2 Project Execution Establishment

In the project execution establishment phase, the main focus of the DfM process is on the product documentation – i.e. verifying existing product data. The main goal is to identify deviations to secure a standardised and correct production process as early as possible to reduce lead-time and cost for the product. This stage should contain producibility reviews and a BOM-analysis.

This project phase in connection to the DfM process includes analysing prototypes. This is where the DfM analysis is performed in three areas; DfM Test, DfM FA (final assembly), and DfM SMA. For filters the main DfM analysis is the DfM FA – in which findings from the filter production through the WA feedback document takes place. For every prototype developed, a DfM analysis will be performed by the responsible PE. This is an iterative process in which the DfM Excel document is continuously filled in and updated for all prototypes developed. As the PE stated – the DfM analysis document is in this phase a "living" document. All changes that are made to the product is gathered and put in the DfM document – so product data is gathered throughout this process.

This project phase includes the first build, as mentioned in [5.2.1]. At this stage the responsible PE builds the first version of a product concept – i.e. the first prototype together with an experienced operator. The product data gathered in this stage is collected in the WA feedback tool – as well as in the DfM document. The findings made here are also shared with internal stakeholders within Engineering and the NPI project.

5.5.3 Project Execution Realisation

When a prototype developed has reached a required maturity level – i.e. it meets set specifications and requirements, the prototype phase ends and the product will be ready for pre-series production. This is also when a product is released, so in this stage the product does no longer require DfM FA analysis. This is where the DfM document is closed and stored in either in the product database through the local document system or through the system interface by the responsible PE.

5.5.4 The DfM-tool

The product data gathered in this process is the one regarding deviations in manufacturing instructions, and PDU design solutions regarding producibility, which are of main interest to the PE. The DfM analysis is based on a template formatted as a Microsoft Excel file. The DfM tool contains an Action Point (AP) list in which deviations found are to be listed. The template also requires users to input date of finding, responsible stakeholder to solve the deviation, picture of the deviation (if applicable), and a rating of the issue on a scale of four values – stating the severance of impact of the deviation found. This is a way to prioritize deviations found based on its impact to the product and process. The deviations and comments that are found during the producibility reviews shall be documented and reported and followed up in the AP-list found in the DfM template.

When a DfM analysis is conducted at PIM RBS, the DfM document is either stored through the local document system in the product database in connection to the filter's other product data, or through the system interface. Depending on which product level the DFM analysis is performed at (e.g. component, filter sub-module, or filter) the DfM analysis is stored under the product level at which the analysis considers. For instance, if a DfM analysis is conducted on a component level, for instance for a PBA board, the DfM review is stored under that level in the product database. This document is then accessible through system interface or the local document system.

5.5.5 DfM Process & Tool Issues

The DfM document has been stated to be a good tool for gathering product data. However, in the present state there are some problems regarding the document. The DfM document is not always used in the NPI for filters, it has recently been introduced and it is still unclear when and how the DfM document should be used is still unclear, stated by a BC. Sometimes other documents such as old producibility reports, which were used before the implementation of the DfM FA document, is used instead of the DfM FA document, which is stated by a BC to create uncertainties.

There is a DfM SMA review as, this process is rather similar to the DfM FA. There is one difference here that causes some uncertainty within Operations. For the DfM SMA document, a BC fills in input in the document. However, for the DfM FA a PE often performs the input of product data from the WA feedback tool. Also, for the DfM SMA document there are pre-defined design rules and an included check-list of specific analysis points that should be reviewed when Operations input product data. According to a BC this checklist is very good and makes the process very efficient – i.e. it enables effective product data management of gathering product data. Through an interview with the PE responsible for the DfM SMA document it was stated that the design checkpoints listed in the DfM SMA document had been defined earlier. According to the same PE, these kind of design specifications are not present for filter products. However, it was also stated that filter products are more complex than PBA boards.

Also, it has been stated by the BC that the fact that some product data is taken from the WA feedback document and put into the DfM document is an unnecessary step considering that it will eventually be combined by a QE for the quality report. It is also a problem, stated by a BC with how the DfM document should be stored, since it is a living document that needs to be updated continuously throughout the development process it needs to be easy to access and easy to update – for effective product data management (Stark, 2011). It is stated in the DfM document that there is a problem and a deviation; this is updated whenever the problem is solved. However, it only stated that the problem is solved not how – i.e. a solution description is not provided, which limits the reuse value of the document.

5.6 MAINTENANCE PRODUCT VERIFICATIONS

At PIM RBS Kista there is a verification process in which a feature of a maintenance product has been changed, which requires that the product be verified (Maropoulos & Ceglarek, 2010). For instance, a component has been replaced or a new supplier has been contracted to supply a constituting component that should be replaced, the product therefor needs to be updated by gathering additional product data. The component then has to be verified in order to secure its compatibility in the product and that is has no negative effect on the quality or feature of the existing product (Maropoulos & Ceglarek, 2010; Harkonen et al., 2009), i.e. verify that no lesser performance is an effect of a change in the product. During the maintenance product verifications the product data is gathered by operators in the WA feedback document – just as for NPI products.

The Verification process at PIM RBS is focused on products that are in the maintenance phase, i.e. when the NPI process is complete, which is described by shown in *figure 6* as volume production & continuous improvement of new product. This is considered to be a standardised process. It has however been stated by several of the interviewees that the NPI process also consists of several "verifications" and that the process for the operators in NPI projects is very similar to the verification process. This since the NPI and in turn the DfM process consists of stage gates where the design changes and rules has to be verified by the operators as also described by (O´Driscoll, 2002) who discusses the usage of verifications during "checkpoints" in the DfM process.

At PIM RBS the work assignment (WA) document and also the feedback file is an important document when gathering product data. There are also another document for process specifications that is a part of the system interface. When the operators work with the verifications in production they use the WA document as instructions for the verification. If any problems occur the problem gets escalated, see deviation management [5.5].

Current State Product Data Output

The verification process is stated to be a process where much product data is created (Maropoulos & Ceglarek, 2010), this is also the case at PIM RBS. It is important that sufficient product data is gathered in this stage since it is crucial for the improvement of the product. In order to efficiently update the product, product data regarding the product is needed (Stark, 2011).

During the verifications the QE stores WAs in the Verification Folders that specifies what should be analysed and what the production should focus on – depending on the assignment. It is stated by the team leader that it is important that the operators go through the WA document thoroughly so that they have the right instructions for how the whole manufacturing chain work and their part in the process. A BC retrieves the WA and creates a WA feedback document from it, which is then stored in connection to the original WA it is created from in the Verification Folders. The operators gather the product data during the verifications by using the WA feedback document. The instructions for the verification can be found in the WA feedback document, this states the objective of the verification and what product data that is needed to be gathered. During the verification the operators can access the instructions for the product assembly in a document that is stored in production folders, which is good since the assembly line then has easy access to the instructions. This is stated in theory to be important (Demoly et al., 2012).

