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Effects of Project Management Processes on Collaborative Product and Production Development

Master's thesis in Product Development and Production Engineering

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Abstract

Being competitive in today's fast-paced global market require companies to have an efficient product development process. An important step in this process to achieve high-quality products with a short time to market is the transition of a product design to production. As many companies choose to place the respective function in separate countries, it increases the importance of a well-functioning collaboration between the functions to overcome geographical and cultural barriers. This thesis investigates this subject by studying a company where the production has been moved from Sweden and Germany to the Czech Republic. The aim is to identify how the company's project management process and other factors affect the collaboration, and find ways to improve it. The investigation has been conducted by a qualitative research approach, including a document study, interviews and observations. This data has been collected from three of the company's sites, representing research and development as well as the production. In addition to the investigation, a literature study was performed.

The investigation resulted in an overview of the current state of the company's development process. Identified issues were broken down into direct project management factors and general organisational factors, with a total of eight factors of focus with effect on the collaboration. Seven improvement suggestions with the intent to support the collaboration by addressing areas such as planning, reviews, training and coordination were presented. The project management process does support the collaboration by defining a workflow of activities and the responsibilities. By adding structures for these areas, it can be even more supportive by creating prerequisites for clear information sharing and involvement by providing structures for when and how information should be shared. The intended effect of having clear information sharing and involvement is to create a mutual understanding about the projects and the needs of the involved functions.

Keywords: New Product Development, Project Management, Research and Development, Production, Cross-Functional Collaboration, Multinational, Product Development-Production Interface.

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List of abbreviations

BoM - Bill of Material

DfA - Design for Assembly

DfM - Design for Manufacturing

NPD - New Product Development

OEM - Original Equipment Manufacturer

PMP - Project Management Process

R&D - Research and Development

SoP - Start of Production

WBS - Work Breakdown Structure

Contents

1 Introduction

This chapter provides an introduction to the subject of this thesis, justify its relevance to the product development and production fields of today. Furthermore, the characteristics of the studied company will be described, as well as the current challenges it faces and potential benefits of the thesis project's outcomes. Furthermore, the introduction will cover the purpose of this thesis, the research questions and delimitations to the project.

1.1 Background

The intense competition within manufacturing industries puts a high pressure on companies to either increase their competitiveness or be outperformed (Pinto, 2012; Wheelwright & Clark, 1992). This competition covers everything from the quality and features of produced products to the process of developing them and producing them. Wheelwright & Clark (1992) discussed the importance of efficient development projects and time to market already at the beginning of the 1990's, and the topic is equally important today (Pinto, 2012). With product life cycles decreasing in length, the time for profiting from these projects decreases and to cope with this, companies need to improve their development processes, developing products more rapidly and at lower costs (Wheelwright & Clark, 1992).

This puts requirements on development processes and internal collaboration, to support projects in how to effectively follow the necessary development steps and get products from opportunities to serial production (Säfsten, Johansson, Lakemond, & Magnusson, 2010). In fact, having a close collaboration across the involved functions in new product development (NPD) projects is linked to the performance and success of the project (Graner & Mißler-Behr, 2014). The definition of collaboration used in this thesis is based on the Oxford dictionary and the Cambridge dictionary, which highlights that collaboration is not only the act of working together, it includes the goal of achieving or producing something.

"The action of working with someone to produce something."
- (Oxford Dictionary, 2018)

"The situation of two or more people working together to create or achieve the same thing"
- (Cambridge Dictionary, 2018)

The currently common multinational organisation structure in companies puts an even higher pressure on collaboration and well-structured processes, in order to cope with cultural as well as geographical barriers (Bruch & Johansson, 2011; Säfsten et al., 2010). As Säfsten et al. (2010) states, by managing interfaces between sites and functions, companies can develop and produce products more efficiently and become more competitive. Further, they discuss two crucial interfaces in this development processes, the interfaces between technology research and product development projects as well as the interface between product development projects and the manufacturing function of companies.

To manage these challenges, companies create their own structural processes, defining deliverables, receiving and transmitting functions of these deliverables (Säfsten et al., 2010). These structures should support the collaboration between functions as well as defining areas of responsibility, it should also fit with the corporate strategy. The situation for an automotive original equipment manufacturer (OEM) differs from the situation of their suppliers, where the large OEMs can have rigid structures and the suppliers need to be looser in theirs to follow the structure of their customer (Taggart, 2015).

1.2 The studied company

The studied company is a supplier active in the electronics industry with customers in areas such as automotive, telecom and medical industry. Focus lays in protecting electronics from electromagnetic interference and heat as well as providing complete systems for wireless applications. Their products range from protective materials used in mobile phones to cooling systems for apparatus used in medical technology for, for instance, x-ray equipment. The company acts globally and have close to 10 000 employees situated in North America, Europe and Asia.

This thesis focuses on a business unit acting within thermal management to protect electronic equipment from heat. Products within this business unit are divided into two segments based on the cooling technique used. The business unit has customers from most of the areas in which the company is active, but with an emphasis on the medical industry where the customers have high demands on quality and reliability. As the products are used as a subsystem, the customer relationships are characterised as a business-to-business relationship.

There are four sites related to this business unit, situated in the USA, Sweden, the Czech Republic and China. The sites in the USA and Sweden are dedicated to research and development (R&D), in the Czech Republic the site is dedicated to production and in China, the site combines both R&D and production. This setup is new since late 2016 and early 2017 when the Czech site took over production from the current Swedish R&D site and a German R&D and production site which now is closed. These changes have led to increased responsibility on both R&D sites to improve their competencies in the complicated product segment previously developed in Germany. Furthermore, they have had to both build relationship with and support knowledge development within the new production facility in the Czech Republic.

The development of new products follows an internal Project Management Process (PMP), which acts as a structure and support to the projects. Each project, regardless of product segment, should follow this process and included deliverables. Projects are managed from the R&D sites where project managers and design engineers are situated. However, as the sites have access to different competencies it means that the projects often are supported by other sites. For instance, as the Swedish site has an established prototyping operation, prototypes are often built for projects from the USA. Also, as the American and Swedish site does not have production capabilities, they need to collaborate with the Czech or Chinese site in the latter parts of the project to design and prepare the process for production.

1.3 Purpose

The main purpose of this thesis is to, through a case study of a business unit, assess how different factors within multinational organisations may affect collaboration in product development projects, and find ways to support the collaboration. The thesis should provide the company with an assessment of the current state of the company and the PMP. Furthermore, it will identify potential improvements of the current state in empirical findings and the documented process.

In addition to the current state analysis and finding of improvement potentials, the thesis should provide the business unit with ideas of how to benefit from these found improvement potentials. Preferably, the changes should be possible to perform within the business unit without external support. Furthermore, these suggestions should be prioritized, providing the business unit with a ranking of where collaboration could benefit the most from these improvements.

The background of the thesis project is based on the recent consolidation of production facilities within the business unit, which has changed the prerequisites for collaboration between R&D and

production. Especially, as the Swedish R&D site has a history of having a close collaboration with production in the same facility, it may require changes in the procedures to adapt to the new setting.

1.4 Research questions

The findings in this thesis will provide the studied business unit with means to improve their current PMP and collaboration between sites. To accomplish this, the thesis will address the following questions, which are derived from the business unit's recent structural change and the fact that cross-functional collaboration plays an important role in the success of NPD (Graner & Mißler-Behr, 2014).

- How does the business unit's current project management process influence the collaboration within product development projects?
- How can the project management process be adapted to improve the collaboration between R&D and production sites?
- Which factors, apart from the project management process, influence the collaboration within product development projects, and how?

1.5 Delimitations

The thesis will only focus on the chosen business unit and its products, with emphasis on the interactions between the respective R&D sites in Sweden and the USA and the Czech production site. The project should focus on areas where the management within the business unit has the mandate to make changes. The NPD project process, or the PMP, should be the central subject of the investigation. Although, the project will still discuss factors such as strategy, cultural barriers and potential technical means.

The current state study will be highly based on interviews and documentation, observations from the Czech site will be limited to a short study visit and the American site will not be visited during the project. Furthermore, the project will limit itself to:

- Only investigate the chosen business unit
- Not consider the Chinese development and production site
- Focus the analysis on the development phases closely related to product introduction
- Only provide suggestions for improvements to the existing PMP, not the implementation of a new process structure
- Only analyse the PMP related to the NPD; engineering change orders and incremental product projects will not be considered
- Only provide general suggestions on areas potentially handled by software tools such as product lifecycle management (PLM) and Visual Management, not suggestions for specific software and exact solutions
- Only provide suggestions and prioritization of improvements, not a full implementation plan

2 Theoretical framework

In this chapter, a theoretical framework is presented to provide an understanding of key concepts used and theories of importance in the study of a project management process. It includes theory and processes directly related to project management, as well as rather general organisational development factors.

2.1 Project management

In following sections, project management related structures, tools and issues will be described from a theoretical perspective, starting with the product development process stage-gate. Issues related to product and process development and project to customer interfaces are then covered, lastly, project time plans and project related physical product testing and verification.

2.1.1 Stage-gate

The Stage-gate, or sometimes the phase-gate, model, consists of typically five phases with gates between where the progress is reviewed and go/no-go decisions are made by so-called gatekeepers (Cooper, 2008). A typical Stage-gate is illustrated in *Figure 1*. Gatekeepers are usually a cross-functional group of senior managers, whose task is to assess the quality of the project's execution as well as ensuring that it is aligned with the company's objectives (Grönlund, Sjödin, & Frishammar, 2010). Each phase consists of a number of activities followed by an analysis of the activities' results and finally, the result of the analysis constitutes the deliverables of the phase (Cooper, 2008). By the use of gates, management gets natural reviews of a project during its path, providing the ability to terminate ongoing projects with low potential before all allocated resources been used (Maylor, 2010). Through this, companies may prevent losses in terms of development costs but also add to potential profit by freeing up development resources for projects of higher potential. It does not only allow the project to be terminated, it allows the project management to correct potential issues before continuing to the next phase of the project. As the phases typically become more costly as the project proceeds (Cooper, 2008; Grönlund et al., 2010), it is beneficial to terminate the project or address issues early in the project. Using Stage-gate gives the company an opportunity to work in a structured way with a process that otherwise potentially could be ad-hoc. It is also said to make the product development faster (Grönlund et al., 2010).

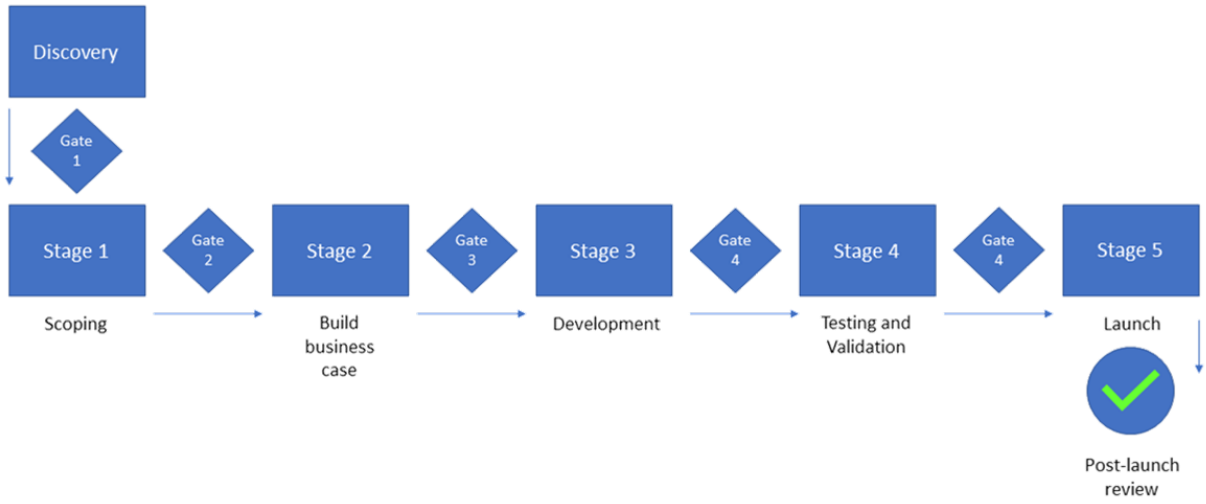

Figure 1: Illustration of a typical Stage-gate structure (Cooper, 2008)

Some of the benefits of the Stage-gate model does also contribute to its own drawbacks. For instance, some criticism towards the model includes that it restricts learning opportunities from the process and that it is bureaucratic (Grönlund et al., 2010). However, Cooper (2008) argues that the perception of bureaucracy may be due to uncertainties of what is expected, unnecessary information or even the design of the company's adapted Stage-gate structure. If the project team is uncertain of what is expected, they may overwork the deliverables and hence ensure that they cover their backs at the gate. Cooper (2008) further explains that the gates may also demand information that may be too in-depth to be useful for the project's continued work. Templates may be used as a part of Stage-gate, but there is a risk that they are overly detailed which also contributes to the unnecessary documentation demanded by the model itself. Hence, to keep effective when utilising Stage-gate, it is important to keep to the bare essentials of documentation as it will simplify the communication between the project team and gatekeepers (Cooper, 2008). Further, Sethi & Iqbal (2008) states that the learning potential of a project may be affected using Stage-gate. If the gate criteria are strict, it inhibits the learning opportunities for the project team as it does not allow for adaption to the changing project prerequisites.

2.1.2 Product development-production interface

As Lakemond, Johansson, Magnusson, & Säfsten (2007) explains, a common way to describe the industrial innovation process is to divide it into three parts, or sub-processes. It includes technology development, product development and production. The reason for dividing the innovation into these specific parts is that the three parts differ in characteristics and time-horizon. That is, the uncertainty is high and time-horizon long at the beginning of the innovation process and tends to decrease and shorten throughout the process (Vandevelde & Van Dierdonck, 2003). Though, as Lakemond et al. (2007) describe, it is important to manage the interfaces between the three sub-processes as the output of one sub-process need to be compatible with the preceding sub-process. For instance, new technologies and products may impose changes in production and investments made in production may restrict or enable choices in technology and product development (Lakemond et al., 2007).

