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Reducing Time to Market in New Product Development

A Case study at Husqvarna Construction Products

Master's thesis in Production Engineering, and Quality and Operations Management

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Abstract

Background New product development covers the entire process of bringing a new product to the market and is the main value adding activity for many of the companies who develop their own products. Achieving a short time-to-market for the process is a key driver in new product success and therefore product developers stand to benefit greatly in achieving a time-to-market reduction.

Purpose The purpose is to examine contemporary research and in doing so, identifying best-practice principles, methods and tools to reduce time-to-market and thereby improve new product success. The findings will be the basis for an analysis for Husqvarna construction products' current new product development efforts, to which the findings will be adapted and recommendations to achieve a reduced time-to-market will be compiled.

Method A single case study approach was adopted of a qualitative nature and involved an extensive theoretical research and interviews with people involved in the new product development at Husqvarna Construction Products. The interviews were mainly held via video link, where notes were taken and later transcribed and compiled. A theoretical framework was produced, which in conjunction with the findings, served as a basis for the analysis and recommendations.

Results The case study provided three distinct categories of challenges for Husqvarna Construction Products in achieving a reduced time-to-market, those related to prioritization and focusing of resources, frontloading, and quality-of-execution. What the findings showed was a general lack of resources that prevented properly fulfilling necessary front-end activities, with a lacking product specification as a result, which in turn impacts the quality-of-execution.

Recommendations The final list recommendation includes reducing the number of simultaneous projects, stricter prioritization between projects, conducting pre-studies to a higher degree, building more early prototypes, involving lead users and employing customer visit teams, standardization, evaluating the IT-structure, periodical co-location of two functions, restructuring of the production parts approval process, and a formalization of the knowledge management practices.

Keywords: new product development, time-to-market, TtM reduction, quality in NPD, lean product development, Husqvarna construction products, stage-gate

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Martin Huber, our supervisor at Husqvarna, deserves a special thanks for providing us with this opportunity, sharing his time and expertise with us in weekly meetings and providing us with valuable insights into both Husqvarna Construction Products as well as the world of research & development. We are immensely thankful to all interviewees at Husqvarna Construction Products for their contribution to this thesis, especially during such an extraordinary time. Their participation and input have provided us with knowledge and understanding of the organization of new product development, how it works, its challenges and how to counter these which without this thesis would not have been possible. Our hope is that this thesis will be of benefit for all organizations striving for enhanced competitiveness in new product development, and specifically contribute towards the goals of Husqvarna Construction Products.

Erik Eurenius & Billy Teräväinen, Gothenburg, May 2020

Contents

Glossary

3P 3P, which means Production, Preparation and Process, is a lean concept adopted at the Husqvarna Group. At the Husqvarna Group the 3P workshops are 1- to 3-day events in which representatives from R&D travel to the manufacturing site to co-develop product and process together with the manufacturing function. It acts as an enabler for simultaneous engineering of product and process and enhances integration between R&D and manufacturing. The 3P-workshops are the main forum for providing feedback regarding the Design-for-assembly and Design-for-manufacturability aspects of the product design. 14, 42, 43

deliverable A deliverable is a constituent of a new product development process. It is an element of output created as a result of completing work packages. 10, 12, 15, 18, 20, 30, 33, 34, 37, 39–41, 45, 52, 57

engineering pilot A product built in a production environment for engineering testing and evaluation. 14, 38, 55

manufacturing pilot An appropriate quantity of products that are assembled to provide a final verification of the manufacturing process to ensure that everything works as planned and to verify product quality and the production arrangement. 14, 44

scope creep Scope creep in project management refers to changes, continuous or uncontrolled growth in a project's scope, at any point after the project begins. 26, 36, 50

should-cost Should-costing is an analysis, conducted by a customer, of the supplier's expenses involved in delivering a product or service or fulfilling a contract. The purpose of should-cost analysis is assessing an appropriate figure to guide negotiations or to compare with a figure provided by a supplier . 14

steering group A steering group is made up of senior management who oversee development projects that serve as advisory as well as make go/kill decisions on projects. 10, 12, 18

technology readiness level Technology readiness level is a type of measurement used to assess the maturity level of a particular technology. 10, 35

Acronyms

List of Figures

List of Tables

1
Introduction

The following section will describe the background of the issues to be investigated in this thesis. The background is followed by the aim and objectives of the thesis. Finally, the section is concluded with some necessary delimitations.

1.1 Background

NPD covers the whole process of bringing a new product to the market (Wheelwright & Clark, 1992). Achieving a short lead time for NPD can entail many advantages such as extended product life, setting industry standards, lower Product Development Expense (PDE), and higher product quality by better responsiveness to customer demands - advantages that eventually result in higher profit margins, greater revenue and what is generally referred to as New Product Success (NPS)(Wheelwright & Clark, 1992). The length of time it takes from that of a product being conceived until its being available for sale is what is usually called TtM.

It is easy to be overwhelmed by the many principles, methods, and tools suggested in the literature for how to reduce Time-to-market (TtM) in New Product Development (NPD). However, there seems to be a gap between research and practice as the literature provide little support for determining which proposed principles, methods and tools that remain feasible for specific product developers to implement in the context that they operate in. There is also a lack of guidelines regarding how a said product developer should prioritize among said principles, methods and tools effectively (Cooper, 2019; Dombrowski & Zahn, 2011; Morgan & Liker, 2006).

Husqvarna Construction Products (HCP), part of the Husqvarna Group (HG), have set a companywide goal to reduce the TtM for their NPD projects. As a part of this endeavor HCP wishes to investigate contemporary research for best-practice principles, methods and tools that can aid HCP in reducing their TtM.

1.2 Aim and Objectives

This aim of this thesis is to make a contribution towards bridging the identified research-practice gap on how to effectively reduce TtM in practice. This will be done by investigating what pragmatic actions a Swedish product developer, HCP, can adopt in order to reduce the TtM in their NPD organization. The ultimate aim of this thesis is to provide HCP with a set of selected principles, methods and tools to adopt in the pursuit to reduce TtM and improve NPS in their organization. The driving question in this thesis is the following:

- What principles, methods and tools are recommended for HCP to undertake in their pursuit of a reduced TtM, and how should these be prioritized for implementation?

1.3 Delimitations

This thesis will be delimited to only investigate the actual development of a product from the start of the pre-study upstream, until the start of production downstream.

Due to the limited availability of participants all interviewees but one are from or work with the same project team.

Eight out of the eleven functions that formally are involved in the NPD were included in this study, as the remaining three were found to have little impact on the sought-after results.

2
Methodology

This chapter starts by introducing the reader to the choice of research approach, strategy, and design, followed by a description of the research process and its different phases. Next, the data collection methods are presented, accompanied by the chosen sampling technique and a description of the data analysis. Lastly, the quality of the research is described in terms of reliability and validity, followed by ethical considerations.

2.1 Research Design

The NPD process at HCP are day-to-day activities, where the sought-after results affect the daily operations. In conducting this research, the most appropriate research design was a single case study, accompanied by an extensive literature study. A case study of a representative nature is according to Bell et al. (2018) useful when exploring an everyday occurrence. Case studies can be of qualitative or quantitative nature, or a combination of both called a mixed-method approach (Bell et al., 2018). In this case a qualitative approach was utilized as the main source of data was collected in form of interviews and based on people's experiences, with some quantitative elements included for use in an effort to triangularize problem areas.

2.2 Research Process

Figure 2.1 below provides an overview of how the research was conducted. The figure is followed by brief descriptions of each phase.

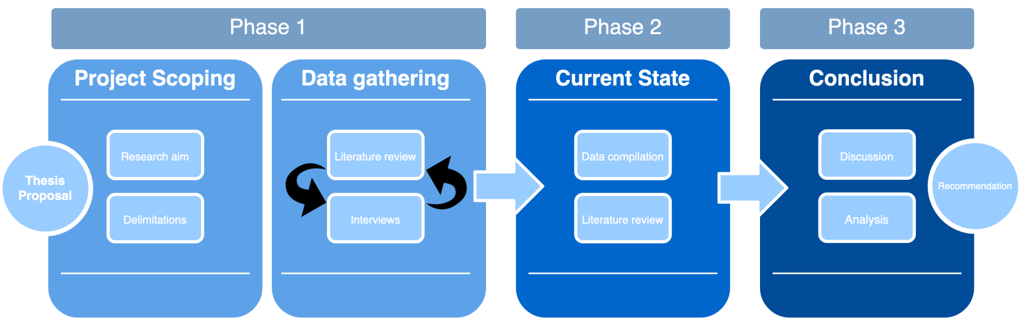

Figure 2.1: The research process

Phase 1

The first phase revolved around conducting a thorough literature review on TtM, its related subjects, as well as data collection from the case company. The literature review was conducted in a concentrated effort at first. After more understanding was gained the subsequent work commenced together with interviews in a more parallel fashion. A total of 14 interviews were conducted in this phase, excluding 12 weekly meetings with the contact at HCP, Martin Huber. The interviews were conducted with appointed members from one project development team. The interviewees were from seven out of the ten functions involved in the product development present in HCP. In addition to this, process descriptions and other documentation available at the HG's intranet were used frequently for clarification of certain elements.

Scoping and delimitations were regularly narrowed down during the process, due to emergence of clearer issues and restrictions in the work process. Due to restrictions at the case company related to the Covid-19 outbreak all interviews but two were conducted via video link. These restrictions also prevented being present on site engaging with the employees in their day-to-day work. During the interview process, due to aforementioned restrictions, it became clear that some of the sought-after information was not readily available and upon reviewing what information was gathered, a change of scope and focus was done. This led to the thesis departing from doing an in-depth analysis of the NPD process through Value Stream Mapping to taking on a broader approach, focusing on the organization of NPD and the coordination and cooperation between functions.

Phase 2

During the second phase the data gathered was analyzed. All the transcripts from the interviews were compiled into a single document. A thematic analysis was conducted where statements from the interviews were coded and categorized in an iterative manner until three major themes had emerged: Prioritizing and Focusing of Resources, Frontloading and Quality of Execution.

An additional literature study, to identify best-practice principles, methods and tools within the identified categories, was conducted. The literature were synthesized into a condensed theoretical framework with guidelines for TtM reduction tailored to HCP, which will be presented later in this thesis. The current state analysis and the theoretical framework for TtM reduction is what forms the basis for the recommendations and conclusions in the third phase of the study.

Phase 3

In the third phase the theoretical framework was applied to further analyze the empirical findings. HCP's NPD efforts were benchmarked towards the best-practices presented in the framework and recommendations were designed to target gaps between HCP and the identified best-practices.

2.3 Data Collection

The data for this report has been collected through semi-structured interviews with employees and stakeholders working in or with NPD at HCP, as well as the HG's intranet to which access have been granted to the researchers. In detail described below.

2.3.1 Literature Review

Denzin and Lincoln (2008) and Yin (2017) recommend a literature review as a foundation for research, as it provides support for the study, increases the validity of the research and stimulates analytical and critical questions. The literature review conducted served to present results of other studies closely related to the research area and provided a basis for a framework and setting the interview results in context.

The resources used to find literature were databases such as Google Scholar and Chalmers library. Articles and books were chosen on the basis of relevancy to the subject, recency of the study as older studies might have less relevance to the subject, and recognition within the academic community. The initial part of the literature review revolved around gathering knowledge upon the TtM subject, from which further, more specific subjects were researched.

A wide range of search terms were used, mainly: time-to-market reduction, new product development, lead time reduction in NPD, lean product development, customer involvement in NPD, knowledge management, stage-gate.

As the research progressed and the problem areas became more defined, some existing research were identified that were of particular interest and relevance to the subject: Cooper (2019) and Dombrowski and Zahn (2011). These two studies were together with the initial literature review were synthesized into a framework based on HCP's conditions and made particularly to counter the challenges HCP face.

2.3.2 Data Sources

Two main sources of data were used during the research - interview data as well as readily available organizational data from the HG's intranet. The research methodology regarding these two data sources will be described below.

Interviews

A semi-structured approach with open ended questions was used during most of the interviews. Semi-structured interviews are suitable for gathering qualitative data with descriptive, elaborative answers (Bell et al., 2018), which might require clarification and probing (Mann, 2016).

To find relevant people to interview in the organization a combination of purposive sampling and snowball sampling was used. These methods are well suited for qualitative studies and are meaningful and provide ways to gain the data sought for (Creswell & Creswell, 2017). The first two interviews were selected through purposive sampling, whereafter snowball sampling was utilized to select the remaining participants. Interviewees that were sought for were employees who worked in or with NPD teams, the center of the research, as well as manufacturing and sourcing. The interviewees were proposed by both the manager at the Product Management Office (PMO) and Project Manager (PM) 1. As PM 1 and both R&D Leads were involved in the same project, an interview with a PM from another project was conducted to corroborate the views of PM 1. The supporting functions had all been involved in multiple other projects and answers from them were more general to the organization as a whole.

Table 2.1 describes the role and department of the interviewees, and they are listed in a chronological order, with the uppermost being the first interview conducted. The interviewees has been categorized into three groups for future reference: Management, Supporting Function, and Core Development Team.

Role	**Department**	**Category**
Operations & Quality Director	Operations	Management
Manager PMO	PMO	Management
Project Manager 1	PMO	Core Development Team
SQA Manager	SQA	Supporting Function
Purchasing Commodity Manager	Sourcing	Supporting Function
Industrialization Lead	Manufacturing	Supporting Function
R&D Lead 1	R&D	Core Development Team
Global Product Manager	Power Cutters	Management
Compliance Specialist	Compliance	Supporting Function
Project Manager 2	PMO	Core Development Team
R&D Lead 2	R&D	Core Development Team

Table 2.1: List of interviewees

The interviews were conducted with one participant at a time and all, but two interviews were conducted via video link. Interviews were recorded by taking notes on computer, an action recommended by Bell et al. (2018), in order not to distort the respondent's answers and to reduce the introduction of errors in the data.

The first two interviews with the Operations & Quality Director and the manager at the Product Management Office (PMO) were of an exploratory nature, with very little structure to them, that served as information and inspiration for where to direct attention. A template was then constructed, which is found in appendix A, which was upheld the first four interviews whereafter it was modified to varying degrees to focus in on the particular problem areas the interviewees discussed. All interviewees were encouraged to provide suggestions and opinions for areas to investigate or other feedback they may have.