Even if they only verify one component they put the whole product through the whole production line, described in [4.5], to make sure that the component does not decreases the performance of the filter in any way. This is supported by Oberkampf & Trucano (2002) to be important since the verified component needs to be aligned with the specifications for the process or product. It can be fairly easily stated that a complex product requires a more complex redesign process. Often a complex product consists of several intertwined subcomponents (Nightingale, 2000). The filter product is indeed a complex product including several interfaces between components. If a change would be performed on one of these subcomponents – there might be change requirements set on other subcomponents (Nightingale, 2000).

When the verification is completed a BC makes sure that the WA feedback document has been filled with the produced product data. To ensure this a BC holds a meeting at the production line with involved operators to do a final review of the product data gathered. This is done in order to review certain findings that might require more information. Also, the meeting represents a last chance to gather some findings that might not have been recorded in the WA feedback document during the production. This meeting is seen as an important forum, from both BCs and operators. It was stated in interviews that not all operators felt comfortable with writing down deviations found – both due to lack of computer experience and due to language barriers. For example, some operators do not feel comfortable to share findings in written text due to the risk of using wrong grammar, spelling, etc. Therefore, some operators rather share findings from the production analysis & verification in a spoken format – which this final meeting enables. According to the BCs the quality of product data gathered from product analysis & verification has improved since implementing this meeting. The WA feedback document is then sent to a QE who verifies the document in a verification report, which also includes product test data and yields gathered from the test data system at the test stations. The verification report is then sent to PDU who decides if the verification is sufficient to update the product.

The verification process is stated to be standardised and works good. The possible improvements that have been found in the verification process are rather improvements regarding the WA feedback document and the deviation management mentioned in other sections in this chapter.

5.7 Deviation Management

The management of deviations is an important aspect of both the DfM process and the verification process (Booker et al., 2005), one can say that the main objective of both the verification process and the DfM process at PIM RBS is to find deviations from the product specifications. This makes the deviation management process a vital aspect of gathering product data at PIM RBS. There are also special roles at PIM RBS that are assigned to solve problems that occur, such as quality coordinator (QC) and the FRAG team. Cross-functional teams are one way to assimilate product data – however the importance of clear roles and responsibilities stands as one pre-requisite for effective team work (Shankar et al., 2013).

The deviations in the production can include a number of aspects. There can be technical deviations regarding components (Munthe et al., 2014) – e.g. component quality. It can also be assembly deviations such as that a component prepared to the production lines deviates from the one listed in product data (e.g. the manufacturing instructions or BOM). When a deviation is found in the prototype stage of the development the product data is only gathered in the WA feedback document. However, when a deviation is found in the production line and a solution can be given directly, a Trouble Report (TR) is also put together as a change order to a PDU. When waiting for the official change an exception is written so that the process can continue. For example, a screw in the filter is wrong, then the problem is escalated and a TR is put together, if the solution is found that another screw can be used instead, the TR gets processed. In the meantime an exception is made that states that the new screw can be used for this particular filter, then when the TR is processed the assembly instructions and BOM are updated.

The trouble report system is a database that is used to store the TR. The TR sometimes contains solution to the deviation but that is only when the person that writes the TR knows the solution, otherwise the TR is just reported. However, even though these TR contains valuable product data the TR are only available for the one who wrote the TR, for example a QC can only access the TR that he/she wrote not TRs that someone else has reported. Another problem that has been stated by the operator and a BC is that the operators receive insufficient feedback regarding the deviations that they escalate, that they should receive feedback regarding the solution to the deviation. A process for gathering this product data has been initiated by a QC who gathers the product data in a document and has monthly follow-ups with operators, this is stated by a QE, BC, and operators to be a great improvement in feedback to the operators. This document and process is however at an early stage and needs improvement with storing and a more continuous feedback to the operators.

If a filter deviation regarding the tuning and testing of it occurs in the production, product data is gathered in the deviation system. In this system the cause of the deviation are registered. These deviations could be related to workmanship, functionality, etc. The deviation system is stated by operators to be inadequate, this since it cannot be used on the assembly stations and it is not compatible with the tuning software. However, in the deviation system, operators can give more information regarding the deviation – i.e. describe the deviation in more detail if applicable. It has also been stated by a QE to be a source of important product data there should however be more focus on input of product data regarding how a problem is solved. It has also been stated that the input is sometimes inadequate and could be more detailed according to the FRAG leader. The product data gathered in the deviation system is used by employees who manage deviations, such as the FRAG team.

Escalation Process

When deviation is found there is an escalation process for how the deviations are managed. Since it is the operators that work on the products, it is with them the problem escalation process starts. When a problem occurs in the production that cannot be solved by the operators they contact a team leader (TL) who contacts a QC or a build coordinator (BC), this escalation process is not standardised, illustrated in *figure 20*. Sometimes a BC is contacted first and sometimes a QC, and sometimes the operators contact the BC or QC without going through a TL. The problem is then escalated if a solution is not found. For example, if a quality deviation occurs the problem is escalated to the Quality engineer (QE) and further to the FRAG team, which can be considered a cross-functional task force that consists of a QC, QE, Product analyst, Test support, and experienced operator. The Planner is not a part of the escalation process, they do however also needs to be informed when a deviation occurs so that he/she can have this in mind when planning the production, this has been stated by the planner to be a problem since he/she does not always receive this information.

Another example is if there are any deviations regarding the assembly instructions then the problem is escalated and a PE is contacted in order to solve the problem and update the instructions. It is very important that these deviations are escalated so that the right assembly instructions are available in the production.

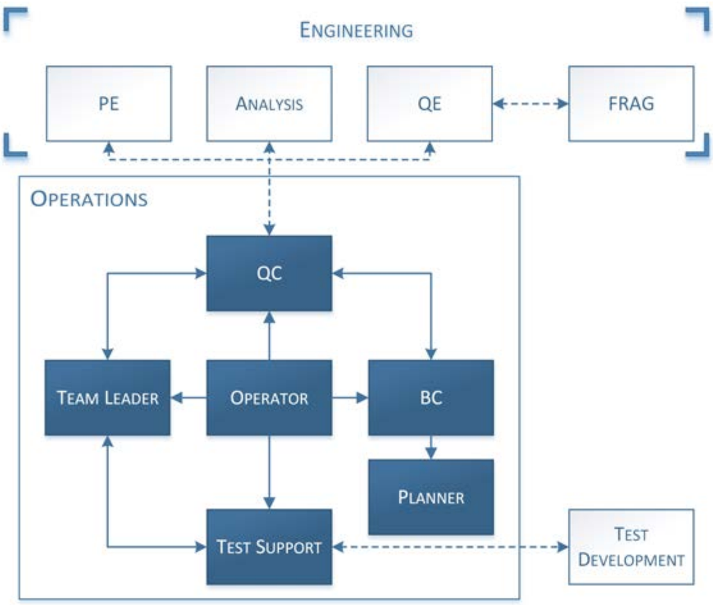

Figure 20: An Illustration of the current deviation escalation process.

During this escalation process different work roles are used in order to solve a problem. It is the QC and QE´s job to contact the employees that are needed in order to solve the problem. For instance, if there seem to be a problem with the material the Material Quality Assurance (MQA) are contacted to see if the material matches the given specifications, if the material does not live up to the set specifications the Supplier Quality Assurance (SQA) is contacted to get in touch with the supplier of the component.