According to Lakemond et al. (2007), the interface between product development and production is affected by a few mechanisms in terms of technology and organisation. Technological mechanisms include technologies that aid product development in their idea creation, IT-tools that aids the integration between the functions and manufacturing technology that increase the capabilities of the production. Further, the organisational mechanisms cover the structural, cultural and people aspects of the interface. For instance, it is important that there is a structured process in place to successfully transfer projects from product development to production when the functions are separated geographically and culturally (Säfsten et al., 2010). There is a need to clarify the necessary activities and time-frames, even though a flexibility in timing may be desirable. Another important factor for a well-functioning interface between product development and production is product development's empathy towards production (Vandevelde & Van Dierdonck, 2003). In this context, empathy refers to that the designer in product development acknowledges the requirements of the production and other differences between the functions. Meaning, the designer considers manufacturability in the design process and has sufficient knowledge to have an understanding of the challenges both functions are facing.

Within the product development-production interface, the interaction between the functions may be described by four modes or level of involvement; "serial mode", "early start in the dark", "early involvement" and "integrated problem solving" (Lakemond et al., 2007). Serial mode refers to when production is involved only when the product development tasks are completed whereas integrated problem solving refers to an ongoing dialogue throughout the whole project. The remaining modes

reflect a combination of the two extremes. As Gustavsson & Säfsten (2017) explain, the tasks related to the interaction, or transfer, are known as the product introduction. Even though it is a collaboration-intense phase, it is also associated with various uncertainties. For instance, it is sensitive to market fluctuations, changing customer requirements and the fact that the company may lack previous experience with the new product. This puts a great demand for open communication between the functions to give the production department the necessary prerequisites to prepare the production (Gustavsson & Säfsten, 2017).

2.1.3 Customer participation

Customer participation in NPD may be described as "the extent to which the customer is involved in the manufacturer's NPD process" (Fang, 2008, p. 91). How the customer contributes to, for instance, the innovation, speed to market and product performance may depend on both the customer's role and the developing firm (Fang, 2008; Morgan, Obal, & Anokhin, 2018). The customer may act as a source of information or play an active role in the development whereas the developing firm may be differently susceptible to the input. The customer participation may have different implications depending on where in the NPD the participation occurs. For instance, the customer may have valuable input in the testing stages which may result in lower product costs and better aligned with the customer's needs (Morgan et al., 2018).

Whether the customer participation has a positive implication to the NPD or not is dependent on the developing firm's so-called absorptive capacity (Morgan et al., 2018). The developing firm needs to have the capability to utilise external knowledge in their own processes to gain an advantage in the commercialization of the product. Even though there is a high level of customer participation, the receiving company need to have the capabilities to utilise the information in a useful way, there is otherwise a risk that it is regarded as an information overflow that has a negative effect on the NPD performance (Morgan et al., 2018).

2.1.4 Time planning

The work of assessing how long time a project will need to finish often starts by breaking down the project into smaller parts and tasks (Maylor, 2010; Mihály & Smith, 1999). Each task's time-need is then compiled into a time plan. A common way to illustrate the time plan is by utilising a Gantt Chart (Mihály & Smith, 1999). As Maylor (2010) explains, to manage the inherent tasks of a project, the project tasks may be arranged using a Work Breakdown Structure (WBS). This gives the project manager a systematic approach to break the project down into manageable parts. There are several WBS that may be suitable for different projects, including activity breakdown, functional breakdown and physical grouping. The characteristics of the time plan are determined by the accuracy of the estimated duration of the activities. Also, the accuracy of the estimates is increased as the project progresses, which means that there is an uncertainty at the beginning and precise towards the end of the project (Maylor, 2010).

To plan the project and determine which tasks are critical to finishing on time, an activity-on-node diagram may be used (Mihály & Smith, 1999). The activity-on-node diagram is based on the duration and dependency of the activities in the WBS. Through a critical path analysis, it is possible to determine the path of activities that will directly affect the completion of the project if they are delayed. By determining the window of possible start times of an activity, it is possible to determine which activities have flexible start times and not and hence will affect the final deadline (Maylor, 2010). However, since the durations are based on estimates, it may change throughout the project and may cause the critical path to shift in the diagram. This means that the project manager needs to keep track of the activities and update the time plan and activity-on-node diagram throughout the project to ensure that enough resources are placed on the most important activities (Maylor, 2010).

2.1.5 Prototype, pilot build and audit

Prototypes can have different forms and be described differently, they can be a physical illustration of a design, one can prototype the design of something but it can also occur in software development as a code (Ulrich & Eppinger, 2012). They define a prototype as "an approximation of the product along one or more dimension of interest", firstly, whether it is a physical or analytical prototype. Secondly, to which degree it is either comprehensive or focused, providing most of the intended features of the final product or just being focused on some. Furthermore, prototypes can have several purposes, supporting learning, communication and milestone assessment. By using a prototype to test ideas and hypothesises, projects can learn from the results. Communication can be supported by using prototypes as illustration support for discussions, they may also be used to assess the status of projects during gate or milestone reviews.

Lim, Stolterman, & Tenenberg (2008) discuss the issue of prototypes being handled and assessed differently, they say that there is no general way to define what is a good prototype or not, without a clear definition of the purpose of the prototype. They describe four classes of prototypes where the last one is the pilot system, being a small-scale test of the intended end product or system. A pilot is described by the Oxford dictionary as trials during a limited time in order to assess the effectiveness of the product, for physical products, this can be compared to a pre-series (Wallace, 2015). Furthermore, an audit is a concept used in production as well, which in production may aim at the processes of customers auditing the production facility and intended production line for their sourced product (Guénin-Paracini, Malsch, & Paillé, 2014).

2.2 Organisational development

In addition to theory directly related to project management, following sections are aimed at providing the reader with collaboration related theory, with an effect not only on project management but organisations in general. These sections will cover areas such as re-use of knowledge between projects, collaboration over functional boundaries, communication and meeting structures as well as motivational factors and design guidelines and reviews.

2.2.1 Project-to-project learning

Organisations are more and more based on projects and within these organisations, knowledge is an increasingly important competitive resource (Van Waveren, Oerlemans, & Pretorius, 2017). The nature of projects is likely to facilitate the creation of knowledge, however, being temporary also affects the ability to sediment the knowledge. It is common that organisations lack proper reviews of gained knowledge, which results in errors reoccurring over and over again (Ajmal, Mian M. and Koskine, 2008). For successful knowledge transfer, it is important that the knowledge is transferred to affected functions within the organisation once knowledge is gained.

It is difficult to obtain project-to-project learning for project teams, however, project-to-project knowledge is learnt between individuals (Goffin & Koners, 2011). How to transfer this knowledge to organisational knowledge is something that organisations struggles with, since being successful in maintaining knowledge is important for competitiveness. Goffin & Koners (2011) also discuss how post-project reviews can create shared knowledge within the project team, however, the knowledge often stays in the heads of the participants without being properly transferred to explicit knowledge.

2.2.2 Communication

Communication is described as a two-way process where a sender and receiver exchange a message of information (Ying & Pheng, 2014,), see *Figure 2*. The message is created, encoded and sent by the sender. On its way to the receiver, the message is carried in a communication channel through a medium where it is exposed to noise that may distort the message. When the message has reached

the receiver, the receiver interprets and decode the message. These encoding and decoding processes are based on the experiences of the sender and receiver. Furthermore, an increased understanding of each others' background and shared experiences, supports the encoding and decoding of messages.

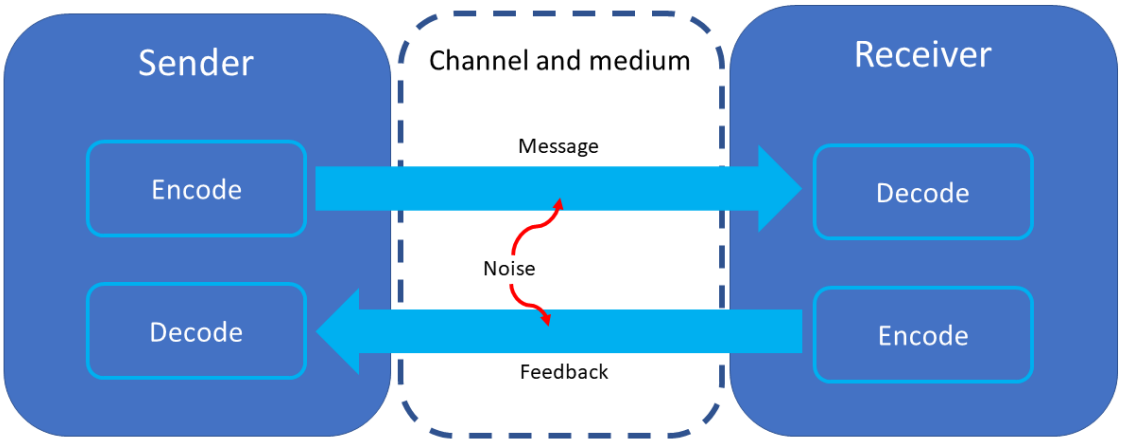

Figure 2: The communication process (Ying & Pheng, 2014)

By encoding and sending a feedback message to the sender, after decoding of the received message, the receiver gives the sender possibility to decode and assesses if the message is interpreted correctly. Using this model as a way to describe communication allows for a dynamism in the process as it means that the sender has the ability to adjust the communication continuously to adapt to how the receiver understands the messages. Although, as Ying & Pheng (2014) explains, the model lacks the social aspect in communication as it solely focuses on the information rather than including the continuous negotiation and consensus that brings meaning to the conversation.

2.2.3 Cross-functionality

Cross-functionality focuses on the number of functions represented or the diversity of them, commonly in development teams (Lee & Chen, 2007). Expressions such as cross-functional collaboration (Graner & Mißler-Behr, 2014; Luca & Atuahene-Gima, 2007) and cross-functional integration (Pimenta, da Silva, & Tate, 2016) are used to address areas of cross-functionality, enlightening the importance of collaborate between and integrate functions for successful cross-functionality. By the use of cross-functionality in teams, innovation is supported, as well as overall performance in new product development (Lee & Chen, 2007). Increasing the number of functions represented in the development team, generally results in a greater variety of the ideas generated from the group.

Cross-functional teams do not only support innovation and performance, according to Lee and Chen (2007) several studies conclude that they decrease development times as well. However, they mention that some studies argue the opposite, that Cross-functional teams may have a negative effect on development performance. The same differences that successfully utilised can increase performance, can also have a negative effect on the communication within teams. Since people with less common generally have more difficult to communicate successfully (Ying & Pheng, 2014).

According to Ulrich and Eppinger (2012), cross-functional teams are an important factor for successful Design for Manufacturing (DfM), since DfM is one of the most integrative practices related to product development. Requiring information such as production and assembling process

understanding, production volumes and product specifications and design, successful DfM requires involvement from several functions.

2.2.4 Meetings

A meeting may be described as a gathering of people with a specific purpose (Fast-Berglund, Harlin, & Åkerman, 2015; Gullander et al., 2014). The general purpose of a meeting is to share information between people where the communication may be supported by various information systems. Meetings may be arranged by a combination of time and location, leading to a total of four combinations; "same place - same time", "different place - same time", "same place - different time" and "different place - different time" (Fast-Berglund et al., 2015). All combinations may lead to different ways of communication, for instance ranging from face-to-face communication to electronic communication such as e-mail.

Gullander et al. (2014) argue that meetings act as the link, or glue, between what is described as a company's organisation system and information system. The organisation system consists of "structure", "people", "activities", "explicit knowledge" and "tacit knowledge". All parts are interconnected in the sense that the organisation system may be described as "a structure of people (human resources), carrying out activities, holding knowledge, some of which is tacit, some explicit" (Gullander et al., 2014, p. 5). Nonaka (1994) describes tacit knowledge as knowledge based on personal experiences and is often associated with know-how and skills. Explicit knowledge is, in contrary, knowledge that typically is documented and easily shared. As Nonaka (1994) describes, the knowledge may be converted from one category to the other in four different ways; "Socialisation" (tacit to tacit), "Externalisation" (tacit to explicit), "Internalisation" (explicit to tacit) and "Combination" (explicit to explicit). In an organisational setting, externalisation is needed to make knowledge available to others in the organisation to act upon (Michell & Mckenzie, 2017).

Further, Gullander et al. (2014) explain that the information system consists of "architecture", "technology", "logic", "information" and "data". As the organisation system, the interconnections in the information system may be described by the following statement; "architecture of technological resources, conducting functions/logic, using/generating information, some of which is readily accessed and some is less used/hidden" (Gullander et al., 2014, p. 5). The information system is connected to factors contributing to an efficient information flow, including "relevance", "timeliness", "accuracy", "accessibility", "comprehensiveness" and "format" (Kehoe, Little, & Lyons, 1992). In short, it describes that to achieve an efficient information flow, the information needs to be relevant to the recipient, available when necessary, error free, easy to access and only include necessary data.

Both systems are needed to achieve an efficient organisation and as they complement each other, meetings are a crucial part to bring them together. Meetings play the role of being the context where the two systems are combined to facilitate knowledge sharing, learning and more within the company (Gullander et al., 2014). Further, as Li, Fast-berglund, Gullander, & Ruud (2016) conclude, the structure of the information and organisation system may help a company to identify improvement potentials in their meetings as well as their communication.

2.2.5 Motivational factors

Hackman & Oldham (1976) presents five dimensions of the characteristics of work that contribute to an employees' internal motivation; "Skill Variety", "Task Identity", "Task Significance", "Autonomy" and "Feedback". "Skill Variety" emphasise the need for tasks that engage different skills and challenge the abilities of the employee. It is said that a task that engages several skills simultaneously contributes to the meaningfulness of performing the task. "Task Identity" describes that completing

a work from start to end gives more meaning compared to performing a fraction of the work. For instance, assembling a whole product gives more satisfaction than attaching a single piece to the part. “Task Significance” refers to the understanding that the work contributes to something more than the fulfilment of the task, meaning that the outcome of the work is of importance for the surrounding organisation or society. “Autonomy” is the ability of the employee to influence the own work situation. It could, for instance, be to set the pace of the work or planning the work. It is also about feeling personal responsibility for the fulfilment of the task. Finally, “Feedback” is the need of receiving feedback on the performance of the task in a clear and informative way to identify what the employee may improve.

2.2.6 Design Guidelines and Reviews

In order to attain desired design objective, organisations may use rules, heuristics and principles in form of design guidelines (Blessing & Chakrabarti, 2009). By using these guidelines, designers could be supported in the reliability of their designs. Furthermore, well-established design guidelines can support organisations in, for example, improved processes for Design for Assembly (DfA) or DfM, resulting in lowered assembly costs (Ulrich & Eppinger, 2012). Reusing knowledge through guidelines may also limit development costs, by not having to redo expensive tests nor having to spend time looking for the required data.