The affinity method was used to analyze the interview data. It is a method, done in six steps, developed by Kawakita (1991) and is a way to organize interview data and gain new insights and ideas in which way to direct further research. The interview data was first condensed into short statements for ease of categorization, which were subsequently coded. These were then categorized into groups that addressed the same issue and the groups were then named after what the issue was identified to be. Interrelationships between the groups were investigated to help in analyzing the content. Finally, the analysis was made upon which further research was conducted.

Organizational Data

Organizational documents available at the HG's intranet were gathered and used to build up an understanding of the organization at HCP and the NPD process.

The documentation from the HG's intranet was presented in form of process descriptions, role descriptions, graphs and visualizations of processes.

2.4 Quality Criteria in Qualitative Research

As this thesis seeks knowledge from the experience of participants who work practically with NPD in the field, a constructivist research approach was deemed suitable. A constructivist approach, as described by Lincoln and Guba (2013) assumes that people construct understanding and knowledge through experience and reflection. In harmony with the constructivist approach, the concept of trustworthiness, as proposed by Lincoln and Guba (2013), was used to evaluate the quality of research. Trustworthiness was established by the following four criteria:

Credibility

To receive multiple perspectives on the issues investigated and, in that way, achieve credibility, the fourteen interviews where held with eleven different individuals from eight separate departments were interviewed, all with different experiences.

Transferability

The interviewees were all tied directly to different functions involved in NPD at HCP, who speak out of experience in that environment. The research is therefore probably only transferable to other organizations of similar size facing related challenges.

Dependability

To enhance the dependability of the thesis a project log has been kept, where major decisions made during the writing of the thesis has been noted. The dependability of the research has also been aided by a continuous audit by external stakeholders, the thesis' supervisor - Joakim Netz, as well as the contact at HCP - Martin Huber.

Confirmability

The research process has been based on a literature review as well as the empirical findings derived from interviews. The conclusions drawn from these were made collectively and has been presented for and discussed with representatives from HCP in order to decrease the influence of each researchers' personal values on the findings.

2.5 Ethics

The main ethical dilemmas of this thesis regard the publication of information that might be sensitive to either individuals or HCP as an organization.

During interviews the interviewees risk disclosing information that can cause stress, harm to the participants' development, self-esteem, career prospects or future employment (Bell et al., 2018). Therefore, the intentions and purpose of the study were thoroughly explained to interviewees so that a consent to participation was based on well-founded information and the transcribed data from the interviews was kept anonymous to as high degree as possible.

Due to a limited number of participants a total anonymity for the interviewees was impossible to guarantee. However, the interviewees were anonymized, and no interviewees disclosed any information that they were not comfortable with being published.

Before publishing, the report was reviewed and approved by a representative at HCP so that any information sensitive for HCP as an organization was not published.

The thesis has been of mutual benefit to both the researchers and HCP as participants. The researchers have gained useful experience of applying theoretical knowledge in a practical setting, while HCP as an organization have gained benefits through the acquired knowledge that has emerged from the study. The benefits for individual interviewees at HCP include a chance to get their voice heard to influence their organization.

3
Empirical Setting

The empirical setting of this thesis is limited to the HG and specifically to the functions that are involved in NPD at HCP, which is one of three divisions in the HG. This chapter will describe the contextual circumstances of the HG, HCP, and the HG's Product Creation Process (PCP).

3.1 The Husqvarna Group

The HG is a Swedish multinational developer and manufacturer of outdoor products such as robotic lawnmowers, garden tractors, chainsaws and trimmers. The group is also active in equipment for the construction industry. The HG currently employs ca 13 000 employees in 40 countries and has a turnover of ca 42 billion SEK per year (Husqvarna Group, 2020).

The HG consists of three divisions; Husqvarna Brand Division, Gardena and the case company HCP.

3.2 Husqvarna Construction Products

HCP is the division of the HG that develops products for the construction industry. The product range includes machines, diamond tools and accessories for cutting, sawing and drilling, as well as polishing floors and demolition. The global headquarter and Research and Development (R&D) center is located in Jonsered, just outside of Gothenburg, in Sweden. HCP contributes to around 15% of the HG's net sales (6.3 billion SEK) annually and occupies ca 2 300 of the group's employees (Husqvarna Group, 2020).

The divisions products are produced at nine different manufacturing sites that are spread out over the world and shared with the rest of the HG. However, most of the high-volume products at HCP are manufactured at the HG's manufacturing site in Huskvarna. HCP itself is divided into six sub-divisions, four located in Jonsered: Concrete Sawing & Drilling, Concrete Surfaces & Floors, Light Demolition, and Aftermarket & Connectivity; and two in Ath, Belgium: Diamond Tools and Stone.

3.3 Husqvarna Product Creation Process

The HG has one overarching process description in place for NPD called the PCP. The PCP is a collection of processes for product lifecycle management that all divisions at the HG are instructed to abide by. The PCP includes processes for all parts of the product lifecycle, from ideation to product elimination. The PCP also includes formal Roles and Responsibilities (R&R) for the functions represented in the PCP, R&Rs that will be described further below in this section. The main scope of this thesis is focused on formal NPD which in the PCP is covered by a process simply called "the NPD". The PCP also includes a pre-study, which has shown to be of interest for the thesis. Both the pre-study and the NPD will be described in this section. The full PCP is illustrated in figure 3.1 below.

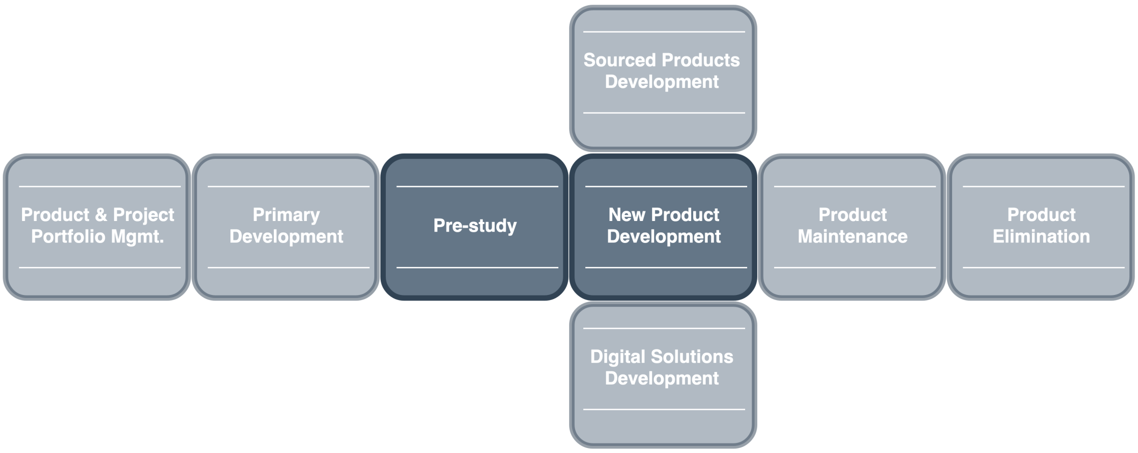

Figure 3.1: The PCP with the research scope highlighted

3.3.1 Pre-study

Pre-studies are a part of the PCP and is to forego the formal NPD process. The general idea of the pre-study is to translate the Voice-of-the-customer (VoC) into functional specifications for the product and to assess the technology readiness level for the intended technologies in the product.

3.3.2 The NPD

The HG employs a stage-gate model for their NPD process, containing seven different stages enclosed by a total of eight gates. The seven stages include a total of 152 deliverables spread out over eleven functions. The deliverables associated with each stage should be fulfilled before a gate-passage in order to move the project onward to the next stage. Each gate passage is reviewed by a steering group at HCP who make the decision for whether the criteria for passing the gate have been fulfilled or not.

3.3.3 Roles & Responsibilities

The NPD process includes a total of eleven functions, who all have different roles associated to them. In order to understand NPD at HCP it is beneficial to be familiar with these roles and their responsibilities. Therefore, to provide the reader with clarifications for future references and an enhanced understanding for the intricate interplay between these functions that make up the NPD, a brief description of these roles and their responsibilities will be given.

The descriptions of these functions are based on input from the interviews and the available R&R documentation from the HG's intranet. Many of the functions that are involved in the NPD at HCP are represented within the organization itself (PMO, R&D, Supplier Quality Assurance (SQA), and compliance) while some of the functions (manufacturing, sourcing, spare parts, Global Design (GD), and brand & marketing) are cross-divisional and serve all divisions of the HG. The eleventh function is the product quality function, which is neither cross-divisional nor represented at HCP. As all functions in the PCP have not been relevant to the research, below in figure 3.2 the eight functions that were found to be relevant for the initiative to reduce TtM are shown.

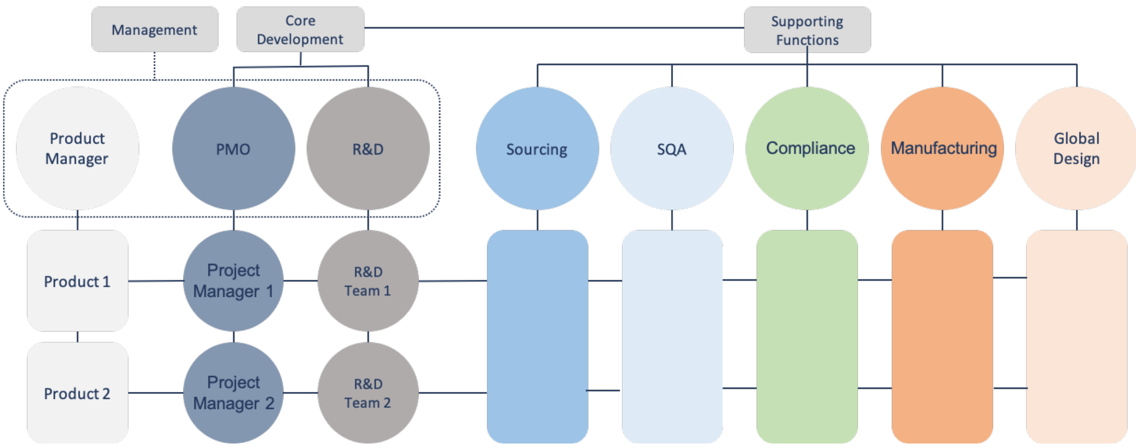

Figure 3.2: Overview of the investigated functions and their place in the NPD

The R&Rs of these eight functions will be described below.

Product Manager

The Product Manager is responsible for managing the product portfolio of the company. The Product Manager represents the market in the development project and is the one who proposes the development of new products.

Some key tasks and responsibilities of the product manager includes conducting market research, creating a business case for the product, compiling market & user requirements, producing recommendations for prioritization between quality, time and cost as well as supporting the marketing and sales organization.

During a development project the product manager works closely with the PM, but also cooperates with other functions such as R&D to translate softer market & user requirements into more "hard" technical user requirements. The Product Manager's at HCP are on-site in Jonsered.

Project Management Office

The PMO is the function which organizes the PMs at HCP. The PMs have full ownership of project(s) and are responsible for effectively managing the full range of stakeholders and driving the projects towards defined and agreed results.

Key tasks and responsibilities include forming the project teams, clarifying the responsibilities for all roles, securing resource alignment with the line organization, reporting progress to the steering group, communicating with all relevant stakeholders within and outside the project, creating and maintaining project budget, and ensuring that requirements are fulfilled for gate passages.

As the PMs' responsibilities indicate, the PMs are highly involved with all functions, and acts as a mediator for communication. Outside of the formal responsibilities, PMs also works with contributing and refining in the NPD. The PMO at HCP is on-site in Jonsered.

R&D

The R&D function is responsible for the actual research & development of an NPD project. The R&D function itself is divided into various segments, such as R&D lead, electric/software, mechanic, simulation, and R&D services.

The R&D lead has the authority to make technical decisions regarding the design of a new product. Key responsibilities and tasks of the R&D lead include securing R&D deliverables according to project time plan, ensuring that required resource demand is identified and communicated to the PM, leading planning and controlling the R&D project team, as well as driving the technical progress of the project.

It is the PM together with the R&D team that form the core of an NPD project team. The R&D lead naturally cooperates much with the PM - but points of contact exist with most other functions during the course of a project. The R&D function at HCP is on-site in Jonsered.

Supplier Quality Assurance

SQA works with supplier development to ensure that the suppliers' processes fulfil the necessary quality requirements. The responsibilities are very focused on the delivery of the Production Part Approval Process (PPAP).

In short, PPAP is a process used to ensure that suppliers are capable of fulfilling quoted requirements. It is conducted to provide evidence that the specification requirements are clearly understood and fulfilled by the suppliers, and to demonstrate that the established manufacturing processes are capable of producing parts that consistently meets all requirements during the actual production run at the quoted production rate (Hermans & Liu, 2013).

While sourcing places the PPAP order on behalf of the PM, SQA is responsible for educating and supporting the suppliers in the PPAP to secure that an approved PPAP can be delivered in time. SQA for HCP is located in offices and factories all over the world, including Jonsered.

Compliance function

The purpose of the Compliance function (Compliance) is to investigate the market in order to map compliance requirements (as in regulatory compliance, i.e. abiding by the law) to ensure that products conform to market regulations and thus have access to markets. The requirements that result in engineering and design constraints are communicated to R&D in a compliance specification and a compliance plan is conducted. Compliance is divided into areas of expertise (e.g. chemical-, electrical-, or emission compliance).

Key tasks and responsibilities are to compile compliance specifications and a compliance plan, and finally compile the documentation needed for access to all markets as defined in market & user requirements. The role includes some additional tasks such as monitoring legal requirements and participating in work on setting industry standards.

The compliance function works closely with R&D and the PM and is located in Jonsered.

Manufacturing

The manufacturing function has the main responsibility for the industrialization of new products. The manufacturing function must secure production capacity for the product and deliver product builds throughout a project. Manufacturing specifies manufacturing demands for the product, as well as supports R&D with feedback regarding design-for-assembly aspects during the course of an NPD project. Manufacturing specifies assembly cost and investments in machinery & equipment as a key input for a project.

Key tasks and responsibilities for manufacturing include providing production capacity, procure new and/or adapt existing production machinery & equipment, arranging 3P-workshops, providing engineering pilot and manufacturing pilot builds, planning factory layout and ensuring that final assembly fulfil quality requirements.

In an NPD project the manufacturing function is led and represented by an industrialization lead. The industrialization lead coordinates with both the core development team and his/her own industrialization team, consisting of its own manufacturing-specific functions.

