LAPPEENRANTA UNIVERSITY OF TECHNOLOGY

School of Industrial Engineering and Management

Master's Degree Programme in Global Management of Innovation and Technology

MASTER'S THESIS

PREPARATION FOR RAMP-UP PRODUCTION PROCESS IN METAL MANUFACTURING

First examiner: Professor Tuomo Kässi

Second examiner: Dr. Sc. Lea Hannola

Supervisor: Msc. Marko Karppinen

ABSTRACT

Lappeenranta University of Technology
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Preparation for ramp-up production process in metal manufacturing

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Collaboration is essential for successful new product development. In the preparation for ramp-up production collaboration between R&D and supply chain functions is crucial. This thesis examines the meaning of collaboration and the effects of collaboration between R&D and supply chain.

The aim of this thesis is to analyse and advice on how to improve the collaboration between the research and development department and supply chain within the preparation for ramp-up process.

This thesis begins by introducing the reader to the product development methodologies and collaboration literature. The following part of the thesis describes the current situation and the results of the qualitative research.

The last part of the thesis will explain the improvement suggestions. The main improvement suggestions are clarification of the processes and responsibilities and the introduction of a kick-off meeting.

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Hyvinkää, 20st of November 2013 Britt Bremer

TABLE OF CONTENT

PART III: EMPERICAL STUDY

PART IIII: DISCUSSION

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

NPD New product development

NPI New product implementation

APD Agile product development

LPD Lean product development

SQM Supplier quality management

PD Product development

PART I: INTRODUCTION

This part of the thesis begins with an introduction to the research problem and the thesis subject. After this, the purpose of the thesis is explained and the research questions and research objectives are clarified. The following part of this introduction chapter focuses on the research methodology and on the methods used. Finally the structure of this thesis report is presented and explained.

1. BACKGROUND

Successful new product development is essential for every company. Most companies see new product development (NPD) as a key activity and a short time to market as a critical issue to long term success. This fact is quite well know and well expressed in the current literature. (Hilletoft & Eriksson, 2010) However, optimizing the NPD process and time to market processes inside the research and development department can be much more efficient when this is done in collaboration with the involved supporting functions. Successful NPD requires not only the technical knowledge but also the knowledge and expertise from the other organizational functions (Barcak et al., 2009).

This thesis is focusing on the new product implementation into the supply chain. In practice this means that the new product will be implemented to the several supply chain functions so the ramp-up production can start. In this process collaboration between the supply chain functions and the research and development department is extremely important. The research and development department is creating the new products that have to be able to be manufactured and distributed within the supply chain. This means that research and development department is determining a large portion of the supply chain costs and the supply chain structure. (Pero et al., 2010) Another reason is the outcome of the research and development department depends on the supply chain. (Van Hoek and Chapman, 2006)

2. RESEARCH PROBLEM, OBJECTIVES AND DELIMINATION

This research takes place inside the product and development department and is focusing on the new product implementation process. In this process there are two main players active, the research and development department and the supply chain. The supply chain consists of several functions. For this research the sourcing, logistics and manufacturing functions are relevant. The selected functions are the main influencers on the new product implementation process and therefore efficient collaboration between them and the research and development department is important.

The case company has earlier conducted a survey on how the current processes and working environment are looking like. This research has shown that employees do not have the feeling that they are collaborating with other functions outside the research and development department.

The research and development department is constantly working on improving the development methods. The organization has been working already several years with a stage gate model and is currently testing Lean and agile product development methods. These different product development methods also have an impact on the collaboration between the different organizational functions.

The aim of this research is to analyse and advice on how to improve the collaboration between the research and development department and supply chain within the preparation for ramp-up production process. This research will be finished on the 20th of November

The research problem leads to the following research questions:

How to improve collaboration between the case company's technology organization and supply chain functions within the preparation for ramp-up process?

- How does the current preperation for ramp-up production process look like?
- What is Lean/Agile product development?

- What is the difference in collaboration within the current process and the LEAN/Agile process in product development?
- What is the current state of collaboration between R&D and Supply Chain functions?