Another way to ensure the reliability of the design is to perform design reviews, which should be performed repeatedly in a generic product development process (Ulrich & Eppinger, 2012). The aim of a design review is to achieve a systematic and thorough analysis of a product or process design (Mital, 2014). By the use of formal design reviews, the modeller should be able to receive recommendations and concerns, preferably from someone knowledgeable in the area and not involved in the project, to receive an unbiased perspective. However, less formal, internal reviews may be used as well. These reviews, with attendees highly knowledgeable in the specific product, can support the design work in mainly the manufacturability and feasibility.

2.2.7 Production transfer

Rearrangement of a production facility is not only a matter of relocating manufacturing equipment, for a successful transfer it is important to manage to transfer knowledge as well, both explicit and tacit (Aaboen & Fredriksson, 2016). According to Fredriksson and Wänström (2014), production transfer includes four critical components, physical, knowledge, administrative and supply chain. They state that, until all these components successfully been transferred and implemented, the production transfer cannot be seen as completed.

When establishing a relationship between sites within an organisation of previous production transfer, it is important to understand that these new relationships require time to work well, a relationship is something that evolves over time (Aaboen & Fredriksson, 2016). Social exchange between the parties of this emerging relationship results in a decreased social distance between the parties, which in turn leads to lesser effects of geographical and cultural distances. As cultural barriers and distances are among the most important obstacles to overcome in production transfer, closing this gap is important for successful production transfer (Aaboen & Fredriksson, 2016; Fredriksson & Jonsson, 2009).

3 Methodology

The methodology chapter will describe the paths taken to conduct this project, describing the methods used to draw the conclusions, providing the reader with an understanding of the methods used. Furthermore, it will strive to justify why the research was conducted in the chosen manner, by referring to theoretical models.

3.1 Research design

With the aim of exploring the effect of both known and unknown factors, in combination with potential solutions, a qualitative research process was chosen for the thesis project. By trying to explore the unknown processes at the studied business unit, the project required a research method that could provide depth and additional understanding in areas the project could not have foreseen. According to Bryman (2012), a qualitative research method is superior in such an explorative study. Instead of narrowing down findings to answers directly related to pre-stated questions, the qualitative study opens up for additional knowledge and follow up questions. By having semi-structured interviews as a basis, the thesis authors kept their focus on the main topic of the interviews, yet it opened up for additional knowledge exchange (Bryman, 2012; Denscombe, 2014).

The research's focus was to assess the current state of the studied business unit, aiming to provide them with an outside perspective of their development process and collaboration. Furthermore, the aim was to provide the company with improvement suggestions, supporting further development of the PMP and their collaboration. Hence, the thesis project was divided into two phases with their corresponding focus, see *Figure 3*. The first phase focused on assessing the current state by applying different methods for data collection and the second phase focused on compiling the findings in phase one and generate ideas for improvement. In parallel to the two phases, a literature study was performed with the purpose of supporting the thesis authors with knowledge within the area and to compare the findings with best practices.

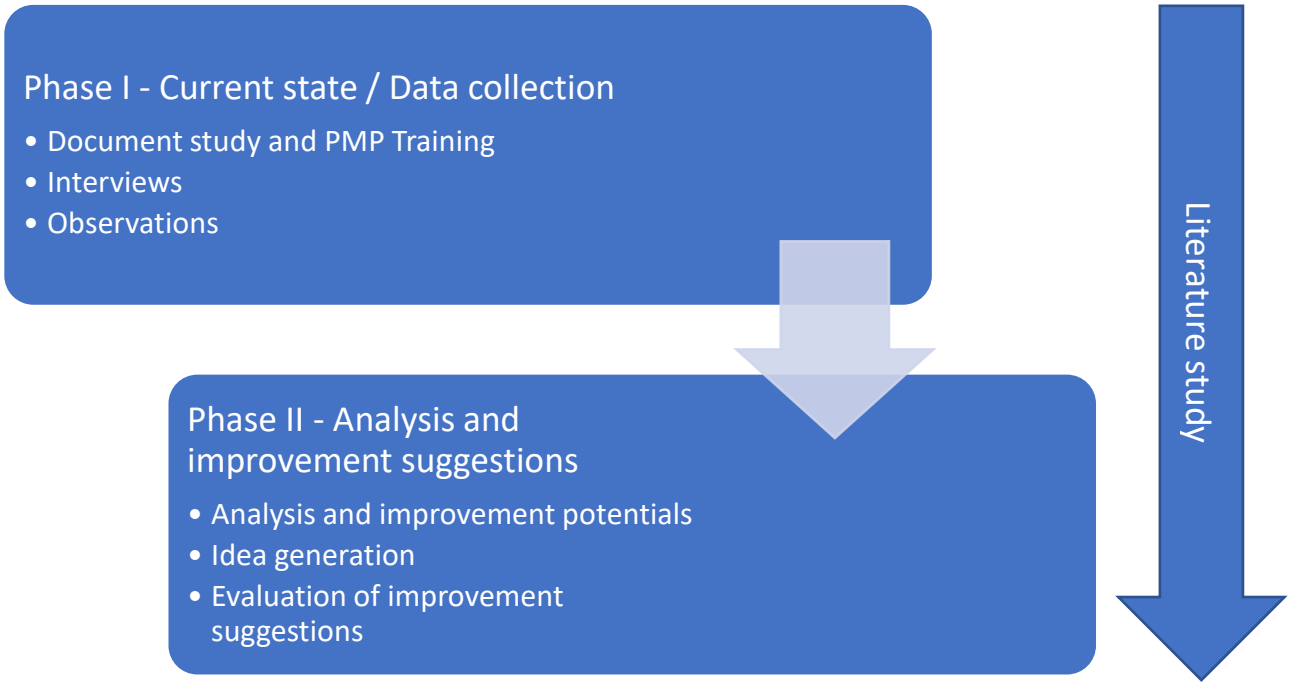

Figure 3: Overview of the research design

3.2 Phase I – Current state / Data collection

The current state analysis has been performed within the field of case study research. By this, the focus of the thesis project has been to analyse an organisation and its processes with the intent of describing and understanding how it works. Denscombe (2014) and Woodside (2010) describe the nature of case studies as encouraging of multi-method researching, by striving for a deep understanding of an organisation or process. Viewing it from different perspectives and by different methods adds to the understanding.

Methods applied to gain an understanding of the procedures and employees perception of the situation include a document study, interviews and observations. Woodside (2010) refers to this as triangulation as it covers several research methods with different time frames. The document study included a training session in the PMP and a study of the available documentation. Interviews were conducted in two rounds, starting with the department managers of the respective functions and followed by interviews with project managers and other project members. Finally, the observations included continuous observations from the Swedish and Czech site throughout the thesis project. In the following sections, the document study, interviews and observations will be further described.

3.2.1 Document study

The studies of the documented process included an initial training session of the process followed by a study of the documentation related to the process and interviews with the different department managers in focus, as well as some related managers. The intent of this part of the thesis project was to provide the thesis authors with an understanding of how the development projects were intended to work, as well as what support these projects had from the PMP. Furthermore, the study of the documented process provided a basis for the following interview sessions and observations in the thesis project.

Project Management Process training

The initial step in the studying of the documented process was a two-hour training followed by a shorter questions and answers session. The training was held by the engineering manager of the European R&D office, which also was the project supervisor at the studied business unit. The training session included a walkthrough of the process, decisions taken during the path of development projects and related documents. In this walkthrough, the thesis authors managed to get an overview of the whole development process. Furthermore, the thesis authors acquired necessary information upon related documents and where to find more information.

The training played an important role in the subsequence structure of the project. By getting an early overview of the whole subject of the case study, the thesis project could be better structured. With relationships and social settings being interconnected, understanding how these factors are linked together is important to understand why they lead to certain outputs (Denscombe, 2014). Being able to deal with a holistic view is an advantage of case studies, getting this overall view early in the study supports the holistic view throughout it.

Project Management Process documentation study

By studying available documentation, the thesis authors could examine the information available for project members and supporting functions. Reviewing the documents without interference from representatives from the business unit, provided the thesis authors with the possibility to examine the process structure more objectively. Furthermore, the material available could be used to form interview guides, to be used as support for discussions in interviews and to examine in observations.

Both Bryman (2012) and Denscombe (2014) describes the use of secondary data as a time-saving method of achieving data or knowledge, compared to gaining the knowledge from interviews and

observations. By examining the process description and checklist, the thesis authors could achieve a good overview of the process, without the risk of receiving an altered view from interviewees, meaning that the source of the information was the documentation directly instead of an interpretation, and potentially misinterpretation, by the interviewees regarding the process.

3.2.2 Interviews

Semi-structured interviews (Bryman, 2012; Elliot, Fairweather, Olsen, & Pampaka, 2016) were conducted on three levels in the company, representing the three studied sites and different perspectives on the work and collaboration in NPD projects. Interviews were conducted with the intention of getting the employee perspective on how the business unit function in their collaboration in development projects and how well does the current PMP support their work and collaboration.

The interviews were conducted in two rounds, starting with the management interviews to get a general direction of the thesis project and continuing with interviews of project managers and project members to collect data about the process and collaboration. All interviews covered the interviewee's role, opinions about the PMP and collaboration and ended with an open discussion where the interviewee was given the opportunity to suggest improvements or give input to what the thesis authors could investigate further. Examples of interview guides for the management interviews can be found in *Appendix A* and project manager and resource interviews can be found in *Appendix B*. Adaptions were made in the interview guides for each interview to suit the exact role and responsibilities of the interviewee.

Sample

The interview sample consisted of five managers, three project managers and ten project members. Interviews with management and project managers lasted for about an hour whereas the project member interviews lasted for approximately 30 minutes.

Management interviews

The management interviews served three main purposes;

- clarifying the process and confirm the thesis authors' understanding from training and document study,
- provide a department perspective of how they interpret and value the current process, and lastly,
- whom they thought would bring valuable input to the thesis authors in further interviews.

The management interviews had a high influence on the thesis project, by combining the different managers' opinions and improvement suggestions, the thesis authors could focus on areas where the managers requested a change. Furthermore, as managers of whole departments, the interviewees were considered to not only share their own opinions but also the ones of their departments, providing an overview of already ongoing discussions within the department. This view could then be either affirmed or altered in further interviews with members of the different departments.

Project manager interviews

As managers of the projects, they should be the ones with the highest level of interaction with the PMP and the related tasks. By being responsible for the success of development projects these interviewees know how a lot of factors affect their projects. That is, the project manager needs to manage many factors in a complex environment, such as strategic decisions affecting the project, selection of project members, stakeholders with interests in the project and more (Maylor, 2010).

Project member interviews

Compared to a project manager who coordinates tasks and facilitates project progress, the project members and support functions are the ones performing the tasks coordinated by the project managers. By working within the process, they should be able to provide information about how well their collaboration with other departments supports them in their tasks. It could include whether they are given the required input, if they know who to contact for support and so forth.

The project member interviews tried to capture the members with the highest effect on development projects, from design and manufacturing engineers to prototype, logistics and quality engineers. All these functions are active within the interface between product and process development. However, a majority has direct responsibilities in the project whereas the remaining functions have a supportive role for the projects. With interviewees with less involvement in the PMP, an explanation of the PMP was given to set a common ground for discussions in the interviews.

3.2.3 Observations

The observations were gathered from being located at the Swedish R&D office during the thesis project, a study visit at the Czech production site and participating in meetings. By non-selective fieldwork observations, in the Swedish and Czech sites, the thesis authors were able to acquire a holistic perspective and knowledge in where to focus the research (Denscombe, 2014). These findings combined with knowledge gained from other parts of the thesis project was further studied in focused observations, with the intention to affirm collected information and adding to the understanding.

Observations took place in meetings as well as continuously in the cafeteria and corridors, by studying interviewees in their everyday situations and catching up on lunch conversations the thesis authors managed to find out subjects of significance that were not anticipated. Furthermore, by observing discussions of, to the thesis project, relevant topics, different views and perspectives could be viewed in direct relation to each other.

Being located at the Swedish office provided possibilities to observe everyday discussions within the team, follow up on where members spent the majority of their time and get a sense for how the projects distributed task within their teams. However, as the thesis authors' focus was how the functions collaborate rather than how well they perform their work, observations of the employees performing project tasks were not performed.

To build an understanding of the producing site, as well as providing a better understanding of their challenges, the thesis authors performed a study visit to the Czech site. To better get the perspective of the manufacturing engineering team, the thesis authors were located in the manufacturing engineering office during the study visit. However, in order to overcome language barriers, short discussions were initiated in order to start communication. The visit included a walkthrough of the whole production site, not only the parts related to the studied business unit, which provided the thesis authors with an understanding of both possibilities as well as challenges related to such a wide product flora.

By observing some, for the business unit, central meetings, the thesis authors intended to get an understanding of how the different departments interact with each other. With departments being geographically distanced and facing time zone differences, the business unit was limited in their possibilities for interaction within the organisation. By creating understanding for the benefits of these coordinated meetings, the thesis authors should be able to declare efficiency of these meetings and potential strengths or weaknesses in the current setup. Furthermore, by reviewing the

interaction among members of the meetings, the thesis authors were able to get a grasp of how the hierarchy within the organisation takes form within discussions over several hierarchical levels.

3.3 Phase II – Improvement suggestions

In the second phase of the thesis project, the data collected in the previous phase were analysed and potential improvement areas were identified. Ideas for how to address the improvement potentials were found within the company and from the conducted literature study. Finally, the ideas were formulated as improvement suggestions and were evaluated through discussions with the supervisor at the studied business unit and presented at an online conference with attendees from the involved functions.

3.3.1 Analysis and improvement potentials

To set a basis for the improvement generation, the findings from the case study were summarised and analysed. By eliciting findings of importance and connect these findings to each other, the thesis authors tried to create a holistic view of all findings and their relation. The intention of providing this holistic view and relation between found issues was to better understand which issues that have the greatest impact on the organisation, if and how these issues could relate to each other. Furthermore, by structuring these issues into areas upon their root causes, it enabled the thesis authors to elicit and define a set of problems to focus on.

3.3.2 Idea generation

From the issues found in the analysis and later defined in the improvement potentials, the thesis authors tried to come up with potential ways of how to tackle them. By eliciting ideas from within the company and from the conducted literature study, a number of ideas were created. These ideas were discussed between the thesis authors and further elaborated to best fit the studied business unit.