The manufacturing function is organized by its associated manufacturing plant, meaning that the representing function depends on the chosen manufacturing plant for the product. The most common manufacturing plant for HCP's product is the Husqvarna plant in Huskvarna, which is represented by a function called Huskvarna Manufacturing that serve all divisions of the HG.

Project Sourcing

The project sourcing drive and follow up the main sourcing activities associated with a project. The sourcing function collaborates with SQA to secure adequate quality from the supplier base and R&D to select suppliers and calculate should-costs for quotation requests.

Key tasks and responsibilities include defining and selecting suppliers for the product, participating in the creation of a bill-of-materials, ensuring that sourcing-resources are available, and creating and maintaining a sourcing time-plan.

The sourcing function serve all divisions of the HG and is located in Huskvarna.

Global Design

GD has the main responsibility for the product design, ensuring that it conforms with the Husqvarna brand.

Key tasks and responsibilities include setting brand design direction, ensuring the right 'feel, fit, and finish' of the product, securing alignment with brand design and securing design protection/patent clearance.

GD cooperates with R&D to a high degree in setting the product design. The GD function serves all divisions of the HG and is located in Stockholm.

Product Quality

The product quality function's purpose is to support the NPD projects to ensure that the required product quality is met. The function's duties mainly include tasks related to knowledge management and customer satisfaction, such as creating lessons-learned documentation and conducting customer validation tests.

The product quality function is formally part of the HG's PCP, but the function lacks representation at HCP. At HCP the responsibilities of this role befall mainly the PM, and the deliverables associated with the product quality function are either done by the PM, merged with other deliverables or delegated to other functions.

4
Theory

This chapter presents the theory for this thesis. The chapter begins with a section of theory on NPD in general, with a critical take on TtM reduction, and an overview of the stage-gate model and lean product development. The chapter is then concluded with a section presenting a theoretical framework, which is an amalgamation of the reviewed literature and is targeted specifically on reduction of TtM in NPD adapted to the setting at HCP.

4.1 New Product Development

NPD is what in business and engineering refers to the whole process of developing and bringing a new product to the market (Wheelwright & Clark, 1992). NPD can be described as transforming a market opportunity into a product available for sale and includes both incremental and radical innovation approaches. The main determinants driving the success in NPD are PDE, TtM, and product quality (Cooper & Kleinschmidt, 1995; Wheelwright & Clark, 1992). Aiming at these three determinants, companies develop practices and strategies to continuously improve products and satisfy customer demands. Central aspects of NPD are thus the understanding of product design, customer needs and wants, the competitive environment and the nature of the market (Wheelwright & Clark, 1992).

This section reviews theory that is relevant for understanding NPD. First the stage-gate model, the most common model for organizing NPD processes, is presented. Then determinants related to NPS are reviewed, along with advantages and trade-offs to consider when pursuing a reduction of TtM. Last, the section briefly reviews the idea of lean development as part of the NPD process.

4.1.1 Stage-gate Model

The predominant design of an NPD process is the stage-gate model (Cooper, 2019). This section will describe the general concept of the stage-gate model, inherent strengths and weaknesses, as well as its typical stages.

The concept stage-gate model refers to management through which a project (such as an NPD project) is divided into distinct stages separated by “gates”. The gates are decision-points that act as quality checkpoints for the project. Typical decisions in a gate-review are: (1) go (to allow the project to continue to the next stage), (2) kill (to terminate the project), (3) hold (to hold the decision until further notice), or (4) recycle (redo parts of the previous phase). These decisions are often handled by a senior manager or a steering group that makes the decision based on whether the criteria for passing the current gate is adequately fulfilled (Cooper, 1990).

Stage-gate models are effective under certain circumstances. Stage-gate processes work well as they enable steering the quality and reliability of a project (Minderhoud & Fraser, 2005). According to Cooper (1990), the main advantage of the stage-gate process is its simplicity — the process is clear and easy to understand, and the steps and gates are easy to follow by everyone in the organization. The model puts discipline into a process that is otherwise ad hoc, as it clearly defines R&Rs for project members Cooper (1990).

A drawback of the stage-gate model is, according to Reinertsen (1997), an uneven workload that leads to low efficiency. Prior to gate passages pressure to complete certain deliverables can entail an elevated workload and a decreased efficiency as otherwise value-adding work is focused towards preparations for the next gate passage (Reinertsen, 1997). Further criticism towards the model is that the stage-gate process is too structured, and risk disturbing creativity and innovation in an NPD process (Holmdahl, 2010).

There is no universally established rule for how a stage-gate process for NPD must be designed, or for the terminology to be used for the typical phases. However, the structure is usually similar, beginning with some form of pre-development or concept generation, moving on to more formal development and concluded with production or sales. In order to provide clarity for the intended audience, this thesis will resort to adopting the terminology used at the HG: Pre-study → Specification → Development → Industrialization → Production → Sales. A general description of these phases is described below.

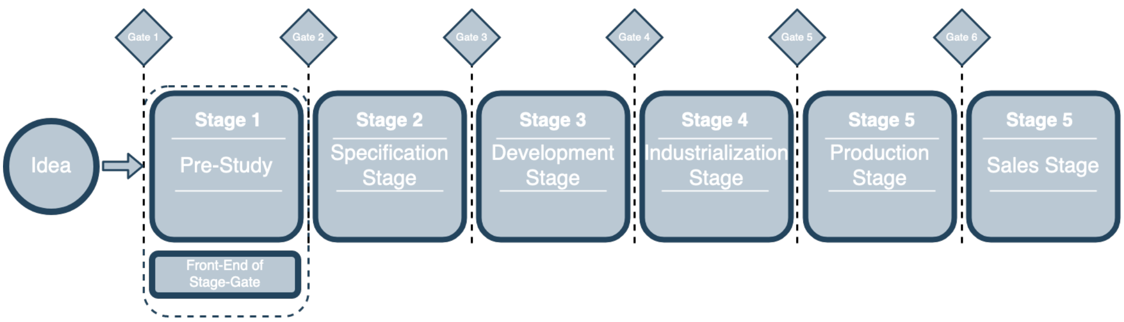

Figure 4.1: A general depiction of a Stage-gate model

Pre-study

The pre-study precedes the formal NPD. The pre-study usually includes market and user research, as well as evaluation of the technological maturity of the technologies intended for realizing a market opportunity.

Specification Stage

The specification stage is where market requirements are compiled, evaluated and specified. Product concepts are developed and fulfilled towards the market requirements. It is in the specification stage that stakeholders typically are involved to evaluate, weigh, and trade-off the most relevant attributes of the product.

Development Stage

The development stage comprises industrial- and engineering design for the selected concept. Typically, prototypes are manufactured, and trial tests are conducted in order to verify and validate the product.

Industrialization Stage

The industrialization stage is where tools, equipment, and other components are procured, and the production processes and tooling are tested and validated. The phase usually involves supplier quality assurance to ensure that the supply chain is ready for production ramp-up and market introduction.

Production Stage

The production stage is where the products are produced in accordance to the production plan, and the product is released to the market.

Sales Stage

Formally outside the scope of this thesis, but in the sales stage, the product is available for sale, and it is ensured that project targets are met before ending project. If the targets are met, the project is concluded and the responsibilities for the product is handed over to daily operations.

4.1.2 Determinants of New Product Success

This section will describe the concept of NPS, along with the three most relevant determinants for it: TtM, Product Quality and PDE. To conclude, trade-offs between these determinants will be presented

New Product Success

NPS in itself is a combination of eleven aspects mainly connected to financial return, formulated by Cooper and Kleinschmidt (1987) as: success/failure rate, profitability level, payback period, domestic market share, foreign market share, relative sales, relative profits, sales vs. objectives, profits vs. objectives, opportunity window on new categories, and opportunity window on new markets.

The concept of NPS is widely adopted in literature on NPD and captures the ultimate goal of NPD - the capability to satisfy a market demand and translate this demand into profit for an organization. The combination of PDE, product quality and TtM is what determines NPS (Cooper & Kleinschmidt, 1995), which is illustrated in 4.2. Intricate co-dependencies and trade-offs between these determinants exist (illustrated by the arrows in the figure) which will be discussed more below.

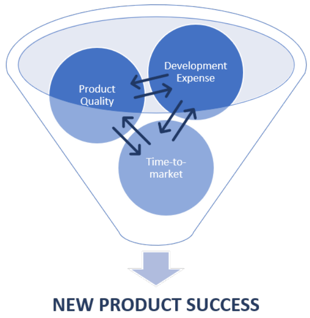

Figure 4.2: Illustration of the determinants for NPS.

Time to Market

The length of time it takes from a product being conceived until it is available for sale is usually referred to as TtM).

There are no set standards for how to measure TtM and the definition for where the start and end of the measurement lies may vary between different industries and organizations. The concept of TtM lacks a uniform meaning, as well. In early literature on the subject, dating from the early 1990's, "Time-to-Market" is referred to as a method for reducing the timespan that, now, in contemporary research is referred to as TtM, and not as a metric itself (Pawar et al., 1994). The concept has since evolved to meaning the elapsed time between conceiving the product and market availability (Vesey, 1992) and for that definition there are several different names used: TtM, cycle time, innovation speed, NPD speed, and speed-to-market (Fang, 2008).

Large discrepancies still remain in the difference in notions of what the starting and end point is for the development of a new product (Fang, 2008). The start can be defined as for example when an idea is conceived, at the start of the specification phase, or the development phase (Wheelwright & Clark, 1992). Similarly, the end period can be defined as the time when the product is sent off to manufacturing, when the product is ready for sale, or when the product reaches its destination at the hands of a customer (Wheelwright & Clark, 1992).

In this thesis the term TtM will be defined as the length of time elapsed between the deliverables that the PCP refer to as project kick-off in the specification stage, until start of production in the production stage.

Product Quality

Product quality, in the context of NPD, refers to how closely matched a product is to customer expectations at the time of launch. Product quality is affected by both concrete attributes such as performance to functional specifications, and less tangible ones such as image and usage experience (Lynn et al., 1999).

Product Development Expense

PDE is a measure of the costs incurred by an NPD project. The PDE is usually put into relation to the projects initial budget, or the revenue earned by the product.

Trade-offs Between the Determinants

Several studies highlight a strong, significant correlation between TtM, product quality, and NPS (Fang, 2008; Lynn et al., 1999; McNally et al., 2011; Pawar et al., 1994). McNally et al. (2011) states that the greater the reduction in TtM, the greater the probability is of success on the market. First, the capability to bring technological developments to market faster than competitors should allow for the same performance improvement (as slower competitors) in a shorter time span, which eventually might create a significant performance gap (Wheelwright & Clark, 1992). Second, possessing such capabilities does not necessarily have to lead to an earlier market introduction - but will lead to a more enhanced product quality in a given span of time (Cohen et al., 1996; Lynn et al., 1999; Pawar et al., 1994). A short TtM also augments product quality due to shorter time from forecasting to launch of a new product, reducing the impact of what is called 'the moving target' (Lynn et al., 1999). The moving target is referring to the shifting technologies or markets during an NPD process meaning that a non-adaptable or too time-consuming NPD process may result in a product that is misaligned with the actual needs of the market, or worst case is obsolete (Wheelwright & Clark, 1992).

However, there are several pitfalls of a strategy focusing on strictly and solely reducing TtM, and a number of trade-offs to be managed (Fang, 2008). There must be made the distinction upon what constitutes being faster as a result of improved organizational capabilities and being faster by simply allocating additional resources to projects and thus reducing the TtM without necessarily getting a higher level of efficiency (i.e. trading an improved TtM off versus an increased PDE) (Bayus, 1997).

Reducing TtM without any organizational improvements, by setting a stricter deadline, may force NPD-teams to shorten or slip key processes, reduce technological content, and trim performance specifications, and in other words simply trade an improved TtM off versus a worsened product quality (Fang, 2008). Working under high time pressure may force teams to consider a narrow range of solutions and have little time to explore different possible alternatives, which may cause expensive redesign and customer ill will (Chen et al., 2005; Fang, 2008; Lynn et al., 1999). An overemphasis on TtM may make the NPD-process too rigid, rendering it unable to respond to changes driven by competitors and customers (Fang, 2008). This is a fact most managers know intuitively according to Bayus (1997), that the trade-offs between TtM, product quality and PDE exist.

One of the trade-offs, the one between TtM and PDE, is depicted in figure 4.3 to the right. It is by no means an exact mathematical representation, as the trade-off would look different for every project and organization, but the figure is meant to be a conceptualize the trade-off that exist. On the "X-axis" is TtM, how long time a project takes to finish. On the "Y-axis", is PDE, the amount of resources a project consumes. The thick blue line, the normal state, shows how a PDE-minimizing TtM exist for a project, which would be the point T_1'. If a project is delayed beyond that point (e.g. due to overworking or rework), towards T_d, the PDE for the project will start to increase. A TtM reduction along the line from T_d to T_1' is always positive as it would save both time and resources. However, if the organization attempts to reduce TtM even more (moving to the left on the filled blue line), surpassing T_1' towards T_c, diminishing returns will kick in and considerable extra resources will be required. Reducing TtM below T_1' will result in a direct trade-off between TtM and PDE, where the balance of the two becomes a strategical consideration. Similar relationships as depicted in this graph also exist between TtM and product quality, as well as between product quality and PDE.

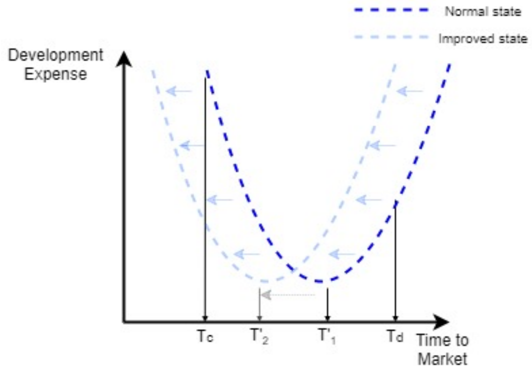

Figure 4.3: Graph describing the relationship between TtM and PDE

In this thesis, when referring to reduction of TtM, the reduction will refer to either reducing the occurrence of unwanted revisions or rework (moving along the original curve from T_d to T_1') or making the whole R&D organization more efficient (pushing the whole to the left, as illustrated by the shaded line) so that more can be done with less - and a shorter TtM can be achieved without incurring additional PDE (compare T_1' to T_2').