6. DISCUSSION

This section will include the discussion of the problems that has been presented in the current-state analysis along with suggested improvements.

The primary data collected in order to analyse the processes used within Operations to gather product data and deliver it to internal stakeholders will in this section be evaluated through a discussion. The processes will be discussed one by one. The discussion is performed with a focus on the product development within the NPI process at PIM RBS Kista and the included processes performed by the operations organisation, especially within the production of filters.

The focus will be on product data – i.e. product related data, information, and knowledge as well as identified complications concerning product data management – to gather, store, share, and use this product data internally. As was stated in interviews with the main stakeholders of outbound product data from Operations at PIM RBS Kista – it is not the quality of product data gathered that is the main issue. It is rather the processes, tools, and systems that can be improved in order to streamline the product development and NPI process.

Unstandardised and poorly defined product workflows increases product lead-time and costs, and can hamper product development projects (Stark, 2011). Therefore is it important to standardise product workflows – activities that create and share product data. This is what product data management is all about – managing the flow of product data. The product workflow in organisations is often not strategically designed – rather it emerges from organisational changes, e.g. reorganisations (Stark, 2011). At the case organisation PIM RBS Kista, several reorganisations has been executed in a short period of time, and involved roles in the product workflow are rather new on certain positions. This has effects on the product workflow.

6.1 PRODUCTION FEEDBACK PROCESS

This process is as stated the main process to gather product data in the product development process within operations at PIM RBS Kista. However, the process includes complications regarding product data and product data management that would be of value for PIM RBS Kista to improve.

6.1.1 WA Feedback Document

The PDM tool (WA feedback document) is used during NPI projects and also during maintenance product verifications. The usage of the WA feedback document is, as stated earlier, almost the same during NPI projects and during maintenance product verifications. However, the meetings that a BC uses at the end of the verifications to ensure that all deviation has been reported in the WA feedback document, which is described in chapter 5, are only done after executed maintenance product verifications. This was stated by BCs to have improved the product data quality gathered after implementation. This could also be connected to that the main internal stakeholders of product data from Operations within the Engineering department – stated that the product data quality has improved lately. This implies that creating a feedback session for production shop floor workers after executed production runs improves the gathering and quality of product data. Also, interviewed operators stated that this enabled information sharing for all operators present at the production shop floor – not only those involved in the production run. This routine should therefore be done during the different development stages in the NPI process as well. By allowing the operators to share additional findings to the document it can improve the amount of product data that is gathered since some product data can be forgotten in the production process. Pentina & Strutton (2007) stated that implementing information sharing processes in a coordinated and successive ways at different phases in product development improves the process.

Regarding the input of product data the operators often use pictures of the deviation to clarify the deviation; this has been stated by the stakeholders as something that they appreciate. To visually present problems in product data has been stated in theory to be beneficial for production workers and engineers (Cardew-Hall et al., 2002). However, not everyone is allowed to take pictures in production, which is stated by operators to create a problem with the workflow since they need to contact someone that is allowed to take a picture. And often are the cameras on their phones used to take a picture. To eliminate this issue, cameras should be available in the production and more of the operator should be allowed to take pictures in the production.

6.1.2 A New PDM-system In Production

Organisational memory can be described as the information and knowledge possessed by an organisation and the included processes used in order to gather, store, and share it internally (Anand et al., 1998). In this thesis the product data represents value for organisational memory – as it represents previous product development experience. Further, Anand et al. (1998) stated that in order to enable organisational memory, information technology must be adapted to organisational processes. This statement implies that a PDM-system or tools must be adapted to the process and to the product data it should manage.

One solution to the main problems in the production feedback process would be to implement a PDM-system within the production line. The WA feedback document used in this process has limited availability. Since only one user can use the WA feedback document it at the time hamper this process – which causes workflow disruptions that extends the lead-time (Stark, 2011) in the analysis & verification process of filter products. This also creates the risk of losing product data – as operators sometimes cannot input findings directly and therefore might forget the finding. Another smaller issue that can cause workflow disruptions, as a cause of the limited access, is if an operator or BC forgets to close the WA feedback document then no one else can access or use the document, it has been stated that this has occurred several times and has created disruptions. The usage of the WA feedback document is fairly standardised in production, it has been stated by a PE and QE that the product data that is gathered has a high quality and that it keeps improving. The WA feedback document is however only accessible at the assembly station, which also creates limitations in the work flow and may be a cause of disruptions. The tuning and test stations also need to be able to make product data inputs into the WA feedback document.

In theory it has been stated that information technology tools has a positive relation to new product performance – especially if used in product development process where products is designed, and prototyping and product testing takes place as it includes cross-functional interactions and intensive information & problem sharing (Durmusoglu & Barczak, 2011). The problems that have been stated above implies that a PDM-system for managing this product data that today is gathered in the WA feedback document would be beneficial – as it could enable effective gathering, storage, and retrieving of product data, which is stated by Otto (2011) to be the main usage of a PDM-system. Also, it could enable effective sharing (Stark, 2011) of the findings to the main stakeholders of product data from operations – identified as quality engineers (QE) and production engineers (PE). The PDM-system needs to be available at all workstations (Philpotts, 1996) to enhance the product workflow (product data management). It is stated that it is important for organisations to leverage the organisational experience (Cormican & O'Sullivan, 2003) – in the case of PIM RBS Kista, this is the stored product data gathered from the production shop floor. This product data includes feedback regarding previous faulty design solutions, inadequate components, and other problems - logging of problems can be seen as codified knowledge (Cormican & O'Sullivan, 2003).

6.1.3 PDM-system Structure

A PDM-system used at a production shop floor has been stated to preferably include the following features; be part based, include visual representation, simple to use; and integrated with current work systems (Carpinetti & De Melo, 2002). Product data should be enabled to be connected to the part the production finding considers. Also, it should be enabled to connect similar products – i.e. through the product platform. Often a PDM-system lack associability between different products in terms of similarities in PDM systems that act as a barrier for effective product design (Demoly et al., 2012). It should also enable a user to search for similar parts in the system – as to access previous experience gathered from previous products realised. When reporting a deviation in the system it should enable visualisation of the problem – as visualising a deviation increases understanding of and the quality of the product data entered in comparison to just written text (Cardew-Hall et al., 2002). This includes attaching a picture as well as enabling operators to mark specific areas with an included marking tool. Simple to use indicates that the system is required to be user friendly. However, certain restrictions are required – as otherwise too little or too much product data could be entered. The system should therefore provide scroll-lists with pre-defined choices that in a step-by-step process guide the user to actually make relevant input. This is also important as to standardise the product data input to be stored. One important aspect here is to have a system admin that continuously develop the scroll-list if it provides insufficient choices. The systems must be integrated to existing systems in use in the production line. For PIM RBS Kista this involves to make the system available at all stations. The system should also include continuous updating of product data that is registered in the system (Cardew-Hall et al., 2002). An experienced operator at PIM RBS Kista stated that the provision of continuous updates regarding deviations reported was desired – in order to actually see that the product data input is processed and acted upon.[For more detailed specifications, see (Cardew-Hall et al., 2002).]