When a set of ideas was formed, these ideas were further defined upon how they should work and how they should solve the discovered issues. These improvement suggestion definitions were designed to map towards the defined problems stated in the analysis, justifying the presented ideas. Furthermore, these definitions should be described clearly enough for the studied business unit to take a decision upon the value and efforts related to each idea.

3.3.3 Evaluation of improvement suggestions

To get some perspective and evaluation of the improvement suggestions, the thesis authors related their suggestions on support from theory and discussed with the local department manager, who supervised the project, at the studied business unit. By allowing the supervisor to comment upon the improvement suggestions, the thesis authors were made aware of which parts that required further explanation and justification, it also provided them with a sense of how the studied business unit would evaluate the mentioned improvement suggestions. However, being part of a department within the business unit, the input from the supervisor carried a risk of being biased. The theoretical perspective was then a support for how to analyse the input from the supervision.

With the input from the supervisor and some reflections from theory, the improvement suggestions were further described and justified. The final results were then presented at the studied business unit during an online conference including members from the three studied departments and the technical vice president.

3.4 Literature study

In the early stage of the thesis project, literature was studied to gain a general understanding of the topic of product development projects and the interface between design and production. As the thesis project progressed, the literature study was focused more on supporting the development of interview guides and a theoretical background to the subject. This enabled the thesis authors to limit the focus on subjects previously identified as potentially difficult for companies to manage. Also, the findings in the first phase of the thesis project were compared with available research in academia to provide a perspective from similar studies and identify potential improvements. Further, the improvement suggestions were assessed by comparing them with what previous studies have identified as important aspects to consider.

Literature used in the thesis was mainly found in scientific databases and libraries, such as Scopus, Web of science and Chalmers Library. The literature consisted of scientific articles, books and dictionaries. Keywords used in the search of literature included: “new product development”, “product development”, “production”, “cross-functional”, “knowledge management”, “collaboration”, “communication”.

4 Current state

In order to provide the studied company with improvement suggestions, a good understanding of the current state of the company was required. By studying the business unit structure, PMP and different functions within the business unit, the thesis authors acquired a basis to build upon. In this chapter the reader will be provided with this knowledge, starting from the structure of the business unit, followed by the documented PMP and the perceived process and issues elicited from interviews and observations.

In the last section of this chapter, the findings are analysed upon their influence on the central topic of this report, the collaboration. Highlighting and describing how these areas may affect the communication and collaboration between the sites, both negatively and positively. The output of this analysis will then be presented in *5.1 Improvement Potentials*.

4.1 The studied sites

With the complexity of managing multinational sites within the business unit being one of the drivers for initiating this project, this section will aim at providing the readers with a knowledge of differences and similarities of the studied sites.

The thesis project studied three sites within the thermal management unit of the company; the Swedish, American and Czech sites. The Swedish and American sites were focused on product development whilst the Czech site produced the majority of products developed at the other sites. Not only does the sites differs from being developing or producing sites, the fact that they were situated in three different countries, with culture and language differences, but also that they had different functions represented. These functional differences may introduce challenges that need to be considered when collaborating across the borders (Vandevelde & Van Dierdonck, 2003). For instance, the three sites had different native languages and national cultures, there was also a significant time difference between the American and European sites, which needed to be considered when communicating. See *Table 1* for an overview of the characteristics of the three studied sites.

Table 1: Overview of the characteristics of the three studied sites

Site	Function	Local time	Language	Other functions represented
Swedish	R&D	UTC +1	Swedish	Sourcing, Prototyping, Quality
American	R&D	UTC -4	English	
Czech	Production	UTC +1	Czech	Logistics, Quality

4.1.1 The Swedish R&D site

As mentioned in section 1.1, the Swedish site develops and builds prototypes for both product segments belonging to the business unit. Available resources at the site includes the engineering manager for the business unit in Europe, the sourcing manager for the business unit, project managers, mechanical or design engineers, electrical engineers, prototype builders and sales representatives. In total, about 20 people work at the site.

Before the consolidation of the production to the Czech production site , the Swedish site developed and produced mainly one of the two product segments. After the consolidation, product responsibilities from the previous German site were split between all three sites. Requiring the Swedish site to build up knowledge about the second product segment before the closing of the

German site, including having to cope with limited time for the transfer and lack of documentation from the previous site. In some cases, it has been necessary to reverse engineer the product to be able to provide necessary changes to the customers.

In the interviews, it was said that the main impact on the Swedish site from the consolidation was the fact that the production was not in the same facility which, in turn, meant that they did not have the same insight into the operations as before. For instance, they previously were attending department meetings jointly with the production which meant that they took part in the daily issues in a more natural way. However, the increased distance from production gave the site more time for development and fewer disturbances from the running production.

4.1.2 The American R&D site

The American site was structured similarly to the Swedish with product development of both product segments. The main difference between these sites was that the American site lacked prototyping capabilities, which means that they needed to utilise the capabilities available in the other sites. Though, they were planning to eventually build up the prototyping capabilities there as well. Another critical factor was that the site was situated in the USA, which means that there was a significant time difference to the other sites, which both were located in Europe. It was said during the interviews that, they did not have the same prerequisites to collaborate with the Czech site as Swedish site had, since they, due to economic reasons, did not have the possibility to visit the Czech site as frequently as the team situated in Sweden. It also meant that they had a limited possibility to arrange meetings with the Czech site due to the time differences. Instead, they needed to rely on e-mail and manage their phone communication within a limited time frame.

4.1.3 The Czech production site

The Czech site has a history of producing products to other business units within the company, to support these other units, the site had a varied set of production equipment and manufacturing processes. This includes stamping of various parts and manufacturing of materials, for instance, mixing of elastomers. As said during the interviews, their history meant that they needed to build up a new organisation for the consolidation as the new products differed significantly from the ones from other segments. In turn, this meant that many in the organisation around the consolidated business unit were new to the organisation of the unit and to its products.

The production of products from the studied business unit operated as a separate silo or plant alongside the other segments within the facility. Assembly of the products in the studied product segments was mainly performed on tables in separate flows. During the thesis project, the assembly area was crowded with tables from the previous production site, but the ambition over time was to reduce the space needed by assembling similar products on dedicated lines with one-piece flow, compared to the current batch flow. In addition to the regular production, they had a small prototyping and tool making workshop. Through this, they had the capabilities to manufacture jigs as well as prototypes.

4.2 The documented project management process

In this section, the documented PMP is described as well as its related checklists and tasks. The process will briefly be described from opportunity assessment to serial production. This will then be followed by a more thorough investigation of the two phases of highest influence on the collaboration between the R&D and production sites. The findings presented are based on a training session within the PMP in place during the case study, combined with a documentation study of process related documents.

4.2.1 The Project Management Process and checklist

Since the beginning of 2016, the business unit followed a PMP. It was used for all NPD projects and by all three studied sites. The process was divided into six phases with related gates, which they referred to as milestones, in between, see *Figure 4*. It ranged from an opportunity assessment phase where a dialogue with a potential customer is initiated to pre-series and Start of Production (SoP). The initial steps covered an assessment of opportunities, feasibility study and proposal or decline of the opportunity. These steps differed a bit from the common Stage-gate process, described in *2.1.1 Stage-gate*. As a tier 1 or 2 supplier, the business unit focused on customer projects, rather than developing their own product flora. By doing so, the idea generation and scoping were replaced by an assessment of customer requests with potential that fit their portfolio, regarding both areas they wanted to develop but also that they judged profitable to develop. At the end of these phases, the terms were to be negotiated with the customer and internally before passing the third gate, or milestone, which marked the start of product development and the point where project running costs increased. Customer fulfilment on accepted requests was therefore highly desired at the third gate.

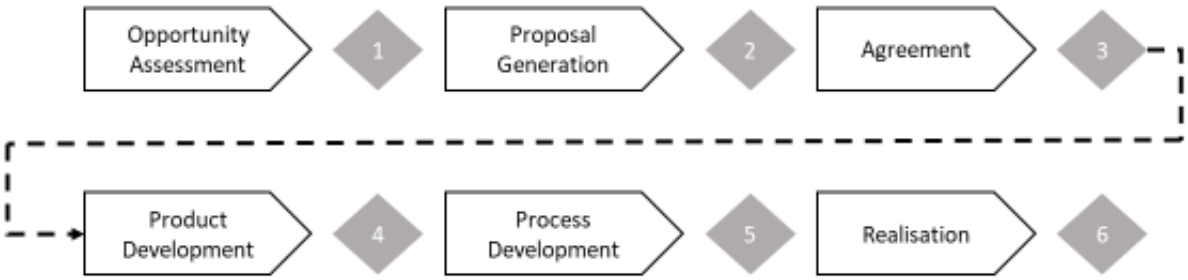

Figure 4: Overview of the PMP

The product development phase was where the development was initiated, and the customer requirements were converted to a design and physical prototypes. This was also the start of were the main focus of this study lay; the interaction between product and process development. These phases will be more thoroughly described in *4.2.2 Product and process development*. The output from them should be a frozen product design and chosen but not yet validated manufacturing process. These phases were followed by the realization process where the production process should be validated for the serial production.

The described process was broken down into phase-specific tasks which each project were to fulfil before passing on to the next phase. These tasks were arranged in a Microsoft Excel sheet, referred to as the PMP checklist or checklist, where involved functions could find their tasks and by which gates, or milestones, they were to be finished. The checklist contained information such as a general description or name of the tasks, the responsible for their performance, the supposed status of the tasks at a certain phase and due dates. For some of the tasks, it also included templates for how the task should be performed and documented. Furthermore, it was the responsibility of the project manager to ensure the fulfilment of the tasks and to further break down and distribute these tasks. In addition, a project tracker was used, which was an overlying document including financial information and a project management tool.

In order to pass the gate prior to the upcoming phase, a gate meeting (at the business unit so called Milestone Review Meeting) was held. These meetings had a long attendee list with various functions

present, where at least two VP's needed to be present in order to give a Go decision. The purpose of this meeting was to review progress and accomplishments in order to evaluate if deliverables had been met or not. This review was to be the basis for whether or not the Vice Presidents of the business unit decided to let the project GO (proceed to next phase), Refine (clarify open issues) or Disengage (close the project).

4.2.2 Product and process development

In the product and process development phases, the customer requirements were converted into a design and physical prototype and the design of the process was created. These phases impose a large part of the costs and time consumption of the projects due to design iterations requiring engineering hours and costs related to material and equipment.

Product development phase

For the product development process to start, it was required that the third gate was given a GO decision, each project was supposed to have a specification of the requirements of the product, cost calculations, development resources assigned and an up to date diary of the project so far. From here on the project manager was responsible for that the project would run according to plan.

The final delivery of the product design or development phase was a fully functioning prototype with acceptance from the customer. However, this design may still be changed due to manufacturability reasons in the upcoming process design phase. The PMP, illustrated in *Figure 4* defines a distinguished line between the product and process development phases. However, looking into the PMP checklist, some limited process development was active already in the product development phase. Despite the highly limited involvement in this phase, the manufacturing engineers were supposed to give final feedback to product design, upon process design requirements, within the product design phase. With some preliminary process/manufacturing deliverables in the product design phase, manufacturing could potentially have enough input to provide this final feedback. Further, it is the responsibility of the designer and prototype builder to ensure the manufacturability of the design which also contributes to a limited need for the manufacturing engineer's input in this phase.

In *Figure 5* below, the workflow of the product design phase is illustrated. As it is stated the product development gate meeting was to be held prior to delivery of prototype to the customer, the outcome of the review should then be whether or not the product was ready to send to the customer. Furthermore, the final decision on whether the project would pass on to the upcoming phase or not would then lie on the customer. However, customer acceptance of prototype was stated as a task in PMP checklist supposed to be finished at the gate meeting. This contradiction created confusion in how the process was supposed to be followed, potentially resulting in gate meetings without the possibility to make a decision or prototypes sent to customer without acceptance from a review decision.

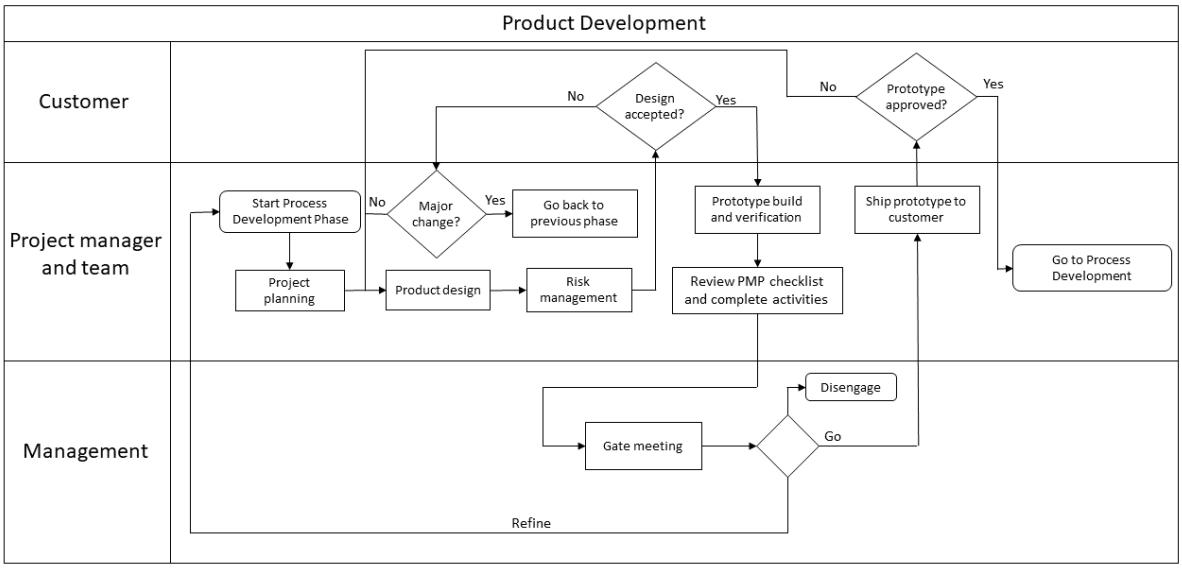

Figure 5: Workflow of the product development

Process development tasks

In the process development, the dialogue with customer continued as the product design and drawings were to be finalized, frozen and approved by the customer.

Apart from these tasks, the finalized bill of material (BoM) structure was to be set in all systems, together with preliminary documents handling everything from test plans to work instructions. The process was heavily relying on the manufacturing engineers, even though the project manager from the development sites kept in charge of the project progress. With a general task description combined with the geographical and in some cases time differences, the possibility for project managers to follow the project progress was limited in this phase. In *Figure 6* below, an illustration of the process development phase can be found.