In conclusion a trade-off between TtM, product quality, and PDE must always be made (Lynn et al., 1999). Sometimes a strong case can be made for using additional time towards achieving a higher product quality rather than releasing the product earlier to the market (Bayus, 1997; Chen et al., 2005; Cohen et al., 1996; Fang, 2008). In contrast, there are other cases in which it is of more strategic importance to release a product early to catch a market opportunity, for example if there is a very high reward connected to early introduction or if the market window is small (Bayus, 1997; Chen et al., 2005).

4.1.3 Making the NPD Process Lean

One established approach to counter many of the challenges in NPD is 'lean product development'. Various researchers, such as Brown (2007), Dombrowski and Zahn (2011), Haque (2003), Holmdahl (2010), Locher (2008), Morgan and Liker (2006) and Reinertsen and Bellinson (2014) attest to the usefulness of the lean product development approach.

Lean product development is derived from lean production, and Toyota Motors (Morgan & Liker, 2006). A vast publication on the subject of lean product development in recent years have led to some fragmentation and unclear definitions of its constituents, with many researchers having their own interpretations (Dombrowski & Zahn, 2011). However, the core philosophy of lean development is to eliminate waste and minimize the resources required to run the organizations operations (Morgan & Liker, 2006). In lean theory the waste is usually divided into three categories: muda, muri and mura – known as the three M's (Morgan & Liker, 2006).

Waste Category	Description
Muda (Non-value added)	Non value-adding activities
Muri (Overburdening)	Pushing people beyond their capability
Mura (Unevenness)	This results from irregularity in workflow

Table 4.1: Waste in lean production (Morgan & Liker, 2006)

Muda is defined as all activities that the customer does not perceive as value-adding. (Morgan & Liker, 2006) and is usually further divided into seven types of waste, as presented by Morgan and Liker (2006), and further elaborated by Locher (2008) who adopted an eighth category: underutilized people. These eight categories of waste in lean development are presented in 4.2 below.

Waste Type	Description
Overproduction	Producing more information than what is needed
Waiting	Idle time due to information unavailability
Transportation	Unnecessary movement of information
Nonvalue-Added Processing	Information processing beyond requirements
Excess Inventory	Unused information or WIP
Defects/Corrections	Erroneous data, information, reports
Excess Motion	Unnecessary movement of people
Underutilized People	Employees not utilizing their full range of skills

Table 4.2: Wastes in NPD (Locher, 2008; McManus, 2005; Morgan & Liker, 2006)

4.2 Time to Market Reduction in New Product Development

This section will present a framework synthesizing the contemporary theory on reducing TtM in NPD. The framework is visualized in figure 4.4.

The identified three main areas of challenges in the context of reducing TtM is: inadequate prioritization and focusing of resources, presented in subsection 4.2.1, lack of VoC and inadequate front-end efforts, presented in the frontloading subsection in 4.2.2, as well as lacking quality-of-execution, presented in subsection 4.2.3.

Figure 4.4: Framework for TtM reduction

4.2.1 Prioritizing and Focusing of Resources

A common issue for product developers is that they conduct too many projects simultaneously for the resources available, with the consequence that projects suffer from lack of time and financial commitment (Cooper, 2019). A strong success factor for top-performing product developers (in terms of NPS) is that they commit the necessary resources to NPD to a much higher degree than worse performing counterparts (Cooper, 2019).

The field of research that covers the management of processes, methods and technologies used to achieve the best possible prioritization and resource allocation across projects is project portfolio management (Martinsuo, 2013). Project portfolio management is often given inadequate attention by product development managers (Elonen & Artto, 2003).

A concept in project portfolio management, to reduce the impact of contingencies, is to have a 'capacity cushion' which means to refrain from scheduling resources to a 100 percent utilization (Wheelwright & Clark, 1992). In a non-deterministic system, there will be a trade-off between resource efficiency (percent capacity used for a resource) and flow efficiency (proportion of value-adding time vs. total lead time in a process), meaning that the higher resource efficiency opted for, the lower the flow efficiency will become (Reinertsen & Bellinson, 2014). This is explained by fundamental queuing theory and illustrated in figure 4.5 to the right. As the utilization of a resource increases, so does the size of its queue, and the length of time a job has to wait before being processed by that resource - leading to a less efficient flow. According to Reinertsen and Bellinson (2014) the average product developer loads their NPD processes far too high, to utilization levels that are only feasible for deterministic processes or processes with very low variability.

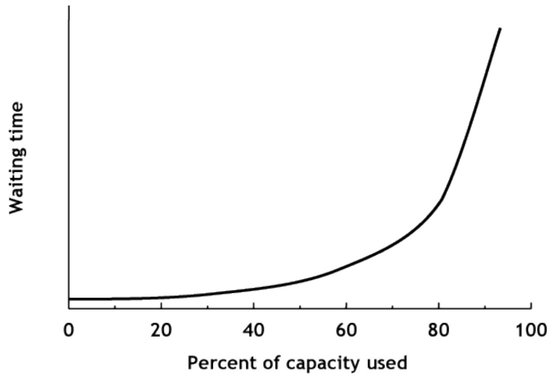

Figure 4.5: Graph describing relationship between waiting time and capacity utilization. (Note: Assumes M/M/1 queue).

The result is a pipeline gridlock, meaning that projects end up in a queue; they take too long to reach the market, and key activities — such as doing a proper pre-study - are omitted because of a lack of time and resources (Cooper et al., 2001).

4.2.2 Frontloading

Frontloading, so called in Lean Development by Dombrowski and Zahn (2011), or what is called Front-End Homework by Cooper (2019), refers to the practice of expending maximum effort in a project as early as possible. The idea is to avoid revisions or re-work later in the process by expending more resources in the earlier phases (Cooper, 2019; Dombrowski & Zahn, 2011). Product design changes are inevitable during a project, but the issues that arise from these can be mitigated if most of these changes occur early on (Cooper, 2019). Doing a thorough pre-study, involving customers early on in the design and testing process, and capturing the VoC are key components in frontloading.

One aspect of frontloading is achieved through pre-development, which takes place before any formal development occurs (Dombrowski & Zahn, 2011). An observation by Cooper (2019) is that product developers that show greater NPS spend around twice as much time and money on pre-development activities than less successful product developers, and that the less successful ones usually display an unbalanced front-end phase relying overly much on the technical aspects and foregoing market-oriented tasks. By properly frontloading, a decreased risk of revisions and rework, a reduced TtM, and ultimately an improved NPS can be achieved (Cooper, 2019; Thomke & Fujimoto, 2000).

According to Cooper (2019), an effective pre-NPD process should cover:

- Preliminary market assessment: Quick market study to appreciate market potential and product attributes.
- Preliminary technical assessment: A first technical appraisal, technical feasibility assessment and technical risk identification.
- Detailed market study, market research and VoC research.
- Detailed. Technical assessment: In-depth technical appraisal, proof of concept, intellectual property issue resolution.
- Business and financial analysis just before investment decision to full-scale development.

The process of capturing and translating customer requirements (wants and needs) is what is referred to as capturing the VoC (Griffin & Hauser, 1993). A thorough understanding of customers' wants and needs, the competitive landscape, and market dynamics is essential to NPS - where effectively capturing the VoC is a key factor (Cooper, 2019; Dombrowski & Zahn, 2011). Inversely, failing to align with the market orientation, not undertaking the necessary market assessment and not involving customers in the NPD is linked to larger probability of market failure in products.

Having a rigid VoC-process is vital in counter-acting scope creep and unstable product specifications which are two of the most frequent time wasters in NPD (Cooper, 2019; Found & Harrison, 2012). How well and accurately the VoC is covered and the product is defined before the development begins is a major success factor that impacts both profitability and TtM positively. A sharp, early and fact-based product definition should include:

- Project scope
- Target market
- Product concept and the benefits to the user
- Positioning strategy
- Product features, attributes, requirements and high-level specifications

Additional positive contributions by having a product definition step built in includes that:

- It forces more attention to the front-end activities
- It serves as a communication tool: all functional areas thus have a clear definition of the product
- It provides clear objectives for the technical development team members

Iterative development

Being agile and able to perform changes during the NPD process in accordance to dynamic market forces is a strong competitive advantage in NPD (Cooper, 2019). A way of handling a dynamic information process with changing and updating information is the utilization of an iterative development approach, with an early inclusion of customers in the process (Cooper, 2019). Cooper (2019) states that many businesses are too rigid and linear in their approach to NPD, and despite having done all the front-end work properly - by visiting customers, determining customer requirements, fixing product specifications and product definitions - end up wrong. NPS is linked to a higher degree of customer involvement in the design and testing process (Datar et al., 1997; McNally et al., 2011; Pawar et al., 1994).

Customer involvement refers to the extent to which customers are involved in the NPD process (Afonso et al., 2008). Brockhoff (2003) and Chang and Taylor (2016) means that customer involvement leads to better financial performance and speeds up the TtM, ultimately improving NPS.

Customer involvement in combination with an iterative process will enhance innovativeness of the product, speed up the development and provide important feedback regularly during the process (Afonso et al., 2008; Cooper, 2019). To fully utilize the benefits of customer involvement, product developers should adopt a more experimental approach in the NPD, with frequent product testing in the different stages of development, also referred to as rapid prototyping (Cui & Wu, 2017; Schilling & Hill, 1998). Cooper (2019) refers to the utilization of deliberate iterations and rapid prototyping and testing as a best practice, findings that are corroborated by those of Vinodh et al. (2010). A more iterative development approach can be achieved through adopting so called build-test-feedback-revise cycles (Cooper, 2019), explained below:

- Build: Build and show the customer – a simple representation of the product such as a rapid prototype
- Test: Test each version with the customer
- Feedback: Gather feedback on the version of the product tested
- Revise: Reset the thinking about the value proposition, benefits and product design based on the feedback and move on to the next iteration

The iterative approach with rapid prototyping is meant to promote experimentation and encourages project teams to fail often, fast and cheaply (Cooper, 2019; Vinodh et al., 2010). These iterations reduce market uncertainties and can also be used to reduce technical uncertainties by seeking technical solutions in the same manner. An illustration of the iterative development approach is shown in figure 4.6 below.

When involving customers, Afonso et al. (2008) differentiates between two dimensions of customer involvement, customer involvement as an information resource or as a co-developer. This section addresses customer involvement as an information resource. There are two methods when involving customers that are of particular interest: Involving Lead users and Employing Customer-visit teams.

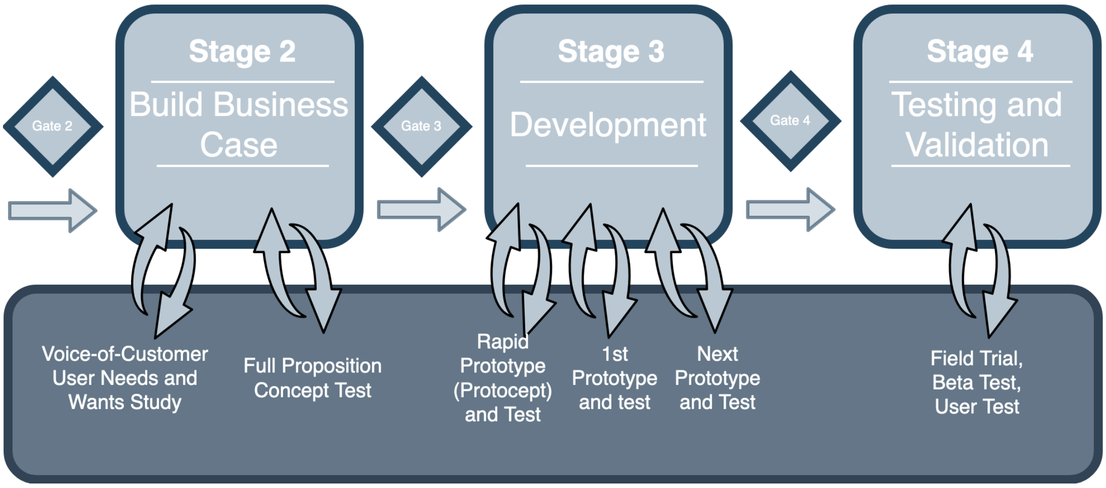

Figure 4.6: Iterative customer development as described by Cooper (2019)

Lead user Lead user involvement is a method proposed by Von Hippel (1986). It is a market research analysis that focuses on involving users whose present strong needs will, in future months or years, become general for the rest of the market. Lead users are to be familiar with conditions that lie in the future for most other users and serve as a basis for forecasting (Von Hippel, 1986). The insights and feedback from lead users may also serve to provide new product concept and design data (Brockhoff, 2003).

Brockhoff (2003) means that as lead users benefit from meeting their needs, they frequently find solutions by themselves, solutions that the development team subsequently might incorporate into new products. However, there is always a cost to consider for the lead user to be involved in a development project, despite standing to benefit significantly from product improvements they propose (Brockhoff, 2003). Lead users will likely expect a reward to cover eventual costs, and customers with a strong and trustworthy relationship are more likely to risk getting engaged and commit in this stage (Brockhoff, 2003).

Customer-visit teams Customer-visit teams is a method where teams visit customers and conduct in-depth interviews based on carefully formed interview guides (Cooper & Dreher, 2010). Interviews are conducted to uncover user wants and needs for new products. In practice this means that customer sites are identified, an agreement for a visit is obtained and the interviewers arrange for a small group of customer representatives to be present (Cooper & Dreher, 2010).

The recommendation to obtain the best quality data of the customer wants and needs, problems, points of pain, and suggestions for new products are to not outsource this research, but to involve the product developers in it (Cooper & Dreher, 2010). This method also works well in conjunction with the lead user method.

4.2.3 Quality of Execution

One of the most effective ways of saving time in NPD is ensuring quality-of-execution reducing the risk of cycling back to redo tasks more than once (Cooper, 2019). Poor quality-of-execution is a common occurrence in NPD that top performers avoid by ensuring that employees are capable and trained, have sufficient management mentoring and support, have time available to do a quality job, and through adopting a clear standardized NPD process with clearly staked out R&Rs (Cooper, 2019).

Another factor contributing to quality-of-execution is effective knowledge management, by retaining knowledge within the organization and reducing the risk that mistakes are repeated.

Capable & Trained People

In order to attain motivated employees who are capable of doing a quality job, an organization should always strive towards enhancing their employees' capabilities (Dombrowski & Zahn, 2011).