3. RESEARCH METHODOLOGY

As mentioned before, this research is a case study. A case study is a research strategy which focuses on understanding the dynamics that are present in within the single setting (Eisenhardt, 1989). This research strategy involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence (Saunders et al., 2009). A case study research is suitable for several research objectives: description, explanation, prediction and control of the organization (Woodside & Wilson, 2003). In this research the case study will have a descriptive and explanatory objective.

In order to answer the formulated research question a mainly qualitative research is conducted. In the starting phase of the research, a literature study concerning the topic is done. Parallel to this, preliminary informal interviews with the case company representatives are held. After a clear understanding of the research problem and the scope of the project is made, the collection of the empirical data can start.

The empirical data will be collected with interviews. The interviewees are employees of the research and development department or employees from the different supply chain functions: sourcing, manufacturing and logistics.

An interview has a natural basis in human conversations and gives an opportunity for the researcher to adjust the pace and style of asking questions in order to get the best out of the respondents (Hannabus, 1996). The interviews have a romanticism perspective. This means that that the interviewer encourages the interviewees to reveal their authentic experiences by establishing rapport, trust and commitment. Advantage of this romanticism approach is that because the interviewer and interviewee are equal to each other a more realistic picture, compared to neoposivist approach, can be uncovered. The interviews themselves are semi-structured. The semi-structured interview involves prepared questions guided by identified themes in a consistent and systematic manner. Advantages of the semi structured interview are the flexibility, accessible and capability of disclosing hidden facets of human and organizational behavior. (Qu & Dumay, 2011)

Semi-structured interviews are the most effective and convenient means of gathering information (lkvale & Brinkman, 2009). The duration of these interviews is between 30 minutes and 1 hour.

During and after the interviews the researcher takes notes. These notes are then analyzed after the meeting and relevant and important issues are highlighted. The interviews are not recorded, this would make the interviewee feel less comfortable. Interviews are used to map the New Product Implementation process and to see how collaboration works and where it is needed. An as-is situation is made for every function.

Together with the interviews also internal documents are used in this research to gain a deeper understanding of the working practices and processes within the research and development department and the supply chain functions. A desk research is conducted to screen the underlying theories that concern the state-gate model – the case company's current development method - , lean and agile product development methods – that are going to be implemented in the future - and collaboration.

4. THE CASE COMPANY

The case company was founded about 100 years ago and is nowadays one of the global leaders in its industry. The company is offering complex products and solutions to its customers in the modernization and maintenance sector. The company is operating on the global market and present in almost every country. Also the production units, distributions centers and research and development locations are globally located.

The case company is suitable for this research because the company is operating globally, collaboration is very important on daily basis for the operations. Secondly the company is developing, manufacturing, and distributing rather complex systems and products that need efficient cross-functional collaboration in order to be successful in the market. Furthermore the company is operating in a high competitive market, which leads to continuously optimization of the product in order to excel in its category. The research is conducted in one of the research centers on the research and development department. This department is located in Finland.

5. STRUCTURE OF THE THESIS

This thesis is divided into four different parts. These parts are presented in figure 1. In the first part of the thesis there is an introduction where the reader will be introduced to the research and familiarized with the research topic. The second part of the report is the theoretical part of this report. In this part of the thesis the theoretical knowledge needed for the empirical part is presented. The third part of this thesis contains the empirical findings and the process description of the new product implementation process. This part also shows the new product development process with the current and the lean/agile processes. There is also a description of the supply chain in the case company. Also a brief description of the processes inside supply chain functions is given. The last and fourth part contains the conclusions of this thesis. This part also describes possible improvements that can be used in order to improve collaboration within the organization.