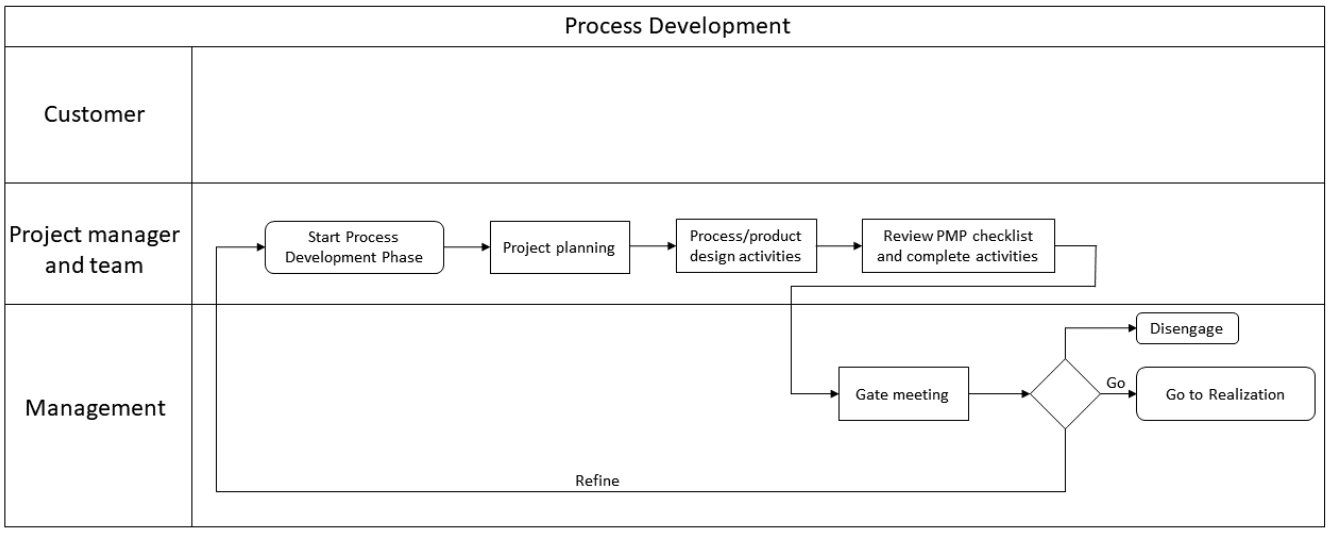

Figure 6: Workflow of the process development

Within the PMP documentation, there was no emphasis on how to handle functional, geographical, cultural or time barriers, leaving each project to decide their own way of interacting between functions and locations. Without clearly defined methods to interact, it was mentioned that project members commonly reached out to persons they felt familiar with, rather than the actual function or

post that should have been assigned. Furthermore, by transferring issues to a colleague not related to the project left them with additional networking, consuming time allocated for other projects and ongoing production issues. Even though the checklist frequently stated assigning of project members, there seemed to lack a definition of how to do so.

4.3 Interview and empirical findings

The following sections will share some insight into how the employees perceived the current PMP and the collaboration between different functions within the process.

The majority of findings shared in this section heritages from discussions during interviews, either from being invited to in the PMP section of the interview guide, see *Appendix A* and *B,* or shared by employees in the general discussion section of the interviewees. Sections *4.3.1 Project Management Process* and *4.3.2 Cross-Functional Collaboration*, are divided into findings with direct relation to the PMP and general findings affecting the collaboration across functions within the business unit.

4.3.1 Project management

In this section, some areas of importance related to projects are described upon how they were handled at the studied business unit. These areas include the decision-making process of which projects that should be prioritized or not, how the projects were affected by their customers' processes, project documentation and how well resources were integrated and familiarised with the PMP.

Gate & decisions

In order to decide whether or not a project could pass on to an upcoming phase of the PMP, gate meetings were held. At the studied business unit these meetings included gatekeepers, department managers, project managers and sales representatives. These attendees originated from the whole business unit and not only from the project passing a gate, resulting in about 30-40 attendees. These gate meetings were not exclusively focused on one project, each meeting was divided into two sessions of 45 minutes, the first one handling new business opportunities and the second handling later gate decisions. These meetings were held once a week and the project managers had to book a slot for a gate decision. However, instead of being allocated with time and order in an agenda, projects to review were chosen by the vice president of the business unit during the meeting.

The R&D teams shared an opinion that these meetings lacked in reviewing their obligations, instead sales figures were heavily emphasised. The only structural review of the project obligations was a question to the project managers if the project checklists were filled in or not, then discussions continued about profit, the return of investment and so forth. Portfolio management was commented as well, however, it was not clear how portfolio value was assessed. Furthermore, the issue was raised of idle projects not being closed or officially paused, leaving project managers with open projects for years in some cases.

During the interviews and observations, there were signs of overallocated resources. For example, each project manager had about ten projects to manage. With some of these projects being idle the burden was not proportional to the number of projects, however, they still had to follow up and report on the status on several of these projects. An issue of customers getting back after months or years were mentioned as well. Since projects were not officially cancelled or paused, customers expected projects to be picked up there they were left without any startup time required.

Customer vs own structure

Even though the documented PMP appeared to be a rigid structure, the projects were flexible towards the customer. That is, the PMP was handled as a sequential structure where phases were

frozen as the project progressed. However, the customers were allowed to make changes late in the projects, which meant that it could be necessary to review and sometimes make changes in already frozen phases. Further, the product design was not frozen until the process design was finished, which allowed the customer to make changes until finalising of production process design. Since the business unit did not track the time needed to perform activities in the process design, they did not have the possibility to communicate clearly to the customer what implications the changes would have on the final deadlines.

In the product development phase, the project needed to get approval on the prototypes from the customer to proceed to the process design phase. As there were no defined restrictions on how long the customer may take to evaluate the prototype, it meant that the projects were on hold until they received feedback. Both the waiting for customer response as well as late adaptions from the customers were mentioned by project and department managers as factors to why the projects were delayed when entering the process design stage.

Project Management Process related documentation

A result of the various documents used within projects was that the project managers experienced that they had to put similar information into several documents, doing the same task repeatedly with different levels of detail. They also experienced difficulties in where to follow project information, since the documents differ in how elaborately the information of the inherent components was described.

Each project manager was responsible for following the project checklist, and in collaboration with the sales representative keep the project document updated, keeping projects on track and performing all necessary tasks. It was then up to the project manager to ensure that tasks got transferred to the intended resource or function. The process of delegating a task and keeping up to date on its status differed between project managers, some were tracking and assigning the majority of the tasks through their project management tool, whilst others relied more on their own memory and local documentation. Furthermore, it was not common that the project members followed the project checklist themselves, instead, they relied on their project manager assigning them to the tasks most vital to complete. For the R&D related tasks, it worked well, but when it came to tasks performed at the Czech site, the project managers experienced difficulties to keep track of the progress, due to functional and geographical distances. However, at the Czech site, interviews indicated that project members had a complementing process supporting the resources in which tasks to perform. This documented process was mentioned to be written in Czech, which made it impossible for project managers to follow without translation support.

Prototypes

Prototypes of different types and built at different places were frequently discussed within interviews. Prototypes were the most common reasons for the teams to interact physically and not only by phone or other remote communication.

The decision upon when to build and required output of prototype builds differed a lot between projects, however, in general, there were three potential purposes of a prototype. The first purpose was to test the feasibility prior to the creation of an offer to the customer, this was commonly done by a “quick and dirty” prototype either with or without compensation from a potential customer. Whether this prototype should be built or not was based upon uncertainties about feasibility, type of product segment and cost. The second prototype category, functionality study, was the most common one. This prototype was generally built in the prototype shop at the Swedish site and should show the customer the final product in order to come to an agreement. This prototype could

be iterated until both the studied company and its customer were pleased with the result. The last prototype category was the audit prototype, for this prototype the customer visited the factory in order to not only accept the product but its production line as well.

All these prototypes could differ from case to case, especially the functionality study prototype, this prototype is commonly built several times trying to answer not only if it is acceptable by the customer but also if it is manufacturable. These prototype builds are initiated at the Swedish site, where the project requested a prototype from the prototype team. The prototype builds were supposed to follow a standard procedure, from a document including a set of general broad questions where the builder can fill in information about manufacturability, adaptions made, settings and other valuable information. During prototype builds, the design engineer supervised parts of the build. In some cases, manufacturing engineers from the Czech site were present during the builds at the Swedish site and, if so, it was often the first time that they got introduced to the product. This was thus the first occasion where they could gain an understanding of the product and come with input. However, the presence of a manufacturing engineer at the early builds was not required and the geographical distances tended to hinder the desired involvement in projects.

It was common that prototypes were performed at the production site, even when there was no requirement from the customer on audits. This provided the manufacturing engineering team with both operator training and creation of work instructions, however, it was not necessarily possible to alter the product at this late stage. The majority of changes made at this stage were based on quality issues which were required to be handled in order to fulfil obligations towards the customer. The presence of representatives from R&D sites were dependent upon project and prototype characteristic. It was common that the design engineer and the project manager supported the first prototype build at the Czech site. Representatives from the prototype team at the Swedish site could also support the prototype build, but it varied from one project to another. Currently, it seemed to depend on the maturity of the Czech site in the manufacturing of the product segments of the studied business unit, rather than characteristics of project or prototype.

In order to facilitate the first prototype built within the Czech site, project managers or the responsible manufacturing engineer needed to interact with both the logistics and operations departments. Where the logistics team were to ensure that material was available for the prototype built and operations that the intended operators were available. It was mentioned that material or operator shortage occurred during the builds, requiring resources to do extra tasks to support the build. From the interviews, these tasks were not necessarily performed by the supposed resources, but rather by the resources known to get stuff done, getting them occupied with tasks that should not be their responsibility.

The issues that occurred at the Czech site were viewed differently at the producing site compared to the others, at the site late information was seen as the cause, whilst the R&D teams lacked information upon availability in production. The planning and coordination issues were during the thesis project taken care of in an additional meeting with managers from the R&D and production sites participating.

The issues related to prototypes built at the Czech site were often seen as more critical than the ones built at the Swedish site, especially when projects were developed in Sweden. It was said during the interviews that the prototype team at the Swedish site had the ability to be more agile, both by being located next to the developers but also without the structural restrictions that project faced when they got closer to production. At the production site, prototype builds were more prone to be delayed, for instance, due to that the material got stuck in the ordinary material handling systems or builds got disturbed by issues in ongoing production. Since project members from the R&D sites were

flown in to support the build of these prototypes, some interviewees emphasised that it was important to utilize the time. Synchronizing these builds, therefore, required more accuracy than in the prototype shop at the Swedish site, both due to all structural limitation in production but also due to the effect of delays.

4.3.2 Organisational collaboration

This section covers discussed aspects not strictly related to how the business unit manages its projects. It includes the cross-functional collaboration, potential implications due to the consolidation of the production, how information and knowledge were handled in meetings and projects, and finally, the employees' knowledge about the PMP.

Cross-Functional Collaboration

In discussions with interviewees, some collaboration factors that currently did not have a direct connection to the active PMP were discussed. Factors such as meeting culture and arrangement of prototype builds were discussed in several of the interviews. Furthermore, the suffering from the transfer of production, especially from the German site was mentioned as an important factor.

During the product and process development part of projects, interactions between the R&D team and manufacturing engineers were intensified. From barely being in the loop, manufacturing engineers were getting more tasks and influence in projects. In fact, the manufacturing engineers played a key role in the process development as they were responsible for most tasks and were to coordinate other functions locally. The manufacturing engineers were to work as an asset reporting to the project manager, however, their rather independent work and local documents limited the ability for project managers to monitor their process.

The intentions seemed to be to include the manufacturing engineering team early by inviting them to meetings where upcoming projects were discussed. However, one party shared a feeling that projects had been discussed whilst the other party felt like it was a surprise every time a project started to request tasks to be initiated by them. The perception from interviews and observations was that projects were not properly introduced to the manufacturing team until the project reached the latter half of the product development phase, somewhere around a prototype build. The project manager contacted the manufacturing engineering supervisor, who initially created an understanding of the project before transferring it to the appropriate resource within his team. Requiring the supervisor to first spend time on building knowledge of the project before assigning an appropriate resource to the project. With responsibilities in the running production and management of his resources, it was difficult to see how the supervisor should have time enough to perform the task as elaborately as he wished to.

It was said during the interviews that, by interacting with the producing site at this late stage of a project, it was often a shortage of time to perform all process development related tasks required, prior to the SoP. This either required the manufacturing engineers to work extra, take shortcuts or end up delaying the SoP. If products required re-design to achieve preferred manufacturability this could delay the project even more, as it required the design engineer to update models and drawings which then was followed by supplier lead times.

Production facility transfer implications

During the thesis project it was clear that the Czech site still suffered from the transfer, leading to a lot of time consumption for the handling of daily production and less for supporting new projects. Members with experience from the previous site structure as well as receivers of unclear information commented upon the difficulties that were related to the previous rearrangements.

Some issues mentioned were quality flaws in parts from new suppliers, training of operators and the effort of trying to set up smoother and more compact product lines. At the same time, new process structures for manufacturing should be analysed and developed to fit the new production site and team. These additional tasks left the manufacturing engineers with not only lack of time for their project specific tasks, but also for analysing their situation and find improvement areas in their collaboration with the R&D teams. It was also mentioned that there were no easily accessed forum for how potential improvement suggestions could be shared between the teams, which made it even more difficult to request improvements and support each other.

Meeting culture

During the interviews, it was mentioned by the employees, especially the ones in project management positions, that a too large portion of their working week was filled with meetings. They shared a feeling of being in meetings where they did not contribute to or got valuable information from the meeting. With already filled project pipelines and difficulties to find the desired time for their projects, this was a highly disturbing factor. Especially two meetings were mentioned as wasteful, gate and project review meetings, both meetings occurring once a week and allocating a minimum of 90 minutes each.

The mentioned meetings in combination with a couple of other meetings tended to clog the schedules for the project managers in particular, yet it was not clear how these mentioned meetings contributed to the projects in their current manner. The organisation showed a desire to keep everybody in the loop and give possibilities to contribute. However, they did not put the effort into creating structured agendas to optimize the use of these meetings. While discussing meetings with one of the managers, an example was given on how a specific meeting managed to control an ongoing issue. Though, the meeting was allowed to go on weekly without properly assessing less time-consuming ways of handling the issue. All in all, meetings seemed to be easily arranged, but not with an emphasis on how to utilise the time of employees efficiently.