Through a conducted benchmark at Scania [Appendix A] a PDM-system was used in the prototype line in order to report deviations found – i.e. product data. The system included scroll-lists, which as stated is preferable (Cardew-Hall et al., 2002), as well as open text input in order to describe the deviation. By the interviewed Process Engineer at Scania it was stated that this system structure enhanced their deviation management, since the deviation escalation could be made in a more structured way. By implementing a structured PDM-system it enhances the ability to retrieve product data (Kumar & Midha, 2001). In an interview with a QE at PIM RBS Kista it was stated that being enabled to retrieve statistics from the production line is a valuable resource. It was also stated that a new PDM-system in the production line at PIM RBS Kista would not severely affect the operators in a negative way – in comparison to the WA feedback tool – if the system provided basically the same input instructions; problem description; suggested solution; main stakeholder; and a picture. According to the presented system above, the only additional input would be what part (component, module, etc.) the deviation concerns – which preferably would be represented by a scroll-list of pre-defined choices. Main stakeholders could also be represented by a scroll-list as implemented at Scania.

The implementation of the described PDM-system could help solve problems regarding product data gathering PIM RBS. However, the implementation of a PDM-system is very complex and could be very expensive (Kumar & Midha, 2001) therefore it needs further research in order to fully establish its structure and if it is a financial benefit to implement a new system. This thesis has no intention to actually develop a PDM-system – only provide input how it could improve the current-state at the case organisation.

6.1.4 Re-usage of Product Data in Production

One of the main uses of PDM-tools and systems is the availability of product data for reuse (Saaksvuori & Immonen, 2005). However, this requires that users and stakeholders that have use of certain product data to have access to it (Stark, 2011). It should also be stored in such a way so that product data can easily be found and retrieved by those who require it in the day-to-day operating environment (Saaksvuori & Immonen, 2005).

At the benchmark at Scania it was stated that the re-usage of the product data gathered from earlier experiences is important to the production and the product development. This was also supported by a business developer at a conducted benchmark, at a consultancy firm [Appendix A] – that building new competence from previous experience is very important for an organisation to develop. The same business developer also stated that this is a key resource within consultancy firm to utilise experience gathered by one individual to another, and provide availability of such experience through systems in a simple way. An experienced operator at PIM RBS Kista also supports this by stating, "*About 90 percent of the operators would benefit from having access to earlier problems*". The document that QC use to store monthly quality deviations is stated by the QC, QE, and BC to be a great source of product data that could be used to enhance the learning of the operators. It has been stated that product development mostly includes information-processing, where information is acquired, processed, and shared between involved stakeholders and required in order to assimilate problems and ideas into product design improvements (Cormican & O'Sullivan, 2003). In addition, a team leader has stated that the operators do not receive enough feedback regarding earlier experience and follow up on deviation, this is also stated by a project manager who thinks that not enough time is spent on lessons learned, which according to Kontoghiorghes et al (2005) is important to the product development. Learning among production shop floor workers – i.e. operators within PIM RBS Kista – is important for production performance and continuous improvements (Letmathe et al., 2012).

The QC deviation document contains pictures and product data regarding deviations but the main contribution of this document is that it includes how the deviation has been managed and solved, which is a part of the learning aspect of the deviation management mentioned by Munthe et al (2014) as a potential part of deviations. This helps the operators to get an understanding of the whole process and what their contribution results in. However, this document should be presented more often in production, both the operators and BC have stated that this information should come more frequent in production and should include all operators to enhance the learning, this since the reusing of product data is an important aspect of product development (Saaksvuori & Immonen, 2005). It is however not enough to just go through the document. The operators at Scania have access to earlier deviations and the ability to see how they were solved. Something a PDM-system could provide. It is important that the product data is available to the employees that have the most use of it (Philpotts, 1996) - i.e. the operators, when they need it (Stark, 2011) - i.e. at the assembly, tuning, and test stations in the production. Dewett & Jones (2001) states that by providing individuals with tools that enables easy access to product data it facilitates problem solving, and in turn promotes learning. The operators should therefore not only be informed about the deviations in meeting but also be able to access the product data on their own at the workstations.

Saaksvuori & Immonen (2005) states that product data management also includes to exploit previous experience stored in product data that different employees might possess. It is important for organisations to decide what information or data is important to store and not, as well as make sure that different systems that handles information are compatible with each other (Shankar et al., 2013). Within PIM RBS Kista – the product data gathered in the WA feedback tool and stored in the Verification Folders is a source of product data and earlier experience, from which a database could be developed from. Further, data registered in the deviation system – that ends up in a FRAG protocol compiled by the FRAG team could be of use for operators to have access to. This FRAG protocol includes repairs action performed in order to solve deviations in the production line – i.e. previous experience. Also, the system should preferably be connected to the test data system and the deviation system that are already in place. This would allow QE and other internal stakeholders to produce statistics from the new PDM-system through already existing PDM-systems.

6.2 DEVIATION MANAGEMENT

Deviations have been paid little attention in theory and are often viewed as a result of lack of planning (Munthe et al., 2014). However, even though deviations cause major problems in product development, it can be a source of learning (Ibid) and are therefore a very important aspect of the NPI at PIM RBS. One of the main purposes of the production at PIM RBS is to find and report deviations during the NPI and verification process.

The process of escalating a problem, that is the result of a deviation, is stated by several interviewees at PIM RBS, including a BC and operator, not to be standardised as described in [5.7]. There are functions that should be contacted first, but this process can be different depending on who finds the deviation and what type of deviation it is regarding. It is stated by the operators that the reason that they do not contact a BC first is since they consider the BC to sometimes have insufficient knowledge regarding who the problem should be escalated to. A BC also states that it is hard to know who they should escalate the problem to in the early stages of production since there are many problems then that need to be solved. The reason for this is that there are higher amounts of uncertainties and in turn deviations in the early stages in the NPI process at PIM RBS, which is stated by a BC and an operator.

However, since the deviations are a source of product data that should eventually be added in the WA feedback tool, a BC should be the first instance in the escalation process. This since a BC are the final reviewer and manages the input of the product data that is later sent to a PE and QE (and other internal stakeholders) and are therefore an important part in the PDM-process regarding deviations. The BC can be viewed as an organisational interface between the production and other functions. If they are not the first instance there is a risk that they do not receive the information, since the BC have stated that the information sometimes passes them by when a deviation occurs. As stated by Munthe et al. (2014) the deviations can be a source of learning, this implies that the BC can increase their experience by having the deviations escalated to them two-fold. Firstly, the BC will gain experience regarding the deviations when they are escalated to them. Secondly a BC could gain experience regarding how the deviation was solved and by whom, when receiving feedback regarding the deviation (Brattström et al., 2012). By standardising the problem escalation process it will also develop a trust between the operator and BC, which is stated by Brattström et al. (2012) to be important as it creates clearer roles, which is stated to be important in product development. Also, the importance of standardised processes and product data management improves knowledge transfer (Shankar et al., 2013).