Employee capability can be enhanced by ensuring that employees receive adequate theoretical and practical training and by adopting methods such as qualification profiles (e.g. qualification matrixes), training-programs (e.g. job-rotation) and training in state-of-the-art technology (Dombrowski & Zahn, 2011).

Employee motivation can be enhanced by increased employee autonomy, feedback meetings, and support from designated mentors (Dombrowski & Zahn, 2011). A crucial element for employee motivation is to give all employees an opportunity for individual long-term career-path planning. A long-term career-path should not force employees into a management position; therefore it is advised to offer engineers the opportunity to make career as a specialist in their department (Dombrowski & Zahn, 2011).

An equally important part is the corporate culture (Dombrowski & Zahn, 2011). An organization should strive towards having a culture that holds the assumption that mistakes occur due to systematic errors rather than intentionally by employees or individuals' shortcomings. This helps employees to feel more encouraged to point out errors and contribute towards common goals (Dombrowski & Zahn, 2011). An organization should also strive for a culture of a serving-leadership, which assumes that as the employees spend the most time with the work they perform, they also are the most knowledgeable in their corresponding areas. A leader's responsibility is to set targets, support and motivate employees to reach those targets, and avoid involving themselves on a detailed level, interfering with the employee's work (Dombrowski & Zahn, 2011).

Standardization

Unclear definitions of processes, R&Rs, and working methods often lead to improvisation and inefficiencies which risks leading to errors, that in turn consume unnecessary time and resources. Standardization reduces uncertainties and provides clarity for the employees (Dombrowski & Zahn, 2011).

Standardization is achieved by having a clear description of the NPD process, its inherent stages and the deliverables associated with those stages. Preferably, each deliverable in the NPD should have its standardized procedures, methods, tools, documents and working instructions (Dombrowski & Zahn, 2011). Also, the R&Rs and their associated deliverables should be fixed. The work methods (e.g. construction methods) should be standardized, coordinated with suppliers, and kept state-of-the-art. Work standards should be managed in a way that all employees always have access to them and know where to find them(Dombrowski & Zahn, 2011).

Apart from being standardized, an NPD process must also be flexible and adaptable enough to fit the differing needs of different projects (Cooper, 2019; Dombrowski & Zahn, 2011). Customization can be achieved by e.g. waiving deliverables according to the needs of the project or by adopting what Cooper (2019) refers to as a scalable process, having one "normal" process for major projects, as well as a "light" and "express" process for minor projects of lower complexity.

A central shared IT system should be in place, an IT-System that permits project team members sharing project information and allows project team members to work effectively together, across functions, locations, and even countries (Cooper, 2019). The software should be able to assign responsibility for methods and documents and enable routine tasks through automated workflows (Dombrowski & Zahn, 2011).

Knowledge Management

To avoid unnecessary regeneration of knowledge and develop capabilities, employees' knowledge should be managed, preserved, and shared throughout the organization. Knowledge management is the identification and utilization of knowledge to gain a competitive advantage (Schiuma et al., 2012).

There are three dimensions to knowledge management; knowledge capture, knowledge transfer and knowledge creation (Nonaka et al., 2000). Knowledge capture and transfer lead to increased efficiency in the NPD process while knowledge creation is what drives innovation, a key driver in market performance (Nonaka et al., 2000; Schulze & Hoegl, 2006). Knowledge management can be said to consist of knowledge processes and infrastructures, in other terms the capabilities and management activities that a company undertakes to support and improve the transfer and generation of knowledge (Schiuma et al., 2012). To be effective in knowledge management, clearly defined processes for capturing both good and bad design insights is necessary as well as low barriers for entering, retrieving and updating data (Brown, 2007).

According to Nonaka (1994) there are two types of knowledge: explicit and tacit. Explicit knowledge is knowledge that is transmittable in formal and systematic language and can be shared in form of data of various types (Nonaka, 1994). Tacit knowledge is deeply rooted in action, procedures, routines etc., and has a personal quality to it which makes it hard to communicate and formalize (Nonaka, 1994).

Pitt and MacVaugh (2008) state that effective knowledge management needs to acknowledge that knowledge is deployed at multiple organizational levels and support production, elicitation and exchange of tacit as well as explicit knowledge as well as accommodating and enabling both informal and formal knowledge processes. Knowledge management is a work in progress and should be treated as such by integrating a holistic view of knowledge management in the organization, utilizing the technical, social and cultural processes within (Pitt & MacVaugh, 2008).

Goffin and Koners (2011) state that focus on capturing tacit knowledge may be the more effective approach in NPD. Individuals working on NPD develop knowledge that is subsequently applied to later projects. Much of the knowledge that is generated in NPD is tacit; being difficult to express and is connected with problem solving and team interactions (Goffin & Koners, 2011). The learnings that NPD personnel perceived to be the most important were according to Goffin and Koners (2011); dealing with project budgets, problem solving, coping with time schedules and coping with changes in product specifications. All factors closely related to TtM-reduction.

Some methods for effective knowledge management are wikis for the exchange of knowledge, workshops for transfer of tacit knowledge into explicit knowledge, and lessons-learned documentation (Dombrowski & Zahn, 2011).

5

Empirical Findings & Discussion

This chapter will present the empirical findings of this thesis. As interviews were conducted, three main themes of challenges emerged: Prioritization and Focusing of Resources, Frontloading and Quality-of-execution.

The findings in these three categories of challenges will be presented in this chapter, along with discussions of those findings.

5.1 Prioritizing and Focusing of Resources

This section will address resource utilization & availability, and how the prioritizing and focusing of these affect the development projects. The findings will be discussed from the perspective of categories Overburdening of the Organization, and Unclear Prioritization between Projects.

5.1.1 Overburdening of the Organization

> "We are often too few in a project to have the resources to keep up with the project plan. This causes some deliverables to be stressed through and become half-hearted."
> - Member of core development team

Resource availability has been expressed by many interviewees as a general problem. A common theme is that interviewees experience their function as very constrained, especially the supporting functions. These functions are according to their own statements scheduled for a very high utilization, which is in line with the observation discussed in 4.2.1 - that most product developers opt for resource efficiency in favor of flow efficiency and inadvertently overburden their organization by conducting too many projects for the resources available (Cooper, 2019; Reinertsen & Bellinson, 2014). This has the consequence of loading the organization to very high utilization levels, making projects suffer from a lack of time and financial commitment.

The typical consequences described by Cooper (2019) are a lack of VoC research, inadequate front-end homework, and ineffective launches - all of which have been stated to apply to HCP as well. This gives further support to the notion that HCP suffers from overburdening of their organization. Apart from long queues that

increase TtM, overburdening may lead to rushed through work which risks causing downstream errors and rework which have negative consequences for quality-of-execution (Morgan & Liker, 2006).
Regarding the trade-off between flow and resource efficiency, in the context of strictly achieving a short TtM, a high flow efficiency is always the most favorable (Reinertsen & Bellinson, 2014). However, the flow versus resource efficiency trade-off (illustrated by figure 4.5) is connected to the trade-off between TtM and PDE (shown in figure 4.3). A high flow-efficiency necessitates excess capacity in terms of resources, which incur additional PDE, making the flow versus resource efficiency trade-off more complex.

However, if achieving a short TtM is the main objective, either increasing resource availability in strained functions or reducing the number of simultaneous projects in the organization to allow for some excess capacity (a "capacity cushion", as described by Wheelwright and Clark (1992)) is likely to contribute towards that objective.

> "HCP does not have enough resources to follow the PCP like the rest of the HG does - so certain deliverables have to be excluded - which can make the process difficult to follow at times."
> - Manager

Apart from the aforementioned strategical issue of how much to load the resources that HCP have; the interviewees have made it clear that the total resource availability at HCP is insufficient to fully adhere to the PCP that they are instructed to abide by - which further exacerbates issues stemming from overburdening.

Interviewees have explained that as HCP lacks sufficient resources to abide by the PCP some deliverables are merged, tweaked, or stressed through to keep the project on schedule. This in turn contributes to an unclear process that is difficult to grasp, which has implications related to quality-of-execution presented in section 5.3. While the merging and tweaking of deliverables on its own is not be a problem, doing so to bridge a resource deficiency is.

Overall, insufficient resources seemingly are a cause of some problems at HCP when abiding by a process that is less suited to their conditions. The argument for the shared process is that it facilitates standardization across the HG as a whole, which is sound, but locally at HCP it seems that it to some degree hampers quality-of-execution.

5.1.2 Unclear Prioritization Between Projects

> "There is a very wide range of products and projects to prioritize, and a lack of an efficient prioritization system. We should prioritize and reduce the project portfolio to only go for the vital few."
> - Manager

Interviewees have made it clear that the current prioritization system at HCP does not serve its purpose. The system itself is described as complicated and is said to be causing a situation with too many high-prioritized projects running at the same time, making the prioritization system somewhat diluted. Also, changes in the priorities are said to happen too often - which hurts the flow as getting up to speed in new projects take up much time and effort (a stop & go effect).

In light of this, it is likely that HCP would benefit from restructuring their prioritization system, simplifying it. Also, being more conservative with handing out high levels of prioritization for projects would be beneficial. A more conservative approach would counteract the dilution of the system as well as reducing the risk of prioritizations changing during the course of a project.

5.2 Frontloading

This section will present and discuss findings related to the pre-development work at HCP. On this topic incomplete, changing, product specifications and insufficient pre-studies have been described as two of the main issues. Interviewees have also expressed a desire for further involvement of customers in the NPD process, specifically through prototyping and field testing. The topics that will be presented and discussed in this section are: Insufficient Pre-development Efforts, Insufficient Prototyping, and Lacking Customer Involvement.

5.2.1 Insufficient Pre-development Efforts

> "The product specification is not quite finished at the start of a project. We know the technology, but we don't know the market, so we start guessing what the customers want. There is a need for more market research when doing the product specifications."
> - Member of core development team

A component that has often been pointed out as a contributor to delays is incomplete product specifications. The product specification includes both technical and market-oriented elements such as market & user requirements, user insight & research, stakeholder requirements specification, system requirements specification, Engineering Bill of Materials draft and a technology readiness level assessment.

The main issues raised are that the product specification is too general with underdeveloped market & user requirements, business case, and technology readiness level assessment. These are all key factors in achieving NPS. Interviewees have suggested that a lot of revisions and rework could have been prevented or mitigated by a more comprehensive and thorough product specification. This view is strongly supported by Cooper (2019), Dombrowski and Zahn (2011), who claim that a well-defined product specification is one of the key drivers in reducing TtM.

The product manager, who owns the responsibility of most of the market-oriented tasks, experiences a general lack of resources and a very broad product portfolio to manage, leading to in-depth knowledge on all aspects of every product being infeasible. In comparison to the whole project length, very little time is spent on the product specification, with the admission by the product manager that more time probably should be spent there. The issues with the market-oriented elements of the product specification are not surprising considering the breadth of products managed, and the relative scarcity of resources for the individual product specifications that follows. The most reasonable take on this problem, within the scope of the thesis, is to consider alternatives to alleviate the shortage of resources by involving customers to a larger degree in the NPD, which will be further elaborated in 5.2.3 below.

> "It can be a stress factor and a source of irritation for project managers to change specifications, but at the same time you have to be a little bit agile. If you do not change the specification during the project, products risk obsolescence."
> - Manager

Apart from being incomplete form the start, changes in the product specification throughout the project has been mentioned by R&D and PMs as more or less of an issue. These findings are in line with what Cooper (2019), Dombrowski and Zahn (2011) state, that scope creep and instability in the process are outcomes of incomplete product specifications. Changes have to be made sometimes, as a project is a dynamic process, which is agreed upon - but to what extent changes are made or the reason for them is where opinions differ.

Compliance has mentioned that changes do happen, but for their part are mostly related to new markets being included as late additions. This leads to an extra work burden for both Compliance and R&D, as identifying standards and regulations and adapting to them on new markets is time consuming, more so the later the addition is. The product manager does not entirely agree that changes in the specification happen too frequently. The product manager's view is that changes do happen, but mostly because of a necessity to cope with market and competitor dynamics. While the product managers view probably holds true, it is also likely that some excess changes happen due to the aforementioned product specifications being weak or incomplete, and not entirely due to external factors.

Formally at HCP, the product specification should be a result of the pre-study in the PCP. The tasks that are part of the pre-study in the PCP corresponds well to what Cooper (2019) calls 'the front-end homework' and is an integral part of the frontloading concept described by Dombrowski and Zahn (2011).

The interviewees have explained that pre-studies are not regularly performed at HCP, having only been conducted in two previous projects. In the absence of formal pre-studies, the tasks in the pre-studies have in one way or another been incorporated into the formal NPD process instead. From the employees' perspective the pre-studies have been seen as an overall success, but not including the market-oriented aspects has been viewed as an oversight. In the cases where pre-studies have been conducted, interviewees have indicated that they have been unbalanced in favor of the technological aspects of the pre-study, foregoing market-oriented tasks. This is a common tendency but is (as described in 4.2.2) usually linked to lower NPS (Cooper, 2019). Top-performers in terms of NPS exhibit a balance between technology- and market-oriented tasks in their pre-development work (Cooper, 2019), supporting an argument that HCP might stand to benefit from trying to incorporate more of a market-oriented focus in their pre-studies as well.

> "Pre-studies won't save time but will save a lot of resources. In a pre-study there are not as many people involved, so it's a very resource efficient way to kick-start a project. The input from the pre-study clarifies a lot of issues and lead to a better product specification. Also, the time-plan for the project becomes more accurate which prevents delays, and the product becomes more aligned with market demand"
> - Member of core development team

It is uncertain to what degree conducting pre-studies would reduce TtM for HCP. While the effect further pre-development work has on reducing TtM is strongly supported by literature, and especially by Cooper (2019), a general perception voiced by the interviewees is that moving tasks from the formal NPD to a pre-study could simply be a way of fiddling with the numbers, where the total TtM would add up to the same in the end. However, the interviewees present a uniform expectation on the outcome of pre-studies, which is that while they might not save any time for the total project, having the elements of the pre-study done before the NPD process consumes considerably less resources while at the same time streamlining the rest of the process and providing higher product quality. Several interviewees have stated that it is not resource efficient at all to conduct the deliverables from the pre-study in the formal NPD process, as it disturbs the workflow.