Project review and project-to-project knowledge sharing

In order to keep track of projects, there was a weekly project review meeting, where the technical vice president, together with project managers, department managers and sales representatives, reviewed project status. The meeting followed the priority assessment from the project tracker document and during the observation it went through all, about 50 more or less active, projects in the project tracker during one session. For 90 minutes, which was not enough for the observed session, these projects were skimmed through with about 30-40 attendees, including a short status update from the project managers occasionally followed by questions from the technical vice president and live updated by the meeting facilitator.

During discussions with members from the different sites, it was mentioned that projects lacked in reviews, despite the frequent review meetings. The review meetings were not able to handle the depth required for elaborately reviewing concept models. Instead of having weekly reviews, some interviewees preferred reviews of projects at certain stages in the development process. The intent was to give the designer input early upon pre-known requirements, both manufactural and functional, and later upon the quality of drawings but also a follow up on manufactural and functional properties of the concept.

Awareness of the Project Management Process

During interviews, it was shared that the manager of a new employee should inform them about the PMP and where to find its documentation. This meant that most of the employees should be aware of the PMP's existence and its phases. However, since it was the responsibility of the project

manager to keep track of the activities in a project, project members only had to follow the directions of the project manager. The result of this was that many of the interviewees had a general understanding of the process, but lacked an understanding of their and the surrounding functions' contribution to the process.

As the manufacturing engineers worked relatively independently from the preceding parts of the process, they needed to keep track of the activities themselves to a higher extent compared to the other project members at the R&D sites. However, as their tasks documented in the PMP were quite general, they had to work with an extended, local, documentation to guide their work, which as previously mentioned was in Czech and not accessible from the PMP checklist.

The overall lack of understanding of the PMP resulted in that the project managers had to have a detailed knowledge about all parts of the process, except some of the manufacturing engineering tasks. The lack of insight in the process design was discussed as a potential risk for lack of commitment, from project managers, in the process related parts of projects.

4.4 Analysis

In this section, the findings from the case study will be summarised and analysed. First by focusing on factors related to project management followed by organisational factors, all with a potential influence on the collaboration between the studied functions.

The basis for the analysis is mainly found within the current state description in sections 4.1 to 4.3 but it also stems from theory on the subject. From this data, the thesis authors have analysed the current state internally, with respect to the requested anonymity of the studied business unit but also to minimize the risk of biases from discussing the analysis with some parts of the business unit.

4.4.1 Project management factors

This section is aimed at analysing factors related to project management, eliciting data from the current state and judge the effect of these findings. The findings are categorised in the areas, involvement, responsibility and test builds.

Involvement

According to Säfsten et al. (2010), it is necessary that activities and time-frames are clarified, even though flexibility with timing may be desirable. However, during interviews was the timing for when R&D was supposed to involve the manufacturing engineers in projects a hot topic, there were different opinions regarding whether or not timing was defined across the functions. Manufacturing was invited to the gate meetings where new potentials and gate passage was discussed, which means that they, in theory, should be aware of upcoming projects. When projects reached the point where they need manufacturing to initiate their tasks, these projects were not known about in the manufacturing engineering team, showing a gap between awareness at the production site and the R&D sites. A potential cause for this gap was the structure of these gate meetings where people were expected to attend to get information about what was in the pipeline. Though, as the meetings lacked an agenda it meant that the participants needed to attend the whole duration of the meeting to ensure that they took part of information regarding relevant projects. This resulted in either lack of concentration during meetings or not participating at all in meetings, ending up with the sender feeling that message had been shared whilst the receiver had not received the message.

Another potential explanation to the timing issue was the lack of insight into the manufacturing-related activities from the R&D teams. Without knowing about time consumption and breakdown of tasks, it is difficult to assess the critical path of projects (Maylor, 2010). As the manufacturing engineering team did not track the time it took to perform their tasks and there was no structure for

communicating an estimated time, it meant that R&D sometimes reached out to close to SoP. This was not only the case for SoP, it could also be related to the planning of prototype builds. As the manufacturing engineering did not keep track of their availability and time allocation for projects, it meant that they were unable to determine their availability when R&D requested prototype builds. This lack of structure for when to include manufacturing engineers and how to manage prototype builds, resulted both in difficulties in managing due dates and issues during prototype builds with lack of materials or personnel.

The involvement factor also includes the customers' participation in the PMP. Meaning, as Morgan et al. (2018) discuss, the customer may have valuable input in various stages of the process. They also discuss that the developing firm needed to have the capability to receive the information given by the customer. In the studied business unit, the customer had a high influence on the project's progress when the prototypes had been built. The customer was to review and agree on the prototype before the project was allowed to proceed from the product- to the process development phase. Also, the customer could change the requirements throughout the whole product and process development phases. It sometimes meant significant changes of the already performed work. This created an insecure ground for the collaboration between the functions as the prerequisites could change and forced the R&D department to make changes in already frozen documentation. This contradicted the documented PMP as frozen documentation was not supposed to be changed, which meant that the projects, in fact, did deviate from the intended process due to the customer's demand.

Responsibility

Until recently, the business unit has been lacking information about who was responsible for the projects on the receiving side in production. To solve this, they implemented an organisational chart that describes the employees' roles and areas of responsibility or specific projects. It solves the problem of knowing who to contact in which matter for specific ongoing projects. However, it was not yet specified how and when to assign a manufacturing engineer to new projects. This meant that R&D still needed to contact the manufacturing engineering supervisor to get resources allocated for, for instance, upcoming prototype builds and other process design tasks. A manager at the Czech site suggested that a possible solution for this would be that the supervisor was contacted early in the project to be able to plan the resource allocation ahead of time. This would mean that when the R&D needed assistance, the contact would go directly to the assigned manufacturing engineer instead of the supervisor. However, a risk with this approach would be that resources were allocated for projects that may be cancelled before being ready for production.

Prototype builds

Another issue discovered were the coordination of prototype builds at the Czech site. The business unit has solved the issue temporarily by having additional meetings with the managers of the respective departments to share plans for upcoming builds and related activities. A possible explanation for the origin of the problem is that the organisation at the site had been lacking a responsible person for the planning and coordination of project-related activities. This meant that when project managers requested prototype builds to be performed, they were accepted regardless of whether a another project had already planned a build at the same time.

These builds were commented upon by several functions, however, the criticism towards the current process was especially emphasised by members of the R&D teams. With members of the R&D team travelling long distances to participate in test builds of different stages at the production site, the planning of their visits was critical to utilise the available time as efficiently as possible. This meant that errors in the planning of the builds could waste many hours for some projects. Furthermore, the

current way of handling the issue resulted in time allocation from already busy managers, it also required project managers to await these meetings before scheduling their plans.

Task interpretation

By studying the documentation of the PMP, both workflow and checklist, in place at the time of the thesis project, a lack of task description was detected by the thesis authors. This opened up for interpretation which, according to some team members, became confusing for the resources performing these tasks, since the same tasks could be viewed differently depending upon the project manager in charge. With resources rather following project manager requests than the checklist, each resource could provide different output for the same task.

However, there were some project members that did not share this opinion, with the opinion that the current structure was a good way of running project and did not see any benefits in knowing more. It was unclear whether these opinions shared an accurate picture of the beliefs at the company or if these thoughts were a result of comfort not having to care about more than their own specific tasks. Reflections from the thesis authors indicate that the majority still feels that it would be good to know more about related processes, furthermore, motivation theory implies autonomy in work tasks and understanding of one's purpose increases job motivation (Hackman & Oldham, 1976).

4.4.2 Organisational factors

This section includes an analysis of the organisational factors with an effect on the collaboration, meaning that they are derived from how the company has chosen to organise themselves as well as how they manage their knowledge assets.

Geography

The geographical distances between the sites caused a lack of into the respective function's activities. As Vandevelde & Van Dierdonck (2003) explains, it is because of the fact that the geographical distance between people reduces the interaction. Further, it affects the information sharing between the functions due to the reduced possibility to have informal and face-to-face communication. In turn, as Bruch & Johansson (2011) explains, the information sharing between the functions has an influence on the insight into the respective function. This reasoning was especially true when the collaboration was to occur between the American and European sites. Mainly, it was because of the significant time difference and physical distance. It meant that the project members had limited possibility to communicate face-to-face as well as electronically. For instance, the time difference created a limited time window where direct communication was possible electronically. Outside that window, they were referred to e-mails and other written communication. Also, the physical distance restricted the possibility for the project members to meet physically due to the economic aspect and the cumbersome travel.

Function

Since the studied functions worked in different fields, they had different perspectives on the projects and the procedures. As Vandevelde & Van Dierdonck (2003) explains, an organisational barrier may be created due to differences in the function-specific goals. Also, they further explain that there are cultural differences due to various characteristics of the respective function's work, such as the time orientation, structure and professional orientation. Bruch & Johansson (2011) discuss that the functional differences may influence the mutual understanding due to differences in training and background. That is because it introduces language problems as the functions may use different terminology which, in turn, has an influence on the functions' ability to exchange information.

At the business unit, the PMP was to a large extent created to support the product development as much of the work was focused on how the product should be defined and which requirement it

needs to meet. This meant that the R&D department worked closely with the PMP as it defined their main deliverables. On the other side, the manufacturing engineers both had the PMP and the running production to take into account. This meant that they needed to prioritise between the daily activities with short time frames and the project-related activities that had longer time-frames but may be more complicated and extensive.

Changes in the customer requirements affected the organisational functions differently. On the R&D side, changes could, for instance, lead to a need to modify drawings or build new prototypes to test the functionality. As much of the work was not materialised, it meant that much of the costs were related to engineering hours. However, on the production side, changes might lead to a need to make changes in equipment design or the process flow. Since much of the work was to physically prepare the production, changes might lead to a need to make new investments. For instance, equipment and other material with long lead times may already be ordered which meant that when the equipment is ready, it may be unsuitable for the new design.

Task review

When projects were supposed to pass on to an upcoming phase of their phase gate process, gate meetings were held to review both the technical and financial aspects of a project. However, the technical assessment of projects at these gates was no more than a question whether the checklist that supports the development of a project was correctly filled in. According to Maylor (2010), lack of technical reviews make it difficult to make good decisions of whether or not a project should pass a gate, it also affects the ability to learn from these projects. Furthermore, lack of technical review was judged to affect the ability to assess differences in the project manager's interpretations of tasks, making project managers continuously interpret the same tasks differently. With the structure in place at the company, at the time of the thesis project, the project manager was able to choose not to mention about potential deviations made, since they may have determined that these decisions would not impact the success of the project. By not having a more excessive evaluation of the technical aspects of a project, the project could easily get biased by the project managers perception of what was necessary within a project, which for example could lead to late and insufficient involvement of some functions.

It was mentioned during the interviews that design documentation such as drawings, included flaws that generated faulty components from suppliers. The mentioned documents were related to products released prior to the current PMP process and relocation of production. However, it was mentioned that the current procedure required design engineers to solely examine their designs for flaws without support from design reviews. Apart from flaw detection, it was also mentioned that manufacturability was not reviewed properly either, resulting in less possibility for design engineers to learn and adapt to knowledge acquired from production. According to Mital et al. (2014) and Ulrich & Eppinger (2012), lack of proper reviews of the design and exclusion of affected functions may have a negative effect on the manufacturability of the designs.

Information exchange

Another potential issue was the fact that the project-related information was documented differently between the sites and projects. That is, the project managers had different ways of documenting and delegating tasks within each project which meant that the project members received and sent information differently depending on the project. When the project members were co-located with the project managers, the difference could be overcome through continuous dialogue with the project manager. However, as the manufacturing engineers were located separately, it means that information sharing and follow-up were scarce as they were not as dependent on the dialogue to perform their tasks. The manufacturing engineers could work

independently as they were supported by local procedures and the PMP checklist. Even though the local procedures were related to tasks in the PMP checklist, it meant that the project managers had less insight in the process and would, therefore, rely on that the manufacturing engineer was coordinating the local resources.

5 Improvement suggestions

The following sections will present the improvement potentials derived from the current state analysis, followed by suggestions of how these areas could be handled. The improvement potentials are based on issues discussed during interviews or from observations and extracted from the analysis of them. All potentials have been discussed with the interviewees and later judged by the thesis authors upon relevance to the specific topic, however, to let the interviewees remain anonymous, their respective department will not be stated. Regarding the improvement suggestions, the majority of them have been discussed in several interviews with a positive response from interviewees, some of them are also inspired by related theory or from experience shared from other manufacturing organisations.

5.1 Improvement potentials

From the analysis of the current state, a number of improvement potentials could be found, all related to how the collaboration between functions affects the success of development projects. Projects within the business unit always included two or more members, which implies that all progress within projects were partly related to improved collaboration or usage of its resources. In the following paragraphs, a selection of improvement potentials will be shortly described, providing an insight in which issues the thesis authors tries to address by the improvement suggestions that follow in *section 5.2*. The potentials will be divided, dependent on whether they are mainly project management related or general organisational factors.

5.1.1 Project management factors

In the following paragraphs, a set of improvement potentials is stated, these potentials are highly connected to project management. Each potential is defined with a finding from the case study and effect of the finding. These potentials are the result of analysed factors in *4.4.1 Project management factors.*

Late and unclear involvement

Involvement of personnel was discussed at several functions of the company, at the time of the thesis project, involvement either occurred too late or not clear enough for the message to get through. By involving personnel from the production site late in the development process, projects risk to miss out on important knowledge when designing products, either ending up in products with flaws that could have been corrected early or with late and expensive changes.

Unclear responsibility

During the time of the thesis project, it was found that employees had difficulties understanding who they should contact regarding different topics. By not knowing who to contact, some persons ended up with tasks that should not be their responsibilities. This resulted in an overallocation of some employees and at the same time lack of control by the ones that should be responsible for the tasks.

Test build delays

When the studied company should build products at the production site prior to finalisation of projects, either prototypes, audits or pilot builds, shortage of either material or personnel were a frequent issue. By not being able to start builds at defined dates, R&D personnel flown in to participate in builds ends up without the possibility to start to build in time and might not be able to stay throughout the entire build. These trips are related to significant costs which end up wasted when the ability to perform the desired task is compromised.

Inconsistent task interpretation

With unclear task descriptions, same tasks were performed differently depending upon which project manager that was in charge. This resulted in project members performing the same task differently depending upon their own and project manager's interpretation of tasks, which led to varied output. This results in inconsistency in quality and timing of the end product as well as the input for later steps of the project, potentially resulting in insufficient input to perform some tasks properly.