When a deviation occurs that needs to be escalated by operators it should be informed to the production team leader. Then the responsible BC should be contacted, who then is responsible to escalate the problem to the stakeholder most suited, this could be a PE, QE or QC etc. as shown in *figure 20*. It is also important, when there is a severe deviation in the production line to the extent that it needs to be stopped, that the planner is informed so that the delay can be accounted for when the production plans are made, stated by a planner and a BC. Since the BC has more direct contact with the planner this problem will decrease if the BC is contacted first.

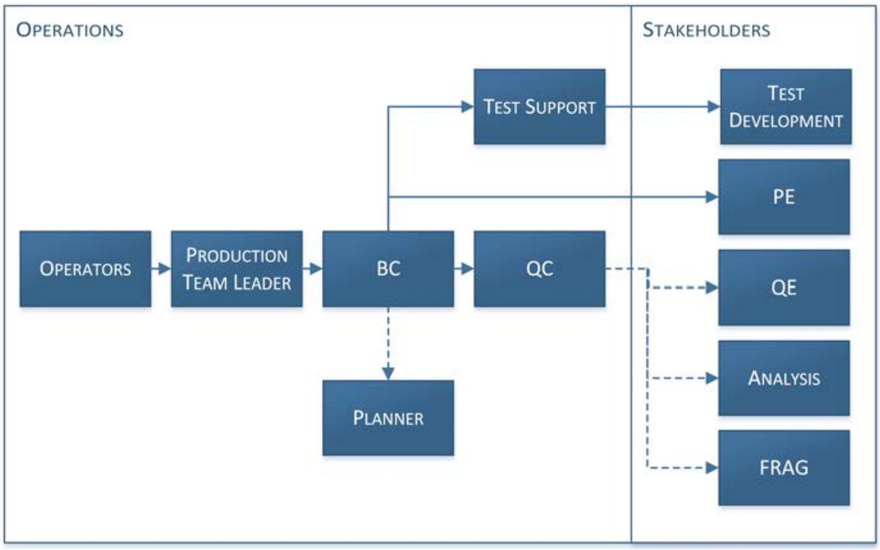

Figure 20: Suggested escalation process for deviations.

It is important that a change in the production always is escalated as a deviation so that the correct assembly process is described in the instructions (Ferrer et al., 2010). It was observed in production that filters were failing and no one knew why, this resulted in a stop in the production line. The day after it turned out that the reason for the problem was that the assembly instructions were not updated, an experienced operator had found that a certain component should be mounted in a certain way to improve the product performance. However, this product improvement (or product data) had not been reported in a formal way and therefore not communicated to the responsible PE – that is responsible for the manufacturing instruction. As the manufacturing instruction was not updated – due to lack of sharing product data – the operator that mounted the specific component just followed the instruction, as he/she should. If this product improvement – or product data – had been reported in an efficient way, the manufacturing instruction could have been updated and the problem would never have occurred. The result was that the product build stood still a whole day – due to insufficient product data management. This could have been avoided it the operators would not have been using the wrong instructions (Ferrer et al., 2010). This shows the importance of the deviation management and also that the operators should see themselves as a part of a process and not as a single station, which is stated by an operator to be important, and that sharing experience in the production.

6.2.1 Trouble Report

As stated earlier, the deviations can be a source of learning, when a deviation occurs it creates and opportunity for improvement. This implies that if information regarding deviations is gathered and stored in such a way that it enables easy access and availability for users – involved in deviation management processes the learning could be two-fold. First, increasing the product related knowledge and experience, and secondly how to manage similar deviations in the future (Brattström et al., 2012). The storage and re-usage of product data is an important part of PDM and in turn in PLM (Gielingh, 2008), this is often done through PDM-systems (Saaksvuori & Immonen, 2005) in the case of deviations the database for TR - the trouble report system, where the TRs are stored. There is however a problem with the storing of the product data that is gathered in the TR and in turn in the trouble report system. Since it is important that the product data is accessible to the functions that are in need of it (Philpotts, 1996; Crnkovic et al., 2003) it is a current problem that the QC only can access the TR that he/she has entered in the trouble report system. All of the TRs should be stored in such a way that they are available to the QC to enable efficient re-usage.

Stark (2011) states that often product change processes within PLM represent a very bureaucratic and time-consuming process, which could increase the time-to market. The usage of escalating a design change suggestion to PDU through TRs is as stated at PIM RBS to be a very time consuming process. The TRs should therefore not be used during the prototyping stages in the NPI process since there is stated to be higher amounts of uncertainties and in turn deviations. The DfM document should rather be used as a continuous collaboration with PDU to suggest design changes at that stage. Stark (2011) does however state that the TR process is a controlled process for making product changes – as it often involves changes in existing product data used by a global organisation. This process should therefore rather be used after the MS1 stage, at which most of the product development is completed and most product data is set.

6.2.2 The Deviation System

The deviation system is a PDM application for gathering product data regarding deviations in the production, and is used at the test station in the production at PIM RBS. The positive aspect of the deviation system in comparison with the WA feedback tool is that it also includes deviations caused by workmanship and the operators can describe the deviation in more detail, which is stated by a QE to be of importance. However, the deviation system cannot be used at the assembly stations and is not compatible with the tuning software. The operators therefore do not appreciate this application; it has been described by operators as being inadequate. The FRAG leader also states that there is a lack of the provided product data in this application – especially concerning lack of detailed input. It is stated by Siddiqui et al (2004) that one of the main reasons that a PDM applications and systems, such as the deviation system, fail is that they do not meet the expectation of the user, in this case – to simplify the gathering of product data. Therefore, if this PDM application is made more user friendly and more compatible with other system it could be a good tool for gathering product data and escalation deviations. Shankar et al (2013) also states the importance of the compatibility between the PDM systems that are used.

6.3 DfM Process & Product Development

The DfM process is performed concurrently with the product development stages performed at the production shop floor, issues related to both will be discussed here. The DfM process consists of what is described by O´Driscoll (2002) as checkpoints, which is executed in relation to the product development stage-gates represented by the NPI project phases within PIM RBS Kista. It is crucial to the development processes that sufficient product data is gathered in the early stages of the NPI process – as this is what actually enables a fully functional product and process so that it can be introduced at an offshore mass-production site. Several interviewees have stated the importance of high focus in the early stages in the NPI process and the DfM process, which also is supported by theory, O´Driscoll (2002) states that implementing DfM in early development (design) stages is important in order to minimise downstream delays. At PIM RBS Kista is has been stated in interviews that the early stages in NPI represents uncertainty. At PIM RIB the plock-check is an important step in the early stage in the DfM process, since there are much product data gathered in this development stage regarding producibility and verifying existing product data (e.g. manufacturing instructions, BOM, etc.). The production team leader stated that the time spent on a plock-check outside the main production line is beneficial – as often the main production line get stopped due to deviations. Stated by both operators and the production team leader, an interruption (e.g. emerged deviation) during a plock-check only affects less employees than a delay in the production line.