It is, however, not unlikely that enforcing pre-studies for each and every project would require a ramp up-period. If implementing pre-studies for all new projects overnight, it is likely to initially cause a surge in resource demand which would put further strain on the organization, but would lead to a leaner, more effective organization in the long run. As discussed in 5.1, the cause for a lack of pre-studies might be that HCP undertake too many simultaneous projects. If so, the resources to fund more frequent and thorough pre-studies initially could be derived from reducing the number of simultaneous projects.

Overall, the empirical findings and the literature study provides support for HCP benefiting from allocating more time and resources towards their pre-studies as this would enable producing more complete product specifications and reduce the risk for unnecessary iterations.

5.2.2 Insufficient Prototyping

> "More prototypes in the beginning would help. You should not skimp on multiple iterations of prototype loops"
> - Member of core development team

Prototyping has been highlighted by interviewees as an effective way to convey understanding of a product and exposing potential issues early. As of now, some interviewees believe that insufficient time and resources are spent on prototyping, making eventual issues come to surface unnecessarily late in the NPD process. As the product architecture at HCP is highly integrated, changes in one part of the product is likely to lead to changes in design on other parts as well. Therefore, performing changes early, as opposed to late, has far less of an impact on the amount of work revisions.

To bring changes to surface at an earlier stage and alleviate the detrimental effect they have on TtM, HCP could benefit from adopting a more iterative development approach by involving customers early in build-test-feedback-revise iterations to expose flaws and make needed adjustments long before tools are ordered, or an engineering pilot built.

5.2.3 Lacking Customer Involvement

> "We are bad at getting out and interacting with customers prior to the product specification. It is done sometimes, but not often enough."
> - Member of core development team

Interviewees from R&D and a PM have expressed a desire for visiting customers more often and performing additional testing in the field. The involvement of customers in the NPD is not being carried out to any meaningful degree at this time and it has been stated that customer visits are too few which R&D, as well as the product manager, would likely benefit from doing more often, were it not for resource constraints.

Involving customers in the NPD process has shown, as discussed in 4.2.2, to lead to greater NPS and a shorter TtM (Chang & Taylor, 2016; Cooper, 2019; Datar et al., 1997; Pawar et al., 1994) and employing customer visit teams and involving lead users, as mentioned in 4.2.2, are two of the most successful ways of doing so (Brockhoff, 2003; Von Hippel, 1986). Lead users would in part serve as a market research source, thereby contributing to the product specification and reducing the aforementioned lack of resources for the product manager, as stated in 5.2.1.

> "I want to emphasize the importance of field tests, where they are used in real life settings by people who use similar machines daily. Issues always arise when the machines are tested in the field. I don't know how it should be arranged, but it would be great to have more field tests."

- Member of core development team

Lead users and customer visit teams do not specifically target field testing, but they could serve as a platform for that opportunity. In HCP's case, with limited resources but with a cohesive product catalogue, settling for a customer, preferably one, could be both an opportunity and a necessity. It is reasonable to assume that one customer, e.g. a large construction company, has the opportunity and possibility to use the whole range of products offered by HCP. Tying in such a customer and involving them through field testing could be very beneficial for both involved parties.

Employing customer visit teams, involving lead users, and conducting field test on-site, with the possibility of interacting with the users of the product, would allow R&D to receive valuable market insights and has the potential to be very beneficial for aligning the NPD at HCP with actual market demand, and thereby increasing NPS.

5.3 Quality of Execution

This section will address quality-of-execution, and how a lack in standardization and cross-functional integration affect the development projects. Some periphery topics such as the PPAP and lack of knowledge management concern is also included. The findings will be discussed from the perspective of the following categories: Lacking Standardization, Slow IT Systems and Unstructured Data Storage, Imperfect Cross-functional Integration, Absence of the Product Quality Function, Missed Compliance Requirements.

5.3.1 Lacking Standardization

> "Since we lack certain processes and since some processes are quite messy, you have to be at HCP for quite a long time before you understand how everything works."
> - Member of core development team

The empirical findings suggest that the PCP can be somewhat unclear for the employees at HCP. As the PCP isn't perfectly suited to the conditions at HCP as it is (presented in 3.3, the process must to some extent be tweaked. On top of that, the PCP needs to adapt to the differing needs of different projects, as presented in 4.2.3. Therefore, as the PCP is tweaked both to fit the general conditions at HCP as well as to fit the requirements of specific development projects - it can be difficult to grasp for employees.

Adaptation of the process is enabled by very general deliverables that don't enforce any strict work methods, as well as by giving PMs autonomy to adapt the process by e.g. tweaking or merging deliverables. Major interventions in the PCP, such as completely waiving deliverables, are also possible but must be accepted by a steering committee.

Interviewees have stated that the degree of reliance on the PCP varies much between PMs, where less experienced PMs tend to adhere to the PCP more strictly than more experienced counterparts. The interviewed PMs have said that it is their ambition to adhere the PCP as stringently as possible, while at the same time expressing that "you cannot be a slave to the PCP", and that a too strict adherence to the PCP would prolong projects and affect TtM negatively. As an example, one dimension of the PCP that can be tweaked in favor of a faster TtM is the sequence in which the PCP prescribes deliverables to be conducted. One PM has described that in some cases deliverables are started in an earlier stage than what is described in the PCP, and thus started working on the next stage before the current one is finished - and in effect overlapped whole stages - a measure that has support from Cooper (2019) as a pragmatic way of reducing TtM. However, such an action is a product of experience, rather than being inherent to the process, meaning that it doesn't indicate a strength in the process itself but rather lends credence to the degree of autonomy afforded to PMs in finding their own way.

Overall, interviewees agree that the possibility to depart from the PCP is a positive thing - as it provides flexibility and speed to a project - but the drawbacks are that the process may look different between projects and PMs, which adds unclarity. In conclusion, HCP would probably not benefit from enforcing a stricter adherence to the PCP, but rather educating employees in the process and more clearly communicating departure from it to everyone involved.

> "A clearer description of roles and responsibilities at HCP is needed. Everyone does a little bit of everything today."
> - Member of supporting function

The R&Rs are experienced as somewhat vague or unclear. Much autonomy is granted to the individual employees to define their own roles. In addition, the currently available R&R documentation isn't adapted to the organization at HCP. This has contributed to the borders of responsibilities becoming vague. It has been described as co-workers often crossing borders to help each other out, so that "everyone does a little bit of everything", which both risk causing some tasks to fall between the cracks, while other tasks might be done twice. However, helping and cooperating in itself would be considered a strength, but the uncertainty of to what extent and where to help is not.

As mentioned in 4.2.3 employee autonomy is overall positive as it strengthens motivation and enhances development - while on the other hand, as described by (Dombrowski & Zahn, 2011), unclear R&Rs is very negative as it causes inefficiencies that in turn consume unnecessary resources and risks leading to errors. The literature and the empirical findings both suggest that HCP could benefit from enacting stricter R&Rs, while at the same time trying not to encroach too much on their employees' autonomy.

> "The format differs greatly in how we present schedules and how requirements and product specifications look. For a designer who works in different product types, it can be difficult to understand different formats and how they look."
> - Member of core development team

As previously mentioned, flexibility in the PCP is enabled by deliverables that are very general and lack strict work instructions. This is mainly an advantage, but it has also been proposed that the lack of standardized work methods might entail some drawbacks such as inefficiencies and enhanced risk for errors.

Interviewees have explained that items such as drawings, specifications or time-plans can look very different depending on who has done them - and that there is a general lack of "Husqvarna way" of doing things. A specific deliverable may sometimes be done in excel, while other times in word, e-mail, or another format. This has been expressed as especially problematic by the supporting functions, as for these functions it can be extra time-consuming to go through drawings, specifications or other documentation when formats differ depending on who has made them, with a certain lack of common theme. It has also been stated that the lack of a standardized format or templates sometimes can cause some constituents to be missed or overlooked.

While some interviewees strongly desire higher degree standardization, other interviewees seem more reluctant towards the idea and are keen to explain that every project is different and that you must be able to be flexible in the way of doing things.

Overall it seems like HCP might stand to gain from a higher degree of standardization in their work methods and formats as it could contribute to higher organizational efficiency, especially for the supporting functions. The drawbacks of standardization are generally lower flexibility and decreased autonomy for the employees. Therefore, HCP have to find a sound balance between standardization and flexibility. One way of achieving this could be by developing more or less formal guidelines (a "Husqvarna way" of doing things, as expressed by an interviewee) that at least maintains the same format across the whole organization, but still gives room for some flexibility and freedom to adapt deliverables to differing needs. Specifications specifically would be the exception, where an enforced use of standardized templates likely would be exclusively beneficial.

5.3.2 Slow IT Systems and Unstructured Data Storage

> "Right now, the data availability really is a problem. The data exists, but with different people in different systems. There are many systems at Husqvarna, systems that are not well integrated. It would have helped with proper system support by common system that is utilized by all functions - a system where it is possible to track the status of a project."
> - Member of supporting function

The data availability has been described as a large problem at HCP. The data does exist, but it is sometimes unclear where and with whom. The Husqvarna Project Management (HPM) system is where relevant documentation for projects is intended to be stored. However, uploading or downloading files from HPM is time consuming which entices people towards the use of substitutes instead - effectively causing documents to end up in many different places such as e-mails, hard-drives or the cloud instead. This in turn is a cause of waste and inconvenience for the functions that need access to these documents and interviewees have indicated that time spent chasing after documents is a source of some waste.

The description of HPM as slow, with poor integration across functions and not providing a good overview of projects stands in stark contrasts to the ideal as described by Cooper (2019), which would be a central, shared, IT system that allows project team members to work effectively together across functions.

A remedy for this issue could of course be for HCP to acquire a new "central, shared IT system", but such an investment is usually a very expensive affair. A first step could instead be to enforce a higher IT-discipline - so that even if the IT-system is slow, documents and other information are stored in uniform ways, so employees always know where to expect to find certain documentation.

5.3.3 Imperfect Cross-functional Integration

> "The collaboration with manufacturing works well. The 3P workshops are great, and involve manufacturing early, which would have been enormously time-consuming without the workshops."
> - Member of core development team

The cross-functional integration at HCP has generally been described as effective across most functions, with some exceptions. One channel of interaction that has been described as highly successful is the one between R&D and Manufacturing. R&D and manufacturing have relatively recently begun utilizing a more iterative development approach trough what is known as 3P workshops, an approach where R&D and manufacturing meet in order to together evaluate the manufacturability of a product together. It is conducted through 2-3 workshop sessions at the production site in Huskvarna, and then with follow ups when necessary.

The hands-on approach is, by all involved parties, seen as an effective way of problem solving as it exposes issues early and reduces the risk of problems arising during the industrialization phase of the NPD process. The effectiveness of the 3P workshops illustrates an importance of showing and explaining in person, with speed and low barriers for the refinement and exchanging of ideas.

The exception to the effective cross-functional integration is the cooperation between R&D and GD that has been mentioned to be a source of some delays in the NPD. Much coordination is needed between R&D and GD during product design - however, the two functions are separated geographically, located in Jonsered and Stockholm, respectively. There is a perception by R&D that GD have too much authority on the final design, where design changes have to be accommodated through engineering revisions, rather than the other way around. The cooperation between the functions is of a more discontinuous, or sequential, nature as no representatives from GD are present in Jonsered - making design and engineering difficult to coordinate and achieve common ground upon. It is however not known to which degree, if any, this affects product performance or quality, but it has been noted to have a detrimental effect on TtM.

> "Design is important, but there should be a bit more focus on function as compared to industrial design. This has always been a discussion between R&D and Global Design. Now we have lost 2 weeks redesigning a hinge on which we had a working model. It would be great to have a surface designer that sits closer to R&D so that the engineers can explain why something won't work. As I said, design is an important part, but we need to work together in a different way."
> - Member of core development team

Interviewees have explained that there have previously been periods where a representative from GD, a surfer designer, has been present in Jonsered - which was said to be of great help to the coordination as changes and compromises could be worked through in real time, face-to-face. It is unclear how feasible it is to have a surface designer permanently stationed in Jonsered, as that has not been explicitly researched, but to have one semi-permanently during particularly heavy design phases could be well worth considering.

5.3.4 Cumbersome PPAP

> "The PPAP is a very time-consuming part of the project. It is very important that you ensure the right product quality, which is something that the PPAP most often does. But at the same time, it's very tedious when two months of PPAP work shows up at the end of a project, that you otherwise thought was done."
> - Member of core development team

The PPAP, further elaborated in chapter 3, has been described as cumbersome, resource consuming and bureaucratic. What makes the PPAP especially cumbersome is that it brings a heavy workload rather late in a development project and is hard to frontload. Suppliers must be selected and the design set before a PPAP can be ordered. Generally, a PPAP should be ordered (i.e. the PPAP started) for a part as soon as it is finished, however this is sometimes postponed or missed, and the PPAP is instead ordered for multiple parts when the whole product approaches maturity. Some of the times an order is postponed due to wanting to wait for other testing and certifications to be completed, at other times it is due to time pressure where more urgent matters are prioritized over ordering PPAP, and sometimes it is missed due to human factors.

PPAP-deviations occur because suppliers fail to deliver parts within tolerances or because of formalities such as missing or wrong format on documentation or test samples. The effects of deviations in the PPAP are a multitude of delays, which varies in degree of severity and how they affect other functions. If there are deviations for a specific part, a decision can be made to continue the project with it as interim approved, meaning that the part has not been fully PPAP approved but the deviation is not deemed severe enough to halt the project in waiting for the supplier to rectify it.

SQA have mentioned that there is a lack of knowledge of the PPAP as a whole, that it at times is ordered for the wrong reasons, to just have it done. This can lead to an order going for an item that is still worked on and where changes haven't yet been communicated to suppliers, or suppliers haven't had time to make adjustments themselves or provide feedback. At other times, suppliers get it wrong on their own, which is the case even with suppliers who are accustomed to the PPAP. Suppliers send in test results despite not being ready just to conform to agreed deadlines, or suppliers cannot meet the standards agreed to and backtrack on the deal to modify its contents.