5.1.2 Organisational factors

The organisational factors from *4.4.2 Organisational factors* are summarised below. As in *5.1.1 Project management factors*, each point highlights the improvement potential and its effect on the business unit.

Geographical distances

The main challenge of the geographical dispersion was said to be the possibility to communicate within the projects and follow-up on tasks performed at the production site. This required the project members, and especially the project managers, to rely on extensive communication, for instance through e-mails, to ensure that they were up-to-date with the status of the tasks.

Functional differences

By being part of different functions, project team members had different backgrounds which resulted in different perceptions and values. The functions related to production had their views while the ones in R&D had slightly different perspective. These differences create a barrier between the two parts of product development, limiting the understanding for each other and ability to communicate and collaborate on the same level.

Lack of task review and follow up

The technical review of projects was lacking at the company, during gate decisions, the majority of questions were related to financial status. With a limited review of the technical details of projects, the organisation gets less basis for their decision making at gates. Furthermore, it affects the ability to learn from projects for future success, since a lot of the knowledge gained stays in the heads of the project members instead of being used to improve the processes at the organisation.

Unstructured information exchange

With project managers being free to control their projects in different ways, project members had to handle being managed in different ways depending on project manager in charge. Projects are also managed differently depending on whether they were in product or process development. This does not only cause difficulties for project members in how to adapt their procedures to work with different project managers, it also limits the ability to follow up and compares between projects.

5.2 Suggestions

In this section, a couple of suggestions with intent to tackle the issues mentioned in *5.1 improvement potentials*, will be described. The suggestions described will aim to support the collaboration in one or several of the mentioned improvement potentials. By mainly reflecting upon responses from employees during interviews, the theory that covers some of these areas and previous experience, the thesis authors have formed these following suggestions. The suggestions described will not include a description of how to implement them.

5.2.1 Introduce elaborate time plans

Some of the issues in *5.1 Improvement potentials* are linked to the transfer and coordination of projects, especially how and when to involve manufacturing engineers and how to plan for prototype

or pilot builds. These issues could potentially be solved by constructing and maintaining a shared time plan in projects, which may be used to structure timing for tasks and activities (Maylor, 2010; Mihály & Smith, 1999). That is, at the beginning of a project, the project manager could construct a time plan based on estimates to get an overview of the project. For accuracy, the thesis authors recommend that logged engineering hours from previous, similar, projects could be used as a base. As the project extends to the SoP, it is important that the manufacturing engineering hours are taken into account as well to get a complete understanding of the project's extent. However, as Maylor (2010, p. 135) explains, the accuracy of the estimates increases as the project progresses. This means that the early time plan primarily should be used to understand if the project is feasible or not within a given time frame. It could also potentially be used for production to assess the feasibility from a capacity point of view. That is, given that an approximated sales volume is available, the production may assess if investments are needed to meet a future production volume increase. Since there is an uncertainty whether the product will reach serial production or not, further information will be needed to assess the risks related to the investments.

A time plan may also be used in the product introduction to determine the point where the manufacturing engineers should initiate process design-related tasks. That is, through a dialogue between the project manager and manufacturing engineer, an estimation of the time needed to prepare the process could be used to determine a proper latest start time for the manufacturing engineer to meet the promised SoP. Based on the data in the time plan, it is possible to an activity-on-node diagram as explained by Maylor (2010). By this, it would be possible to find the critical path of activities and hence prioritise which activities to place resources on. To determine the critical path for the whole extent of the project, it is necessary that all activities are included in the time plan. That is, to be able to assess the critical path to SoP, all process design tasks need to be included in the analysis. By this increased understanding of the critical timing of tasks, projects should be able to develop products according to set due dates to a higher extent, compared to the case during the thesis project, or provide customers with the effect caused by late changes.

5.2.2 Introduce a technical milestone review

With the current lack of checklist evaluation at gate meetings, a Go or Disengage decision is based on the financial status of projects and whether or not the project manager shares that the checklist is properly filled in. The intent of the PMP checklist was taught, during the thesis authors' PMP introduction, as a way to make sure that projects perform certain tasks. In order to follow the checklist, the project manager needs to collaborate with different functions and, in some cases, make them collaborate with each other. If fulfilment of the checklist tasks is not assessed correctly, there is a risk that the output of a project will lack in areas perceived as less important by the project manager.

By having a milestone meeting prior to gate meetings, that is dedicated for technical review, the project checklist could be discussed by the project and relevant instances. Which for the studied business unit preferably should include the technical vice president, local department manager and project members. At this meeting, the project manager could get support in assessing the risk of deviations made to the process and getting a second opinion on pending issues. This meeting should also support the gate meetings in their decisions since the milestone meeting reviews issues and present status at the gate meetings. The thesis authors had experience from other companies, where these milestone meetings were used to provide a better basis for decisions, regarding which projects that should be allowed to move on or get closed. Which is why this was judged to support the studied company in this matter as well.

The intent of the milestone meeting is not to add meetings to already clogged project managers, troubling them with being reviewed by higher instances. These meetings should be able to exclude some discussions currently occurring in meetings with too many attendees and help to close projects with low potential. They should also help the project manager to highlight issues, leading to constant improvement of the process. By reviewing projects more elaborately than before, it should be clearer where the current structure does not support projects and their collaboration sufficiently. Doing so with someone with more power within the organisation is judged by the thesis authors to support changes for the better. An area that was considered likely to benefit from such a review is the tasks related to the process design. That is because the project manager does not have as close collaboration with the manufacturing engineers as with the local design engineers. These processes would, therefore, require more support from the PMP to ensure a good collaboration.

5.2.3 Define a purpose-oriented meeting structure

Meetings are often facilitated with a goal to either share information or to use the shared information in the group to make decisions. A good meeting structure can facilitate effective decision making, which could support both the review of projects as well as address issues, apart from providing attendees with a purpose of attending. As Gullander et al. (2014) discuss, and mentioned in *2.2.4 Meetings*, to have an efficient information flow, there are a set of criteria which may be considered in this case. A potential way to decrease the risk of missing important project-specific information, as well as increase the ability for attendees to contribute to a meeting, is to ensure that the meetings have a structure that facilitates information sharing. The structure would address the "relevance" and "timeliness" criteria by defining who should attend the meeting and what will be addressed during the meeting. Meaning that the attendees of the meeting will receive relevant information and the information will be presented at a clearly specified time.

The current general meeting structure for project and gate reviews lacks a predefined agenda. This means that the attendees need to attend the whole duration of the meeting to get information about and potentially give input to discussed topics. By having an agenda, it means that attendees could determine which parts they need to attend and can thereby be fully focused on other tasks when they do not need to attend. Also, the gate meetings may differ in relevance for the different company functions. For instance, the gate meetings may not be relevant to attend for the manufacturing engineering representatives until a concrete quote has been discussed with the customer which gives an understanding for what characteristics and volumes the product will have. This also allows the manufacturing engineering supervisor to determine which manufacturing engineer which would be suitable for the project.

The agenda for gate meetings may be set by allowing the projects to book a time slot and if discussions exceed the booked time, they may be referred to a separate meeting. The available time slots may be arranged in accordance with the time zones for the different development sites to ensure the availability of the attendees. This would help the business unit to reduce the risk of functions missing important information as it will be easier for the management to overview who attended for what purpose and the functions will easier understand what information is intended for them.

5.2.4 Introduce design guidelines

By doing projects repeatedly as well as gaining knowledge from the functional expertise and previous experiences, knowledge could be reused and shared to appropriate functions. To aid the designer, this knowledge that colleagues obtained, could be transformed into guidelines intended to support function and to avoid design features that may be difficult to manufacture or assemble. The idea with guidelines was taken from the researcher's previous experiences, which was discussed during

the interviews and positively received by several employees. Some of them saw that issues could have been deferred if some general inputs could have been shared with a designer early in projects. Furthermore, the literature states that design guidelines may be used to attain desired objectives (Blessing & Chakrabarti, 2009), as well as support DfM and DfA (Ulrich & Eppinger, 2012).

These design guidelines were proposed to be developed jointly by the product development department and the manufacturing engineering department to take aspects from both a design and production point of view into account since both parties considered to have valuable input for early stages of design. The guidelines could potentially be combined into a single document, taking both technical functionality and manufacturability into account or be separate documents to be used in different stages of the design work.

5.2.5 Structuring the use of design reviews

In addition to the design guidelines, design reviews could be used to aid the designer by discovering potential flaws and ensure reliable design (Ulrich & Eppinger, 2012). Apart from relevant roles within the product development department, representatives from manufacturing engineering and quality may be involved in the reviews to ensure that their interests are considered. Design reviews have been performed occasionally at the studied business unit, but there is no structure within the PMP that support the decision of when it should be performed. Structure is something that Mital (2014) defines as a benefit and strength of design reviews, highlighting the importance of keeping them structured. Despite not being structured in when they should occur, discussions from the interviews state that previous design reviews have been a positive experience, as it encourages improvement of the design and gives the possibility to discover flaws in the drawings that may introduce problems later in the process.

It is up to the company themselves to find a structure for the design review, but it is suggested that the occasion for the review should provide the possibility to change the design prior to the design proposal being sent to the customer. In order to ensure that what the customer receives is as close as possible to the final design, requiring these meetings to be held in advance of the milestone reviews. Furthermore, these reviews should only asses the design of the products, limiting the number of required attendees.

5.2.6 Introduce Project Management Process training for project members

Through training within the PMP and how its inherent phases and related sub-processes affect each other, employees active within projects can get a better understanding of the whole process of developing products at the organisation. By learning how tasks are dependent on each other, employees can be provided with a purpose of why it is important that they perform their tasks well. From better learning of the challenges in tasks preceding their own, employees are expected to better understand colleagues' delays and how to support them. Furthermore, by knowing the importance of their tasks, employees are provided with a purpose as well as a belongingness of the success of the whole business unit. This sense of belonging, as well as the esteem from accomplishing these purposeful tasks, are both factors contributing to the task significance dimension described by Hackman & Oldham (1976). By achieving fulfilment of these factors, satisfaction and motivation of employees should be supported, making them more interested in performing well.

5.2.7 Introduce a project coordination role at the production site

As discussed in *5.1 Improvement Potentials*, there is a need to coordinate the resources between the functions to plan for, for instance, upcoming prototype and pilot builds as well as how to address issues. Also, as the functions are geographically distributed, there is a need to follow-up the status of

project tasks, especially as the project managers are not co-located with the manufacturing engineers. A potential solution to coordinate project is introducing a coordinating role situated at the Czech site, this is something that the thesis authors seen at use in other companies facing similar situation. The idea was discussed at the studied business unit with a majority of positive feedback. This role would be used as a link between the R&D sites and the local resources in the Czech Republic. The intent is that the role would support the manufacturing engineers by coordinating the local resources and plan for upcoming pilot builds. Since the role will not be a part of the running production, it will be able to attend gate meetings to gather information about upcoming projects and potentially defend the interests of the production. It will also support the R&D departments with follow-up on project status and be able to refer to relevant people. Hence, the role will to some extent act as a local project manager that assist the usual project manager with the coordination and follow-up of the project. Using a local project manager at the production site was discussed during the interviews, the intent was to support the project manager with coordination of the local resources.

As the coordinator might end up being only an intermediator between the functions, when the sites have bridged their common understanding, a software tool was discussed as a long-term solution. This tool should support the collaboration with information rather than taking the responsibility for it. However, by closely collaborating with both R&D sites and the production site, the coordinator should be able to facilitate a better understanding of the sites. By better understanding the different persons that the coordinator interacts with, communication between the coordinator and the personnel from all sites should work better (Ying & Pheng, 2014). By the time that the, still relatively new, production site and the two R&D sites have gained a better knowledge of each other, the role of coordinator limit to almost solely function as an intermediator between the functions. The software tool would then facilitate documentation and reuse of knowledge in the projects as it creates a common platform for sharing and storing project-related information. Further, it could also aid the collaboration by standardising the format of task delegation and follow-up, which would facilitate the communication as it will not be dependent on the project manager but rather the characteristic of the shared information. A software tool was also something that was requested from R&D during the interviews, with the intent to reduce the need of e-mail conversations for the project managers to receive updates about the projects when tasks are performed remotely. It is also a way to compensate for the time differences in the communication as the information may be accessed immediately instead of having conversations by e-mail, potentially with a delay, or phone conversations within a limited time frame.

6 Discussion

In this chapter, the findings and the applied research methods will be discussed. Also, as the thesis project to a large extent has been based on interviews, the ethical aspects of the data collection will be discussed. Lastly, some implications and future research suggestions will be discussed.

6.1 Findings

Collaboration is an important factor for the performance of a new product development project (Graner & Mißler-Behr, 2014). That is, if the involved functions share information and coordinate their activities, it increases the chances of good results at the end of the project. This study has mainly focused on the product introduction, which includes the transfer of a product design to production. Lakemond et al. (2007) emphasise that the transfer management is of high importance for a well-working interface between the functions. Transfer management includes "product manufacturability analysis", "early production involvement", "continuous communication" and "active involvement and dedicated resources for production involvement" (Lakemond et al., 2007). The findings in this study have touched upon most of these factors by providing suggestions to structure the production involvement and facilitate information sharing.

A factor that may have influenced the findings in the thesis project is the fact that only one transfer of a product development project occurred from the R&D to the production. Even though smaller projects where changes were made to already existing products had been transferred, only one project for a new product has been transferred. As the thesis project was limited to the process for new product development, it means that most experiences discussed in interviews referred to one occasion. Although, some active projects have reached stages close to the transfer which reflects experiences from the current setting. As some interviewees were not involved in the PMP for new products directly, discussions were also based on experiences from other projects and the collaboration in general. This means that all findings may not reflect how the transfer will work in future projects. Also, since the setting is new, surrounding factors may influence the experience of the transfer as well. That is, due to a high number of new employees in the production organisation, experiences and knowledge about previous transfers and products may be lacking. This, in combination with the fact that a lot of knowledge from the German site was lost, means that new knowledge needs to be obtained to support the projects. The lack of knowledge and information influenced both the R&D and the production as the R&D needed to reverse engineer solutions to continue the development and the production was lacking drawings to be able to order and assemble components.