"I believe that we are standing still quite often because of not conducting a plock-check on a product before it enters the production line"

- Operator

It is therefore important that the plock-check always is conducted, even in the maintenance product verification process. This in order to gather as much product data at an early stage in the product development process – i.e. in the prototype stage, and in turn minimise occurring problems in the production line. It is stated by operators that this is not the case today – it is not standardised. A plock-check is often done, but not always and sometimes it is performed in the main production line – and sometimes in smaller production assembly lines. It has also been stated by operators and the production team leader that during a plock-check a lot of deviations are found – especially regarding product data related to the assembly process and prepared material.

6.3.1 The DfM Tool

The DfM document at PIM RBS is a fairly new gathering tool regarding the filter production. This product data gathering process has been in usage for the development of other products at PIM RBS, such as in the SMA production, and is well established in this production. The implementation of the DfM document has increased the collaboration with the PDU since they receive a more direct and continuous updates regarding the progress in production, which is supported by Guardiani et al (2005) who stress the importance of continuous collaboration with the PDU during the product development.

Since the product data that is gathered in the DfM document is essential to the future development of a product it is important that this product data is accessible to the employees that are in need of it (Demoly et al., 2012). It is important that if the product data in the DfM document are to be reused in later stages it needs to contain sufficient product data, which is supported by Siddqui et al (2004) who mentions the importance of structuring a PDM tools according to the expectations – i.e. in this case to find relevant product data. The current state at PIM RBS shows that this, to some extent, is not the case, it can store product data regarding different product platforms at component level which is positive. However, at the moment the DfM document is only used to store product data and deviations regarding producibility, this product data is taken from the WA feedback document, which also contains product data regarding quality-, tuning-, and test deviations.

One solution would be to directly gather all the product data from the WA feedback document in the DfM document, which could minimise the loss of product data and enhance the usage of the document. There is value in information if it is easy to understand and organized in a standardised way (Shankar et al., 2013). This would rid the step of extracting only producibility product data from the WA feedback document and insert this into DfM document, and then in a later stage QE has to compile product data both from the WA feedback Word document and the DfM Excel document into a word document in the form of a quality report – which also includes product test data and any deviation analysis reports written.

Several interviewees have stated this to be an unnecessary step. If product data is stored in many different files it creates a need for understanding many different processes, which is a time consuming process (Stark, 2011). Since the DfM document is an Excel document it could be used with a different tab for each area of deviations and product data, it should be one for: Producibility, quality, test, and tuning. That way it will be of higher value and work as a unified document for almost all product data that emerges from operations. QE would still have to include the yields from the test data system and the product data from DfM SMA into the quality report since it has been stated by a PE that it would be impossible to join this in a combined DfM document. It has been stated by a BC that it creates confusion for operator and BC when a PE enters product data in the DfM document during the production. The process should be as such; BC received product data from the operator in the WA feedback document, this is then sent to a PE who is the owner of the DfM document. The PE can then enter the product data in to the DfM document and ad additional product data if needed then send it to a QE.

It is important that the document is stored so that the function in need of the product data has access to it (Demoly et al., 2012). There is a problem at the moment with how the DfM documents are stored at PIM RBS. The DfM document at PIM RBS is a live document that is updated continuously throughout the DfM process, it is therefore important that it is easy to make changes in the document. How to store this document should be decided – as to reduce unclear product workflow of the document. As it is a continuously updated document, it should preferably be stored in a PDM-system that enables users to access it fast and simple.

In connection to the implementation of a new PDM-system in the production – to gather product data – this system could provide the input that PEs require in connection to the DfM reviews performed throughout the product development process. Then the PE can take the findings from the PDM-system and input the relevant product data in the DfM Excel document.

6.4 ORGANISATIONAL ASPECTS

The Managerial aspect of product data management involves several factors. Unstandardised and poorly defined product workflow increases product lead-time and costs, and can hamper product development projects (Stark, 2011). Therefore is it important to standardise product workflows – activities that create and share product data. This is what product data management is all about – managing the flow of product data. The product workflow in organisations is often not strategically designed – rather it emerges from organisational changes, e.g. reorganisations (Stark, 2011). At the case organisation PIM RBS Kista, several reorganisations has been executed and involved roles in the product workflow are rather new on certain positions. This has effects on the product workflow. The discussion above has highlighted some issues and complications regarding product data management (PDM) that could improve the NPI process.

PDM can be seen as a tool to improve the efficiency of production operations, enhance cross-functional collaboration, and organisational collaboration (Heim & Peng, 2010). The product development within PIM RBS Kista includes a lot of cross-functional interactions. Cross-functional teams are one way to assimilate product data – however the importance of clear roles and responsibilities stands as one pre-requisite for effective teamwork (Shankar et al., 2013). Formal structures are important as it sets the basis for managing, finding, and access to diverse knowledge pools and decision capabilities (Egelhoff, 1991). Management should foster trust and openness in order to increase information capability, especially in the development phase of products (Frishammar & Ylinenpää, 2007). The focus should be on streamline technical information management – in terms of gathering, storing, and using (Ibid) – in this thesis defined as product data management. Firstly, Managers must lead and inspire teamwork and foster a culture that shares information, instead of giving strict hierarchical directives in order to reduce knowledge loss (Shankar et al., 2013). Management also needs to ensure that members in cross-functional teams have clear job descriptions and responsibilities in order to minimise unclear and diverse ways-of-working which leads to knowledge losses (Ibid). At PIM RBS there are uncertainties present regarding ways-of-working especially connected to individual preferences of how to perform work tasks. Clarifying roles and responsibilities, as well as state cause-and-effect involvement in processes would therefore reduce knowledge losses and as a result the sharing, assimilation, and accuracy of product data internally could be improved. From the interviews it was stated that there is uncertainty regarding different roles – and this affects the process of developing new products and the usage of product data in the organisation.

6.4.1 Individual Level

Shankar et al (2013) stated that knowledge loss connected to loss of experienced workers is a main issue within organisations. During this research it has been shown that within PIM RBS Kista, there are individuals with high product knowledge and experience. If these individuals were to be lost the impact would be highly negative. In the early phases within the product development process the most experienced operators are highly involved in collaboration with the PDU and Engineering function. The most experienced operators represent a great source of providing product data from realised products within PIM RBS Kista. The departure of these experienced operators would be critical to the organisation – as a lot of product related experience and knowledge would be lost.