Formally the PCP prescribes all parts to be PPAP-approved before the manufacturing pilot is built. However, it has been stated that it is unusual for the manufacturing pilot to be built without at least one or more parts being interim PPAP-approved. Accepting a certain number of interim-approved parts is described as a necessity on behalf of the NPD project as a whole, as it is not feasible to sacrifice valuable TtM in ensuring that each and every product is formally approved. A function that is affected by this is manufacturing. Working with interim approved parts is resource consuming for manufacturing, as non PPAP-approved articles are not sourced through the HG's material planning and thus requiring a more time-consuming and ad-hoc sourcing process. Interim parts also give cause to extra revisions for manufacturing as the production system is adapted to parts that might be off-tolerance and may be slightly revised after PPAP-approval.

As the cause for some delays in the PPAP process can be attributed to human factors and unclear definitions for the R&R involved, a viable means to reduce these deviations might be further standardization of the process. Also, standardizing the interfaces for communication between SQA and R&D, by e.g. appointing a designated team member responsible for keeping SQA updated, might be beneficial. Overall SQA have expressed a wish to be more involved in the process, to better prepare the suppliers for the PPAP. SQA does not want the final responsibility for ordering of the PPAP but rather want to be more informed of the progress to green light when they find everything ready. This approach seems reasonable, as it is far more resource efficient to act proactively in this manner, minimizing the amount of surprises. As of now the integrating work is conducted by SQA and PMs, which is an approach that seems to be evolving in the right direction.

5.3.5 Absence of the Product Quality Function

> "There are many mistakes that are repeated today. Other divisions have dedicated staff who work with lessons-learned after each phase, but it is unclear how it is done at HCP. The lessons learned should be read from previous projects, but that is not done today. The lessons learned workshops are not fun to do."
> - Member of supporting function

Formally, the PCP contains deliverables that manage the furthering of knowledge and competence within project groups and across functions. However, the functions who owns the responsibility of these deliverables, the product quality function, is not represented at HCP with the result that the deliverables are delegated to other functions which could lead to a lack of continuity in executions.

The aforementioned deliverables are present in all stages of the formal NPD process and are at HCP usually absorbed and performed by the PM. Most often these come in the form of lessons learned-documentation, summarizing learnings for intended future use and are usually merged into fewer lessons-learned workshops. Looking at the process description and intended outcomes for the lessons-learned they would likely be productive if included and engaged with enthusiasm. However, many testify to having participated in writing lessons-learned documentation but have seldom read such documentation produced by others. It is expressed that the lessons-learned deliverables mainly are a bureaucratic procedure that is done simply because they are included in the PCP, and when lessons-learned documents are shared, it is usually by chance or in an informal manner. For example, a PM might ask another PM for their lessons-learned documentation from a previous project.

As stated by Goffin and Koners (2011), capturing knowledge and tacit knowledge in particular, is related to problem solving, managing time pressure, and coping with changes in product specifications. This supports the case for a more formalized and structured knowledge management system. Dombrowski and Zahn (2011) mentions the personal development as a crucial part of employee motivation, where a formalized knowledge management system would be a key component in achieving further skill enhancement of employees.

The risks HCP face is repeating mistakes, doing the same work twice, not catching up on best-practices and missing opportunities to synergize with other departments with similar products. However, synergizing with other departments has been mentioned to be unfeasible for certain products as the differences in produced volumes makes it uneconomical for either party to adjust and adapt products to fit the needs of both. Despite this, there are products that are likely to benefit from closer knowledge sharing between departments, especially the power cutter section. Finding common articles or components in the IT-systems when developing products has been described as "finding a needle in a haystack", accentuating a possible need of easy identifiability in the IT-systems.

The risk of repeating mistakes is less of a problem within the individual project teams, but more of an issue cross-product or cross-division, where the flow of information has been described as poor. In order to improve this flow of information employees have expressed wishes or raised ideas around partaking in meetings with other project teams, show-and-tell of products where solutions to particularly challenging problems are presented or simply to exchange lessons learned in a more structured manner. These initiatives have not been met with enthusiasm and requests have not been positively received. The negative responses may come from being perceived as a nuisance or perhaps because of insecurity in being observed when working. Interacting more with other project groups could be mutually beneficial and would be a way of enhancing cross-product learning.

5.3.6 Missed Compliance Requirements

> "We have our own requirements to adhere to and it is quite easy to miss some of them, even if you are experienced. Such a miss is often only noticed at the absolute end of a project when the product is to be certified. This directly affects the project plan - there is no leeway when you detect problems that late.
>
> To fix this it would have been good to have some kind of review of the product by those who have not worked with it directly, as you easily become blind when you have been working with the product for a long time. Maybe an internal audit function, checking up on the standard, or maybe some kind of external cooperation. Problems with compliance occur quite often in the review phase. Early in the project it may be a trifle to fix, but towards the end of a project it is a huge job."
> - Member of supporting function

Compliance conformity is crucial when developing products but is a difficult field to navigate as the products are intricate and complex, where small changes in design may lead to non-conformity, which makes changes a nuisance. There have been cases where compliance deviations have caused large delays in a project, but the norm is rather that such issues are small but persistent and discovered too late, when most of the work is completed.

To reduce the occurrence of such issues an interviewee has proposed a product review by an outside party who has not been involved in the project, a party that could be either from HCP internally or possibly even an external party from outside of the organization. The rationale is that having a fresh set of eyes with no biases in regard to the product design might better discover non-conformities when scrutinizing the product. It stands to reason that this might be a viable solution, as the resources consumed for such a control might very well be offset by the resources saved at the end of the project.

Measures have also been taken by other means, as a compliance checklist has been introduced by one PM in cooperation with the Compliance department, where both parties are positive and hopeful to its future effect but where no conclusion as to its effectiveness can yet be drawn, because the project is still ongoing.

5.4 Summary of Findings

Altogether 11 distinct challenges were identified. These are presented in table 5.1 below. Suggestions for how to best manage these challenges will be presented in the next chapter.

Empirical Finding	**Category**
Overburdening of the Organization	Prioritization and focusing of resources
Unclear Prioritization between Projects	Prioritization and focusing of resources
Insufficient Pre-development Efforts	Frontloading
Insufficient Prototyping	Frontloading
Lack of Customer Involvement	Frontloading
Lacking Standardization	Quality of execution
Slow IT Systems and Unstructured Data Storage	Quality of execution
Imperfect Cross-functional Integration	Quality of execution
Cumbersome PPAP	Quality of execution
Absence of the Product Quality Function	Quality of execution
Missed Compliance Requirements	Quality of execution

Table 5.1: List of empirical findings

6

Recommendations

Based on the literature review and the empirical findings, the following list of recommendations have been derived. The recommendations represent areas where improvements can be made for TtM in particular, as well as NPS in general.

6.1 Prioritizing and Focusing of Resources

What will be presented in this section are principles, methods and tools to assure that projects have ample resources to enable a fast, high-quality NPD process.

6.1.1 Reducing the Number of Simultaneous Projects

To reduce TtM, HCP should reduce their project portfolio and the number of simultaneous projects in the organization. This would allow for some over-capacity in terms of resources and enable HCP to cease planning for a 100% resource utilization. This would focus more resources towards the truly deserving projects and reduce the impact of contingencies.

As a trade-off between resource and flow efficiency exists, focusing on fewer projects should contribute to reduced TtM, but higher PDE per completed project. Deciding on the most favorable balance between flow and resource efficiency (or TtM and PDE) would require further quantitative analysis, but in the context of reducing TtM opting for a higher flow efficiency is always more beneficial.

A larger resource availability would enable HCP to abide by the PCP to a higher degree, allocating more resources to the pre-development, and increasing NPS.

6.1.2 Stricter and Simplified Prioritization System

A clearer prioritization of projects and their importance is advised. Also, HCP is recommended to be more conservative in classifying projects as of high prioritization, to counteract dilution of the prioritization system. When being involved in multiple simultaneous projects, there should be an easy-to-understand prioritization system in place that ensures that efforts are focused towards the most deserving projects.

6.2 Frontloading

HCP is recommended to focus more resources towards the front-end of their NPD process. What will be presented are three method and tools to shift towards a more frontloaded NPD approach.

6.2.1 Start Using the Pre-study Format Already Available

Strongly recommended is allocation of additional resources to start using the pre-study format that is already part of the HG's PCP. When conducting pre-studies, it is advised to not omit any part of the pre-study concept, to achieve balance between market-oriented and technical aspects. In other words, the pre-studies should include both a thorough market study, as well as a full technological assessment to ensure the product specifications that stem from pre-studies are fulfilling their purpose.

The end-result of the pre-studies should be a stable product specification that serves to counter-act scope creep and unnecessary changes.

Additional resources for pre-studies should be seen as mid- to long-term measure, as it initially may require additional resources that HCP may not have. However, more resources allocated for pre-development would reduce waste and save resources in the long run and thus has the potential to significantly reduce TtM.

6.2.2 More, Earlier Prototypes

More, early prototyping is recommended. As prototyping is a way of uncovering problems and refining solutions in the early phases of NPD, they are an effective means to frontload the NPD process.

Also recommended is exposing these prototypes to customers early on, to receive feedback from outside sources with practical knowledge of how the products are used. Doing so would allow for an effective incorporation of the VoC into the NPD process, which should align the product better to the market and reduce the need for revisions later in the project.

6.2.3 Involving Lead Users and Employing Customer Visit Teams

A higher degree of customer involvement is recommended to be approached through involving lead users and employing customer visit teams.

Lead users should be identified and be relied upon to primarily provide market insights and to contribute with ideas and solutions on their own. Taking in regard who the typical user of HCP's products is, it is likely that a lead user is a larger contractor and therefore could be involved in the try-out of prototypes and field testing as well. In the short-term the most feasible approach is to identify local contractors who are willing to cooperate and provide feedback on products. The long-term goal should, however, be to tie in large contractors who can use HCP's whole range of products. This will likely require incentives on HCP's behalf to entice contractors to enter into close partnerships, but such partnerships should have the potential to be beneficial to both parties.

Customer visit teams should be formed of R&D personnel and, preferably, the Product Manager as well. These customer visit teams should visit customers on site to interview them to gain insights that further the understanding of how the products are used in the field. These visits provide a great forum for field testing, as well. Doing so would result in a greater understanding of the VoC which in turn enables development that is better aligned with the market demand from the start, effectively reducing the need for revisions.

6.3 Quality of Execution

What will be presented in this section are principles, methods and tools to assure quality of execution by reducing waste and minimizing the occurrence of unwanted iterations and rework.

6.3.1 Standardization of R&Rs and Work Methods

HCP are recommended to clarify the R&Rs in the organization. This can be achieved by producing an up to date R&R-documentation that clearly describes the responsibilities of the roles present at HCP and ensuring that this document is widely available for all employees.

HCP should also attempt to standardize work methods and formats to a higher degree and establish a "Husqvarna way" of doing things so that items such as drawings or specifications are easily recognizable and ensuring that constituents are not overlooked. HCP should also attempt to educate their employees on the PCP, enhancing the process knowledge in the organization. PMs should also be encouraged to clearly communicate their intended process for a project to everyone involved, so that all employees are aware of when to expect the PCP to be followed, and when not to.

While standardizing is the direction to head, it is strongly recommended to try to uphold the level of employee autonomy now present at HCP. Implementing these means of standardization would reduce waste in the organization, free up resources and reduce the occurrence of unwanted revisions and rework - altogether enabling a shorter TtM.

6.3.2 Evaluate Current IT-structure

HCP should look over their IT-systems as the current IT situation has some detrimental effects on the overall efficiency and cross-functional integration in the organization. A thorough cost-benefit analysis should be conducted to investigate if procuring an updated IT-solution is a viable investment.

Meanwhile, a stricter IT-discipline should be encouraged, to ensure that information is stored in uniform ways - so that employees will always know where to expect to find certain documentation. Doing so would reduce waste and free up resources that could facilitate further TtM reduction.

6.3.3 Co-location of GD and R&D

HCP needs to improve the integration between R&D and GD. A pragmatic way of doing so would be to have a representative from GD, preferably a surface designer, periodically available on-site at Jonsered.

During more intense phases of the product design co-locating GD and R&D would enable the iterative interplay between engineering and design to progress much faster, facilitating a higher development speed and shorter TtM.

6.3.4 Re-structuring of PPAP

It is recommended for HCP to structure how they conduct the PPAP and clarify R&R for the parties involved in the process.

This should be done by formalizing the involvement of SQA earlier and setting in place instructions that serve to involve or alert SQA on important events. This would allow them to better synchronize the process with suppliers to ensure that all things are in updated and in order for the PPAP call-off. SQA is not recommended to own responsibility for the call-off, but to be involved in the decision and review whether a part is ready for PPAP call-off or not.

Also recommended is to appoint certain members in the R&D-teams to have a more direct responsibility for the PPAP-related activities to avoid any confusion and to facilitate communication between functions, departments and suppliers.

Implementing these actions would make the PPAP more convenient and decrease the risk of delays stemming from PPAP deviations.

6.3.5 Formalizing Knowledge Management Activities

HCP should further formalize their knowledge management activities, not overlooking the deliverables that fall under the responsibility of the Product Quality function. Over time HCP would benefit establishing a Product Quality function in their own organization, as this would ensure the desired concern for knowledge management related aspects and align HCP's organization better to the PCP and rest of the HG.

HCP should also attempt to enhance cross-product and cross-project learning by encouraging cross-divisional show-and-tells of products, as well as problem-solving discussions for sharing of ideas. A workshop is a possible forum for this kind of interaction.

Finally, information on articles and components need to be more readily available and easy to find. Therefore, methods for making information more available should be investigated, in order to mitigate the risk of conducting similar work or solving similar problems multiple times. This is related to the recommendation regarding IT-systems, as a solution should facilitate easy-to-navigate archives of previously developed articles and components.

Implementing these actions would retain knowledge within the organization to a higher degree and reduce the risk of repeating mistakes or doing redundant work, which in turn would enable faster and more efficient development projects.

6.3.6 Additional Compliance Reviews

In order to avoid delays that occur due to missed compliance conformity, HCP should consider implementing compliance checks by parties external to the individual NPD teams, either from other functions within HCP or outside. As mentioned in 5.3.6, costs derived from such checks are likely to be offset by avoiding delays and additional costs caused by them.

The addition of compliance checklists that is already utilized by a PM should be evaluated when the project is finished and then possibly be implemented as a standardized measure.

6.4 Conclusion of Recommendations

The implementation of all of the recommendations simultaneously is not very feasible as it would put tremendous strain on HCP and probably be met with much resistance from within the organization. There can, however, be made some prioritization of what order recommendations should be implemented.