Another potential bias, that could have affected the outcome of the thesis project, was project manager responsibilities. With project managers being the ones with the highest interaction with the PMP, they were also the ones with the best knowledge of how new product development projects were executed compared to the intended process. This made the project managers one of the most important functions to interview, however, due to their responsibility to ensure that the projects followed the intended processes, they were also potentially biased by this. Claiming that deviations from the standard process were due to flaws in the standard process to adapt to customer variation, rather than poorly executed project management, could potentially be a way to cover their own backs. Since the project members followed directions from their project managers, instead of following the process according to the checklist, it was difficult to compare reality to an intended process for them. Despite these potential biases, there was a shared opinion that customer adaptations limited possibilities to follow the intended processes to some extent.

6.2 Applied research methods

To study the collaboration between the R&D department and the production, different methods were needed to identify potential issues from several perspectives. Even though case study research is not an explicit methodology, it suggests ways to study a company or organisation to gain a deep understanding of its processes. Hence, this study applied three methods for data collection suggested within case study research; document study, interviews and observations. All three are qualitative methods to collect data about the studied object. However, the methods are dependent on the users, meaning that the results may be influenced by how the methods are applied.

A factor that may have influenced the results of the thesis project is the early department manager interviews. Meaning, as the department managers shared their opinions in an early state of the project, it could have influenced the thesis authors' view of the situation as they had not yet formed their own opinion. Also, the fact that the interviewees were selected by the managers of the respective department may have influenced the results. This means that the interviewees may have opinions representative of the manager's view of the situation rather than the general opinion of the department. However, as several different roles were interviewed, in combination with observations and study of the documentation, it was regarded by the thesis authors to have a low impact on the findings. Further, an aspect of the interviews that may affect the interviews is the interviewee's relation to the PMP. For instance, as the project managers are responsible for the performance of the projects, there is a risk that they deflect issues toward the PMP to protect their interests. By comparing the answers from several interviews, the risk of one answer skewing the results toward one direction is minimized.

The results of the interviews could potentially have been improved by testing the interview guide in a pilot interview before conducting the interviews. As the interview guides were adapted for each interviewee's respective role, it would mean that pilot interviews would be needed for each role. However, it could have been possible to test the characteristics of the questions rather than the specific questions to reduce the risk of questions leading to an anticipated answer by interviewing someone in a different part of the organisation, potentially providing input that would have changed the structure of the interview guides. Given the result of the interviews and that only minor changes were made in the structure during the path of the thesis project, the effect of not having pilot interviews was considered by the thesis authors to be small.

Another factor that may have influenced the thesis project is the fact that the thesis authors have been located at the Swedish site most of the time. Furthermore, one of the thesis authors had a history with the Swedish R&D team, having been a consultant there during a short period prior to implementation of the PMP in use and closing of production in Sweden. Being located at the site provided the thesis authors with the ability to participate in discussions in informal discussion, during both lunch and coffee breaks, accessing information not covered during interviews. With one of the thesis authors having previous knowledge of the business unit, the understanding of products and relations within the business unit and towards customers could be assessed more quickly. However, this also means that there is a risk that the thesis authors are biased towards the Swedish site since there has been a closer interaction with the employees at the site and therefore possibility to take part of their view of the situation.

Interviews with researchers in the field of product and production development could have been conducted to increase the understanding of the topic and challenges related to the interaction between the fields. However, as the literature study provided with an understanding of the subject from previous research projects within the field that covered similar challenges addressed in this study, the literature study was regarded as sufficient.

As the improvement potentials mainly originated from the interviews and compared to literature, there is a risk that other potential solutions were missed. If, for instance, workshops or brainstorming sessions were conducted with knowledgeable people within the field of research and the employees at the studied company, more ideas may have been discovered. Also, to further improve the quality of the improvement suggestions, they could have been developed iteratively. That is, the improvement potentials could have been evaluated and reformulated on several occasions during the thesis project to ensure that they met the expected outcomes.

6.3 Ethical considerations

The thesis authors has taken ethical considerations into account to ensure that it did not influence the studied company or employees negatively. Bryman (2012) presents four ethical principles to consider in social research; “harm to participants”, “lack of informed consent”, “invasion of privacy” and “deception”. In short, the principles convey that the participants in the study should not be harmed physically or psychologically, gain enough information to make an eligible decision on their participation in the study, their privacy should be protected and the researchers should not delude the participant to an expected result. In this study, these aspects have been considered in the following ways: The participants have not been harmed and their privacy has been protected by ensuring that their answers in interviews have not been shared with people besides the thesis authors. When information gathered in interviews has been used, precautions have been taken to minimize the possibility to trace the information to the source by removing personal information and other identifying information from the answers. Further, at the beginning of each interview, the thesis project’s purpose was presented for the interviewee to provide an understanding of what they would participate in. They were also given the possibility to ask questions for clarification. Also, the introduction of each interview served the purpose of being transparent to the interviewee about what the thesis authors aimed at investigating, minimizing the risk of unintentional deception.

6.4 Future research and implications

To implement the suggested improvements, the company need to investigate the prerequisites and further define how the solutions may work in their specific setting. For instance, reusing knowledge within an organisation may be applied in different ways. The suggested improvements regarding the reuse of knowledge, such as design guidelines and reviews, in this study, are suggested because the company has previous experiences with the methods and that the business unit is focused on aiding the product introduction. That is, they are linked to what Lakemond et al. (2007) refer to as “product manufacturability analysis”, which is a part of the facilitation of the product introduction. However, working with knowledge management includes more than implementing specific tools to facilitate the reuse of knowledge. It includes what Wild & Griggs (2008) refer to as three perspectives of knowledge management; “culture”, “information” and “technology”. Culture includes aspects such as communication and business processes. Information includes, for instance, accessibility of the information, its duration and where it is stored. Technology refers to how the knowledge will be handled, i.e. which systems will be used to store and communicate the information and which other tools will be used to utilise the knowledge. This means that the company may need to work with the cultural aspects of knowledge management to create the necessary prerequisites for a lasting solution.

Previous research indicates that cross-functional collaboration is an important aspect in new product development to successfully transfer a product from the design stage to the production and hence provide a good performance of the project (Graner & Mißler-Behr, 2014; Lakemond et al., 2007). This thesis adds to the research by investigating what may improve the collaboration between the R&D and production in a multinational company. It includes suggestions that may be included in the

project management process to create a structured way of considering this aspect in development projects. Working in a structured way, it also facilitates future improvements as it creates a stable base for improvements to be developed on (Liker, 2004).

7 Conclusion

This thesis has been conducted with the aim to gain an understanding of what may affect the collaboration between the R&D and the production in a multinational company. The thesis project has been centred around three questions, where the influence of the Project Management Process (PMP) on collaboration is assessed, combined with how it potentially could be adapted to further facilitate collaboration. Apart from focusing on the PMP, the thesis authors assessed other factors that may have a significant effect on collaboration within a multinational company.

1. *How does the business unit's project management process influence the collaboration within product development projects?*

Through its workflow definition, the PMP guides projects in which order to conduct major steps, furthermore its included checklist defines general tasks and the responsible functions. By defining these tasks and in which phase tasks should be conducted, the PMP facilitates collaboration. However, since tasks were vaguely defined, and the overlying workflow only contains major events without any clear estimated duration, there were gaps in the structure, which led to inconsistency in task execution. From interviews within the studied business unit, it was mentioned that projects were run differently depending on which project manager that was responsible for the project, requiring project members adapt to collaborate with different project managers and having difficulties to support colleagues in different projects. This indicates that even though the PMP supported collaboration, lack of structure or information within it left the success of collaboration to be dependent on other factors as well.

By focusing its emphasis on certain organisational functions or parts of new product development, the PMP can either include functions to support collaboration or focus on some areas at the risk of neglecting others. By not including the appropriate organisational functions or including too many non-contributing functions, the team set up may lose performance as well as innovation. Since the PMP should define when tasks should be done and by whom, it defines the basis for collaboration, proving its influence on collaboration.

2. *How can the project management process be adapted to improve the collaboration between R&D and production sites?*

With the PMP defining when and by whom tasks should be done, it can be used to structure new product development projects into focusing on aspects that support collaboration. An example of this could be to define when functions should interact with each other through detailed time plans, so that there is enough exposure time for the team to get the most out of their combined knowledge.

Furthermore, the PMP can aid information sharing by defining ways of how to share gained knowledge and what knowledge that should be valuable for whom. For example, knowledge regarding manufacturability from the prototype team should be transferred to the design engineer, through design guidelines and reviews, which affects these abilities within the project. Resulting in designs adapted to fit the production team and available equipment.

Sharing the knowledge within the ongoing project will require collaboration within the specific project. However, by not successfully transferring this knowledge from the specific project to future projects, knowledge will be lost and potential issues related to previous methods will re-occur. For

example, it could lead to designers re-designing parts over and over that could be re-used by projects. By creating structures for how to keep on benefiting from gained knowledge is then a way for PMP to aid collaboration, not only in current projects but future ones as well.

The adaptations of highest potential found for improvement of collaboration between the functions R&D and production are the task and timing structures within the PMP, but also how it directs information both within and between projects.

3. *Which other factors influence the collaboration within product development projects, and how?*

Collaborating across functional borders means that the projects need to take two different perspectives into account. Differences in educational background and experiences mean that the respective function shapes their language, which may be a source of misunderstandings (Bruch & Johansson, 2011; Vandevelde & Van Dierdonck, 2003).

Another factor that may influence the collaboration is the geographical distances between the sites. Not only does the distance affect the ability to have physical meetings, the time difference between the American and European sites limits the available time-frame for direct communication. With the lowered possibility to work together between the different sites, the collaboration gets limited. Aids such as physical prototypes and observing issues in production can support the shared understanding of a situation, which affects the ability to collaborate successfully.

In the specific case of the studied company, the factor of relocating production definitely affects the collaboration within the business unit, as it affects the personnel within as well as informal structures of how to tackle challenges. By collaborating over several years, personnel within the old production sites and current R&D sites, should have had the time to build up an understanding for each other, which should have supported their collaboration. This understanding between functions now needs to be rebuilt to acquire equal prerequisites for successful communication and collaboration in the future.

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Appendix A - Management interview guide

General (personal info etc.)

1. Name, title and age?
2. Educational background?
3. Years within the company?

How does the department work with development projects?

1. Can you describe the typical process of a Development project and its effect on your department, from an example project?
    a. In which stages does it interact with whom?
    b. Preferably generalise with a typical development project performed?
    c. Compare to the gate structure
    d. Comment upon when persons interact with project manager and process engineer etc.
2. When is the production involved in a development project?
3. How is a pilot production structured?
    a. Who is responsible for setting up a team and delegate responsibilities?

Problems in development processes and communication channels

1. What is the biggest problem related to communication in your projects?
2. Where would the organization benefit the most from improved communication?

PMP Process

1. Are you and your team familiar with the PMP and do they know where to find:
    a. The process templates
    b. Underlying documents related to it
2. Are there some areas where the PMP isn't followed?
3. Are there some areas of importance which the PMP process lacks to define best practise procedures within?
4. Communication
    a. Is it clear when to include certain positions in the discussions regarding where you are in a project?
    b. How well do you believe this is followed, and to which degree is this position not only included in the invitations for a meeting but rather included in the discussion?

Differences pre/pro move of production

1. Organizational changes
    a. Is production equally involved in decisions as before?
    b. Does production have the same authority as before and do they feel involved in the department?
2. What has been improved vs. worse after the change of production site?
3. How does collaboration work between different business units, does the production unit benefit from being part of a larger manufacturing site, e.g.:
    a. Sourcing benefits from its volume in sharing standard components and suppliers
    b. Lending production equipment
    c. Sales channels

Areas of interest to cover

1. Personal or department interests desired to include in the study
    a. Where do you see most improvement potential?
    b. Do you have ideas of how to improve collaboration?
    c. What do you lack from R&D/production, are there any specific area or issue where commitment is lacking?
2. Positions/persons who might be valuable to interview regarding the topic of the study
    a. Is there production personnel left with experience from production in either the Swedish or German site?
        i. How is this considered to affect the performance of the production and its knowledge exchange with development?

Appendix B - Project manager and resource interview guide

General (personal info etc.)

1. Title and age?
2. Educational background?
3. Years within the company?

Your role in development projects

1. How and when are you assigned to development projects?
    a. Do you discuss your availability prior to assignment with project manager and manager or are you just assigned to new projects?
    b. In which stage are you assigned to projects?
2. Process structure, task management.
    a. By which structure do you mainly work? Following PMP documentation, PMP checklist or other?
    b. If you are not working by the documentation or checklist, do you still keep updated about their progress?
3. In our project, we want to focus on the PMP process and gate 0, 1 & 2.
    a. What kind of input and from whom does you/your team expect to get after gate 0 is passed?
    b. What are your initial tasks in the phase following gate 0?
        i. How do you/your team consider producibility in this early phase of the development?
            1. DFM/DFA experience?
            2. Czech production requests/guidelines?
            3. Experience from studying the production?
    c. Lack of rigid deadlines and projects with long phase between gate 0 and gate 1.
        i. Do you follow any methods to keep yourself/your team from overdeveloping?
        ii. How do you work with detecting flaws?
            1. Design reviews?
            2. Structural methods?
        iii. When are you reaching out to the production site and regarding which issues/tasks?
            1. How do you know when to contact them?
            2. Who are you first reaching out to and how do you know who this is for different projects?
    d. What physical testing/validation is done in this phase?
        i. When to build prototypes or not?
        ii. What info do you intend to get from prototype builds?
        iii. How do you interact with prototype team prior, during and after prototype build?
    e. What are your deliverables at gate 1?
        i. Does it match the PMP checklist?
        ii. How do you know what is good enough? (Bullets are quite general.)
        iii. Have you worked with the other R&D office, do they interpret the bullet similarly or do expectations differ?

f. What tasks are you starting at the beginning of the phase following gate 1?
    i. What is the status of the design, what can be changed and uses to be changed?
    ii. Which persons/positions are you interacting with and in which task
g. Are there any physical testing, how often?
    i. How do you decide whether to pilot or not?
    ii. Where is the testing located?
    iii. What are your objectives in this procedure?
    iv. What are your interests in this procedure?
h. What are your deliverables at gate 2?
    i. Discuss deliverables, what is considered ok and not?

Discussion

1. What are the main issues as you see it in the collaboration between production and development?
2. Any comments regarding the PMP process and PMP checklist, flaws? Improvement potential?
3. How do you work with feedback?
    a. How do you facilitate that you get the feedback you want?
    b. How do you work with giving others feedback?
    c. Structural procedures, personal responsibility…
    d. Wishes
4. Anything to learn from collaboration with Germany or China that could help collaboration with the Czech site?
5. How do you work with timekeeping?