6.4.2 Functional Level

In a study consisting of questionnaires including a sample of 223 Swedish technology-based medium-sized firms, Brattström et al. (2012) found evidence of that organisational trust is important in product development. The study was based on the authors' theoretical outset that trust improves learning and creativity, and that both are important in product development. Brattström et al. (2012) argue that trust is fostered by a clear and structured organisation and schematised information procurement processes. The main argument was that by increasing the structure of ways-of-working, trust develops that decreases uncertainty in product development. The argument was based on that individuals will not only learn how and to whom to interact with over time, but will be given the knowledge of it and therefore is predictable behaviour within the organisation increased. In other words, individuals in a structured organisation will develop trust in each other as the predictability of that specific tasks will be performed in a certain way increases – as a result work tasks and roles become clearer. One organisational issue, and therefore managerial implication, for PIM RBS Kista is that new roles have been formed that is employed by individuals with little previous experience of included work tasks. This is primarily a result of executed reorganisations. In connection with Brattström, et al. (2012) research, it can be argued that the predictability and trust in the organisation is low. This implies that by structuring information related processes and ways-of-working, trust can be increased. This can result in increased learning and creativity capability of the organisation and therefore enhance the product development in the NPI stages. To manage trust in an organisation, the product development process should be clearly documented (Brattström, et al., 2012). Firstly, this includes specifying and defining; processes and sub-processes; included roles and responsibilities at each step; how and when information should be disseminated; and include phase-gates (if applicable). Secondly, the processes must be clearly communicated. Thirdly, management should facilitate activities that enhance interactions between product development teams to foster experience sharing. In PIM RBS Kista's case – this can be implemented for NPI projects, responsible for different products. Preferably the interactions should be based on sharing lessons learned derived from executed NPI projects in an actionable way. Finally, the perception that trust is an organisational value should be communicated and also promoted in a leading-by-example manner. Failures in projects or in processes should be turned into an opportunity for learning – instead as a negative outcome. By doing so, managers will show trust in employees and therefore foster trust within the organisation. At PIM RBS the process of specifying organisational processes is under development and this thesis has to some extent contributed to this work. According to the cited research, this is an important initiative in order to foster and manage organisational trust and therefore enhance performance. This also implies that managers at PIM RBS, also outside Operations, must foster trust in the organisation and do so by focusing on that the organisation is developing and learning from experience in order to improve.

From interviews with individuals within PIM RBS Kista some organisational issues was identified. There are to some extent unclear roles that include individualised work routines within work roles that create cause-and-effect issues. Through this research the main findings indicates that this is a result of the historical downsizes and reorganisations that has occurred. Even though this is pointed out as a distortion factor in the PIM RBS organisation and the information flow – a great sense of understanding is present. The organisational culture that could be subconsciously understood during interviews implies that people understand that certain new roles and positions created, or people employed in these positions, are not perfectly developed yet and that it will take some time. However, the management at PIM RBS must understand that there exists a desire for more structural ways-of-working. This is however not an issue this report has the objective to answer, only to take into consideration and highlight. This does however represent a future investigation area within PIM RBS Kista – to further improve the internal PDM.

6.4.3 Industry Level

Regarding more external issues, as an example, for NPI projects the PDU sometimes sends a build assignment specification (BAS) and in other cases another type of assignment document is used. Also it is sometimes send through an e-mail or through an information system (which should be the standard). This can be connected to product data management (PDM) – as stated by a BC within Operation, a BAS used in a NPI project sometimes contain specific instructions on what to focus on in the production, which was stated to simplify the BCs work of what product data is most important to the PDU. It was also stated that for maintenance product verification assignments from PDU – the WA document sometimes lacked information. This resulted in a process in which a QE had to contact PDU and acquire further information. The information in the assignment could also affect the quality of product data gathered within Operations. Therefore, discussions with the PDU should be initiated in order to try to standardise this process – as it could indirect affect the internal PDM positively.

7. CONCLUSIONS

In this section our conclusion from the research will be presented together with limitations of the research and suggestions for future research.

This research was conducted in order to examine what tools and processes a high-tech firm use to gather, store, and use product data in a NPI context. The case study research was conducted at PIM RBS Kista, a supply-site responsible for the product development and industrialisation of filters for radio base stations within the world leading MNC Ericsson in the ICT industry.

The research focus was on the Operations department and the production on-site. This was based on an argument that most initial product data is gathered at the production shop floor. The research has proved that the production workers – blue collars – play an important role in producing product data as it is within manufacturing product concepts is realised into a physical product of adequate quality. This has clearly been the case within PIM RBS Kista – as when a product is developed, the gathered product data is used to verify that a products performance is adequate to pre-set requirements set.

It has also been found that the product development process involves complex product workflows. The thesis has described processes used within Operations and been analysed in order to the answer the main research question. The main processes involved include a Production Feedback Process – in which operators gather production findings from verifications and testing of new products during development in different stages. The product data is gathered in a simple PDM-tool – an ordinary text document. This product data is then what essentially initiate other processes in order to implement design changes to a product under development for further improvement. In addition, the DfM process has been found to be an important process to gather and use product data. This process has been described and discussed. From the empirical findings, the DfM process includes verifying initial product data such as instructions and BOMs – in order to create an efficient production process that can be industrialised to an offshore mass-production site. It also includes product data related to producibility issues related to product design – in order to ensure a high-quality process. During the research it was also shown that the product data gathered during the NPI process mainly involved deviations. This process was identified to produce a lot of product data that is of great importance within product development – and therefore is product data management important in this area as well.

The research has found several complications related to the presented processes implemented at PIM RBS Kista. Standardisation of product data and product workflow is beneficial – even if it is hard to achieve in certain ad hoc processes, such as deviation management processes. The usage of different PDM-tools and the lack of compatibility between systems have been established as a problem. Further, the value of reusing product data and enabling stakeholders with availability of product data has been implied. Effective PDM is argued to be valuable for organisational development – as it contain previous experience gathered during product development in the NPI process.

The processes identified within the case organisation to gather product data, as described, were stated by internal stakeholders outside Operations in the product development process to be of great value and quality. The stakeholders discussed in this thesis involve general functions such as engineers within quality and production & process. Therefore can the identified processes and ways-of-working be of value to academic research. However, the management of the product data could be improved within the case organisation. By standardising the PDM systems and/or tools and processes used for the product data that is created within Operations and shared to internal stakeholders a more effective and efficient NPI process could be obtained. This involved certain issues previously discussed in theory.

During this research the importance of product data availability has been discusses regarding several areas and has been concluded to be of high importance. It is important that the right product data is accessible to the right stakeholders. It has been shown in this research that when product data is managed in the wrong way more deviations will occur in the production line, which may cause an increase in downstream delays. By enabling the operators and other functions to have access to structured product data from earlier productions the product development can be improved, and also the learning factor of the employees in the different functions can increase. The main conclusion to be drawn is that product data management is important in NPI and the including product development process.

7.1 LIMITATIONS

This thesis contains much information gathered from semi-structured interviews. While this stimulates open answers from the interviewees it might also result in much needed interpretation by the researchers regarding the answers. Several employees of each function were however interviewed to increase the liability of the gathered information.

7.1.1 Generalizability

This research conducted includes only one case unit under study, at a department within an ICT company, which might create a low generalizability in this research. The company operates in a industrialised country and in a high-tech industry. The findings are therefore limited regarding these aspects. However, the identified and described processes used to gather, store, and share product data and the complications found are performed within rather general product development activities. Therefore can the processes identified be applicable to other organisations with NPI and product development responsibilities – at least provide insight of complications related to product data management.

7.1.2 Reliability

In terms of reliability, as this is an interprevistic case study it is rather low. This research has been conducted on-site with direct access to individuals and a lot of primary data has been collected through observations throughout the research. Also, the research is based on observations and interviews during a specific time-line. So if the research was conducted at another time – the results could be different regarding the processes described.