This section will present the recommendations from the perspective of the impact they might have on TtM and NPS in contrast to eventual drawbacks that the recommendations might entail. The section also includes some discussion on how HCP should prioritize the implementation of the recommendations. The recommendations will be presented in falling order, the most highly prioritized first. All recommendations with the corresponding issues they target are presented in that order in table 6.1 below.

Area	**Issue**	**Recommendation**
Frontloading	Insufficient pre-development efforts	Start using the pre-study format already available
Quality of Execution	Lack of standardization	Standardization of R&Rs and work methods
Quality of Execution	Cumbersome PPAP	Re-structuring of PPAP
Frontloading	Insufficient prototyping	More, earlier prototypes with customers involved
Prioritizing and Focusing of Resources	Unclear prioritization	Simpler, stricter prioritization system
Prioritizing and Focusing of Resources	Resources spread too thin across projects	Reducing the number of simultaneous projects
Quality of Execution	Imperfect cross-functional integration	Co-location of GD and R&D
Quality of Execution	Missed compliance requirements	External compliance reviews
Quality of Execution	Slow IT-systems and unstructured data storage	Evaluate current IT-structure
Frontloading	Lacking customer involvement	Involving lead users and employing customer visit teams
Quality of Execution	Absence of the Product Quality function	Formalizing knowledge management activities

Table 6.1: Summary of the recommendations and issues they target

First. Start using the already available pre-study format to a higher degree. Doing so would alleviate many of the challenges that HCP face, such as incomplete product specifications, lacking market & user insights and scope-creep during projects. As the pre-study concept has already been used and is readily available for HCP, the barriers for utilizing it to a higher degree should be surmountable. The barrier most difficult to overcome would be associated to the additional resources required to do pre-studies prior to projects. However, this effect should be offset by the enhanced efficiency that is expected in a project after a pre-study, which should free up more resources in the long run. Altogether this makes the regular use of pre-studies as the most highly prioritized recommendation for implementation.

Second. Standardization of R&Rs and work methods. Furthering the degree of standardization should entail small costs and has the potential to have very positive effects on the organizational efficiency at HCP. The standardization initiative is recommended to be approached through incremental, continuous, improvements over time - however, an immediate review of what templates (e.g. for the market & user requirements) are available should be conducted. Where there is a lack, measures should be undertaken to produce a standardized template as soon as possible. If there is no lack, but the templates are simply not used to their full capacity, means should be undertaken to encourage personnel to utilize the already available templates to a higher degree. Other more pressing matters include restructuring the PPAP by formalizing the involvement of SQA in the PPAP-call-off as well as overlooking the storage and sharing of documents and data (IT-discipline). The barriers to be expected would be resistance to change from some employees, as such initiatives can be seen as encroaching on employee autonomy. Encroaching on employee autonomy is something that should be attempted to be avoided, therefore such barriers should be mitigated by involving employees in the standardization-process, allowing them to impact their future work methods to a high degree.

Third. More, earlier prototypes are a recommendation expected to have relatively large impact at a low cost. The barriers for implementing additional prototypes should be low, as many interviewees themselves suggested such a method to reduce the occurrence of late revisions of the product design. The drawbacks of building additional prototypes would be that adding additional tasks to a project would claim additional time and resources. However, it is expected that this would be offset by a decreased risk of unwanted revisions and rework later in the project, as well as possibly a reduced needed number off engineering pilot builds.

Fourth. An additional measure that is expected to have an impact at a relatively low cost concerns an updated prioritization system. Implementation of such a recommendation would not have a very large impact on the average TtM across all projects but would ensure that the truly critical projects can expect a speedier process towards the market. The overall efficiency is expected to be somewhat increased due to less frequent switching in focus between projects. The drawback is that the gains might be at the expense of projects considered to be of less critical importance. Barriers and costs exist in the form of a learning period, with some time required to educate personnel and gaining widespread acceptance to work by the new prioritization system.

Fifth. Regarding a reducing the number of simultaneous projects, such a measure has a large potential to reduce TtM. However, the negative consequences of having fewer simultaneous projects has not been sufficiently investigated to be able to provide a clear recommendation on this topic. Reducing the number of simultaneous projects would not improve the organizations NPD capabilities per se but would trade conducting numerous simultaneous project off versus conducting fewer, faster projects. The appropriate balance of such a trade-off has to be decided by management at HCP.

Sixth. A more distributed approach for GD, with co-location of surface designers and the R&D teams has the potential to speed up the NPD in the phases with greater need for an iterative interplay between industrial design and engineering. However, there are strong arguments for a concentrating the GD personnel as well. The GD function's main purpose is to ensure coherence in industrial design across the Husqvarna brand, and the functions ability to do so is enhanced by a concentrated approach, by being in close vicinity to other representatives from GD. Therefore, the recommendation is to attempt to gain the best of both approaches, with periodical co-location of GD and R&D at intense phases. Barrier and costs for implementation would be increased travel, especially for GD personnel - which might be met with resistance

Seventh. Additional compliance reviews is a notion raised that is likely to contribute to time saving in the NPD. While it might add more work to the NPD process, it probably will decrease the likelihood of delays, in effect reducing TtM. An external party to the project team is proposed, but as to who in particular should conduct the reviews is unclear. It warrants further research and analysis from HCP. There are costs involved with conducting such reviews, but which probably should be offset by saving time avoiding delays. Likewise, should time spent on the review in the end be negated by avoiding delays.

Eighth. Evaluating the IT landscape. A functioning IT-landscape is important and would serve to facilitate the cross-functional integration and enhance coordination in NPD projects. However, updating the landscape is probably so costly and time-consuming that it may not be an immediate priority. Despite the costs, it is well worth considering as a longer-term measure. Therefore, a cost-benefit analysis of procuring an updated IT landscape should be conducted, eventually.

Lastly. Some less urgent recommendation includes involving lead users, employing customer visit teams, and formalizing the knowledge management activities. While the specific measures of lead users and customer visit teams are less urgent, there is no need to delay finding local contractors to try-out products, field-test and provide feedback. All of these actions will however contribute to enhanced competitiveness and should be implemented at some point but are not of the most pressing concern.

7
Final Remarks

This chapter will include some final remarks on the study that has been conducted. The chapter is commenced with a general discussion regarding the research method, followed by a summary of the thesis' contribution to the research. The chapter is then concluded with some general thoughts on HCP as an organization.

7.1 Thoughts Regarding the Research Method

This master's thesis was conducted as a case study, focused on NPD at HCP. The thesis was first scoped to only include the formal NPD process, and the goal of the thesis was to reduce TtM, defined as the time elapsed between two deliverables in the NPD process - project kick-off and start of production.

The initial proposed methodology was a mixed research approach combining both quantitative and qualitative data through performing a so-called value stream mapping of HCP's NPD process. Value stream mapping includes the formation of a current state map, in which a process's information flow and lead times is mapped, investigating where waste such as waiting or unwanted iterations occurs, in order to enable analysis and the proposal of improvements in the shape of a so-called future state map. However, due to the covid-19 outbreak of the spring 2020 which led to a change in circumstances to conduct the research, the approach was abandoned. There were restrictions imposed on visiting the office and who you could meet which prevented following the employees in their daily work and data collection by being on site. Another issue was a general unavailability of sought data and specifically lead times for certain deliverables. Had the original approach been possible, a deeper and more specific research on the causes for prolonged lead times in the NPD would have been possible, allowing for more targeted and precise recommendations.

To get around the limitations, a more qualitative approach was undertaken, seeking for more general challenges while conducting the interviews. The interviews enabled the interviewees to elaborate on areas they considered important to the purpose. Interviews via video link instead of face-to-face was a further hindrance, to some degree losing detail and resolution in the interviews. Follow-up interviews were sought for with the functions deemed to have the most insight to provide, but only conducted with SQA and PM 1, due to not receiving any response from other interviewees who were asked. This did probably not affect the results and recommendations to any greater degree but would likely have been helpful in pinpointing certain aspects.

Structured interviews could have been used to capture a more structured data set. This would have made it easier to codify and quantitively analyze the data (Bell et al., 2018). However, as this research was more of a seeking nature where general challenges as well as suggestions for how to manage these challenges was sought, semi-structured interviews were seen as the best choice. Another intended method that could have added value to the study, which were prevented by the covid-19 outbreak, were focus groups. Using focus groups could have increased the amount of qualitative data, enhancing the understanding of conflicting as well as aligning goals between functions and further enhanced the involvement of HCP in the study.

In total, representatives from seven out of the ten functions involved in NPD at HCP were interviewed. This allowed for multiple perspectives to be represented in the study. The functions that were not interviewed were Spare Parts, GD, and Brand & Marketing. Spare Parts' and Brand & Marketing's influence on TtM were regarded as having little or no impact on the NPD and contact was never recommended by other interviewees. In retrospect it would probably have been a good idea to include the perspective from GD, as one of the main findings was the that integration between R&D and GD did not work satisfactorily.

As the research progressed it became evident that the time elapsed in the formal NPD largely depended on how the preceding steps had been conducted, in particular the pre-development efforts. It also became evident that a co-dependence between the determinants for NPS, namely TtM, product quality and PDE, exists. In the context of reducing TtM, improvements in either of the determinants for NPS could be deemed desirable as such improvements would provide the conditions for a more weighted focus on TtM while keeping all else equal.

Therefore, the scope of the thesis was changed to also involve the pre-study at HCP, and the aim changed to reducing TtM and improving (or at least maintaining) overall NPS, rather than strictly focusing on reducing TtM.

7.2 Contribution to Research

The findings of this case study largely concur with what is presented in contemporary research regarding what typical challenges product developers face and what areas to target in achieving a reduced TtM. Therefore, the study contributes, to some degree, to the validity of the previous research.

There has been little previous research of a practical nature, as there is no set of instructions for how to effectively implement many of the principles, methods and tools suggested in literature. This study helps filling that void by providing a pragmatic set of recommendations and, with the help of input from individuals working with NPD in practice, evaluating the feasibility of the recommendations.

A weakness in the contemporary literature is that it does not provide any unambiguous guidelines for how to prioritize the vast array of principles, methods and tools it proposes. This thesis aims to contribute with a suggested prioritization order, that is believed to be effective, at least for the case company. While this ambiguity the literature presents does likely serve a purpose, as the context for all companies differ and recommendations are to some degree company specific, it still believed that the learnings from this case can be generalized to a broader context. Especially to other product developers striving for a reduced TtM or a general increased competitiveness in NPD.

7.3 Regarding Husqvarna Construction Products

The overall impression of HCP and how they conduct NPD has been very positive. There is a risk that this has not been conveyed well enough when presenting the empirical findings, as this thesis has been more targeted identifying underlying improvement areas and ways to address those, rather than strengths.

Management commitment and support is one of the greater strengths seen at HCP, and they show a good understanding of the organization and a willingness to improve. It serves HCP justice to emphasize the positive experience and the helpfulness of everyone involved, with the good nature of cooperation and how the company culture promotes a strive towards a common goal.

When constructing the framework for TtM reduction certain aspects, given much attention in the literature, were excluded. These aspects were excluded as they were either not deemed relevant for the scope of this thesis or were already being conducted successfully at HCP.

From the frameworks by Cooper (2019) and§ Dombrowski and Zahn (2011) Parallel processing, Cross-functional teams and Visualization are three of the highlighted areas with no apparent issues to address at HCP. Parallel processing already is conducted to some degree, with increased integration of manufacturing contributing to that. Cross-functional teams are, with the exception of GD, utilized and Visualization, while not being conducted exactly as in the same way as described in the literature, has already being successfully implemented through the use of obeya/pulse-boards.

As for the other areas, Kaizen, Agile Development and Flow-and-pull, these were deemed to be not entirely suitable to include as implementing these principles either did not fit HCP's organization or may have warranted separate research on their own.

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A

Appendix 1

A.1 Initial Questionnaire

<Initiate interview with a brief introduction of us and what our aim is>

- What kind of background do you have? How long have you been working at Husqvarna?
- How does your role and responsibilities look like?
- Which function do you belong do, and which other functions do you most collaborate with?
- How does the collaboration work?
- Is there anything that other functions could have done differently to make your job easier? (in the context of reducing TtM)
- Do you have any ideas or suggestions on how TtM could be improved at HCP, from your own perspective?
- What are common causes of delays in the development process?
- Can you give examples of some (unnecessary) iterations that are often repeated in the product development process?
- How can they be avoided?
- Do you have any other thoughts or recommendations that you wish to share?

A.2 Revised Questionnaire

<Initiate interview with a brief introduction of us and what our aim is>

- To what extent is the Husqvarna PCP followed?
- To what extent is it possible to follow it?
- Do you, personally, have a good knowledge the PCP process?
- Is it clear to you which deliverables that are to be implemented next?
- How is progression in the development work communicated?
- Are the deliverables that you have responsibility for in the NPD well described?
- Do you think that the "Market & User Requirements" fulfill their purpose?
- How well-developed are they?
- Does do they capture Customer needs?
- Are changes in specifications during the course of a project well-justified?
- Do you find that HC uses standard formats for documents / drawings / other deliverables to a sufficiently high degree?

- Do you have any thoughts on eventual pros/cons with a higher degree of standardization?
- Is there a satisfactory supply of templates for different deliverables in your work?
- Have you experienced any differences between how different project managers work?
- Have you experienced any particularly positive or less positive behaviors?
- How well do you think the IT-landscape at HCP function?
- Do you have experience of working in projects with pre-studies at HCP?
- How does it work?
- Do you experience that it saves time / resources?
- Do you manage to capture customer needs in the pre-study?
- Do you have any general thoughts?
- How many prototypes are usually done? How do you decide the number?
- Do additional prototypes cause delays in the project?
- Do the PPAP risk causing delays in the project?
- Do the PPAP entail much "unnecessary" bureaucracy?
- Is SQA sufficiently involved in the PPAP?
- What types of deviations usually occur in the PPAP?
- How is knowledge created during a project captured? How do the lessons-learned documentation work? Does anyone read it?
- How does knowledge dissemination work between functions on HCP?
- How is knowledge shared between the employees at HCP? If someone works according to some type of best-practice- what can be done for more to follow that practice?
- How are components reused?
- How to find reusable components?
- Is it necessary to call all to project meetings functions?
- Do you feel that the meetings fulfill their function?
- How does collaboration with supplier work?
- Is there enough exchange?
- Is it a common problem with supplier changing spec after they get a job?
- What do you think about the degree of early involvement of customers?

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