7.1.3 Validity

This research had a holistic approach from the beginning – in alignment with the interprevistic case study method used. This involved qualitative methods to collect in-depth primary data primarily through interviews within the case organisation – also outside Operations. This is stated to increases the validity of the findings (Collins & Hussey, 2009). Also the research is conducted within an organisation incorporated in a world leading MNC in the ICT industry – so the conducted case study stands as a valid research object for the conducted research and objective.

7.2 THEORETICAL CONTRIBUTION

It has been stated in theory by Giachetti (1999), Swift & Brown (2003), and Letho et al (2011) that further research in the area of DfX is needed. This thesis therefore makes a theoretical contribution by investigating and discussing the process of DfM at a major ICT company. Also, by focusing on the management of product data, which is stated by Crnkovic et al (2003) to be needed in literature, in a NPI context, this thesis makes a contribution to the literature regarding PDM. It has also been stated that further research regarding practices and process solutions within high-tech firms are welcomed contributions to the PDM academic literature (Kropsu-Vehkapera, et al., 2009). This has been the main purpose of the thesis – to contribute with through empirical findings from the case organisation.

7.3 FUTURE RESEARCH

New product development, and therefore the NPI process, can become more efficient if processes of gathering and disseminating market information are at place and in a timely matter (Pentina & Strutton, 2007). This information should be implemented in R&D, engineering, and manufacturing efforts. Also, the feedback from these departments should also be assimilated back to design-, production-, and development- processes (Pentina & Strutton, 2007). This implies that the NPI process within operations in a high-tech firm could be improved if information sharing between different departments were more efficient. This is however outside the scope of this thesis, but it does induce a future research topic. How can information be shared in a streamlined way between involved departments - i.e. the market-, design-, engineering-, and operations department in NPI? This is especially the case for product related information - i.e. product data connected to product development as it directly affects product development processes (Pentina & Strutton, 2007).

Based on the research conducted, more research is needed in order to investigate how a PDM-system especially designed for product development and its constituting activities can be developed. This research highlights some aspects that could be seen as a foundation of what types of features such a system would require and what types of functions and interests should be included when designing such a system. In a NPI context, this system should preferably also be on a global scale – as global NPI includes the transfer of manufacturing process and product technology to offshore production sites (Li, et al., 2013).

Further research is also required in order to further investigate processes used by firms, especially MNCs, to gather, store, and use product data within NPI and product development. The academic research is scarce as stated by (Kropsu-Vehkapera, et al., 2009) and this research has tried to contribute to the PDM research field. But, as stated, further research is required in order to find some kind of best practices regarding product data management.

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Appendix A

SCANIA

SCANIA is one of the leading manufacturers of heavy trucks and busses etc. SCANIA operates in approximately 100 countries and have over 35 000 employees. The production at SCANIA is focused on using a limited amount of components they can make adjustments and at the same time keeping the cost for product development, production and spare parts to a minimum.

Process description

One part of the SCANIA truck production site is the MP-line. Since there are being updates made to existing components and development of new components there needs to be somewhere that this components and parts can be tested and verified before they are introduced to the production line. This is done so that the product deviations can be identified at an early stage of the development phase, this will lower the occurring problems in the production line. This is what the MP-line is for. The MP-line can be seen as a smaller version of the regular production line that has a focus on doing verifications of new components and products to find deviations.

The development process starts with Construction that creates blueprints for the new product. This is done in collaboration with the product engineers. When the blueprints are doe the next step is the test phase, the test phase is done in two steps, digital and physical. The digital process is first where the product is tested in a digital production lite to see if it fits with the surrounding parts. After that the physical test phase starts, if necessary, this is not always the case. The constructors together with the Product engineers write a list of things that needs to be verified. A PA document is written by the constructors that contains a description of the verifications and what the goal of the verification is, this document contains all the information that is needed to conduct the verification such as tool specifications etc. when the physical tests are conducted the observed deviations are registered in a database. Depending on the deviations it either sent to the constructors or the product engineers. Once the product is verified they start verifying the structure i.e. the MONA documents and the element documents. It is at this point that the MP-line takes over the verifications and starts managing and registering the deviations.

The operators have much collaboration with the Constructors at an early stage in order to make sure that the process is done correctly. This is also an opportunity to see improvement areas and get first hand suggestions from the Constructors.

Managing Deviations and verifications

When deviations are found during the verifications they are registered with a project number which automatically delivers the deviation to the person in need of the information. In the deviation report the project number, a picture of the deviation, a short description, and a suggested solution should be included. They use one standardised system for the deviations that is accessible by everyone. When registering a deviation there are areas in the report that needs to be filled in order to send it. in this the name of the operator that registered the deviation, this way it is easily traced back to the operator. The system that stores the deviations are available in the line. There are different search strings that one can search on components name, e.g. axis, and then get all the deviations related to tat axis. in the deviation registration they use scroll lists in order to in some way standardise in what categories the deviations should be. The MP-line has a course regarding the management of deviations and how they should be logged. This is conducted by the more experienced operators

The importance of storing the verification deviations is to be able to access information regarding earlier deviations and suggested solutions for said deviations. High experience at the MP-line is crucial since they are the ones that are to make sure that everything works perfectly before the product is produced in the line and globally. Therefore they need to be able to see deviations and problems that can occur.

ÅF

ÅF is a technical consultancy firm with a focus on energy, infrastructure, and industry. They have about 7000 employees globally. ÅF take great pride in their employees, network, and especially their experience database, which is the biggest in the business. ÅF is chosen for a benchmark since they have a high focus on managing knowledge and experience within their organisation.

Interviewee

A Business Developer within ÅF was interviewed – involved in developing and implementing knowledge management system within ÅF on a local and global scale.

Experience database

ÅF has a database structured for finding employee depending on their skills and areas of experience. The database is structured so that the person that does the search can be very specific regarding what area he/she needs help in. this search function creates great assistance with the networking and assignment distribution. The employees can fill in what they are good at and grade themselves, then co-workers can leave comments regarding their experience working with said employee. The workers can also search in the database regarding assignments within areas of their interest and apply to them.

Project database

At the moment the project database is not optimized at ÅF at the moment. This is since the information regarding different projects often is classified, but also since some of the employees are not always putting in all the information regarding the project when the project has finished. The interviewee stated that this however is very important to have a optimised project database to reuse earlier experiences from projects. He also states that a new system is under development at the moment. This will have a global focus with the ability to specify the search alternatives depending on the local need, the interviewee mentions the importance of the ability to structure the system to match the local needs. The interviewee also stresses the importance of making the input of project related information a part of the work routines. The combination of a experience database focused on employees with a project database focused on employees will create a great total database, stated by the interviewee.

Appendix B

INTERVIEWED FUNCTIONS

- Quality Engineer – two employees
- Production Engineer – four employees
- Quality Coordinator – two employees
- First line support manager – one employee
- Project Change Leader – two employees
- Inbound Preparation Leader – one employee
- Project Manager – three employees
- Planner – two employee
- FRAG Leader – one employee
- Build Coordinator – two employees
- Operators – three employees (two former instructor)
- Team Leader – one employee
- Product Quality Leader – one employee
- Product Test Development – three employees
- Supply Quality Assurance – one employee
- Operations Manager – three employee