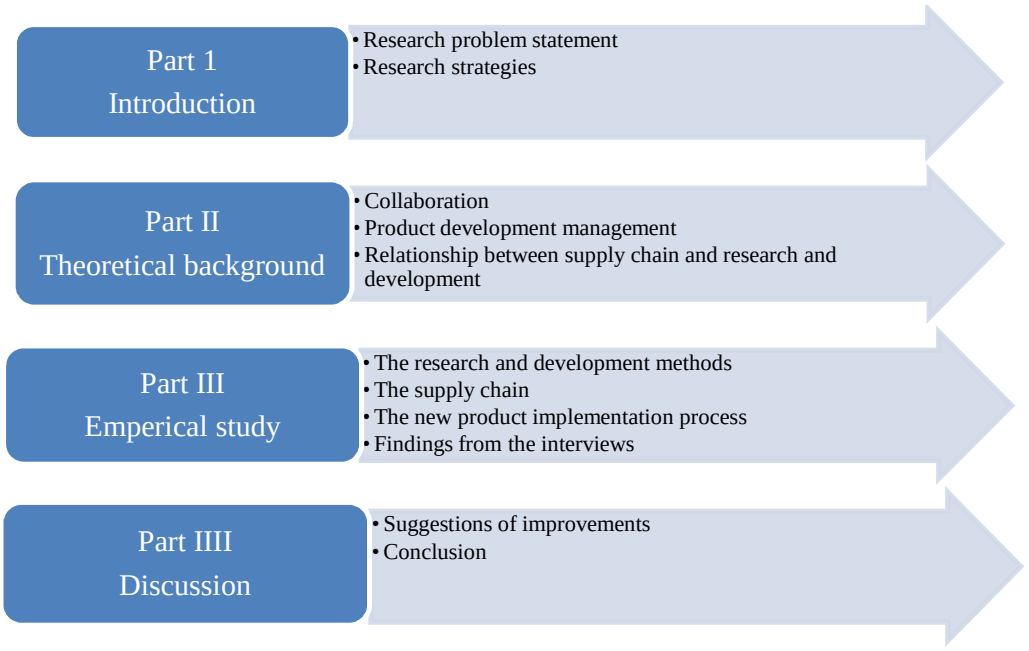

Figure 1: Structure of the thesis

PART II: THEORY

This chapter presents the main theories that have been used for the analysis of the qualitative research and to answer the research questions and objectives of this thesis.

6. NEW PRODUCT DEVELOPMENT

New product development concerns the management of the disciplines involved in the development of new products (Trot, 2012). For many companies new product development (NPD) is very important. The development and introduction of new product is critical for survival. Cooper (1993) describes in one of his books that the product market is like a war; “Corporations everywhere are engaged in a new products war. The weapons are the thousands of new products developed in the hope of successfully invading chosen marketplaces. Sadly most new product attempts fail.”

In the citation above becomes immediately clear that new product development is not always successfully. Instead the high rate of new product development failures makes NPD risky, because there is a possibility of large financial losses (Ogawa & Piller, 2006). There are different NPD methods developed in order to manage different NPD project in different ways.

In figure 2, the different product development methods are shown in an R&D spectrum. On the far left side of the spectrum the highly agile NPD methodologies are shown. Highly agile projects are the projects that can be tested with consumers readily. A typical project would be a software project where prototypes and pilot products can be coded, shipped, tested, and revised with minimal effort and capital requirements. In the middle of the spectrum are the traditional NPD projects. Traditional NPD project are the project are epitomized with market research and more traditional design methods. (Marion et al., 2012)

Figure 2: The technology R&D spectrum (Marion et al., 2012)

On the right side of the spectrum are the science push methodologies. This kind of NPD project includes heavy scientific research that will cost a lot of capital and time. Examples of this kind of NPD projects can be found in the pharmaceutical industry. (Marion et al., 2012)

For organizations it is hard to decide which product development methodology is the best. There are several ways of deciding which methodology to choose. In some cases organizations have to change their methodology. To define the most suitable product development for the organization, the organization should follow four steps. The first step is to identify the business the organization is operating in. Secondly the organization should analyse the current product development method and see if this method meets all the business needs, further should the organization see what other product development markets are possible and if this would be applicable in the organization. The third and fourth steps are the definition of the new or current product development method, implementation plans and monitoring how the new product development method is fitting in the organization. (MacCormack et al., 2012)

In general the technical risk of the product and the market risks are influencing the product development method. Figure 3 illustrates this relation. (MacCormack et al., 2012)

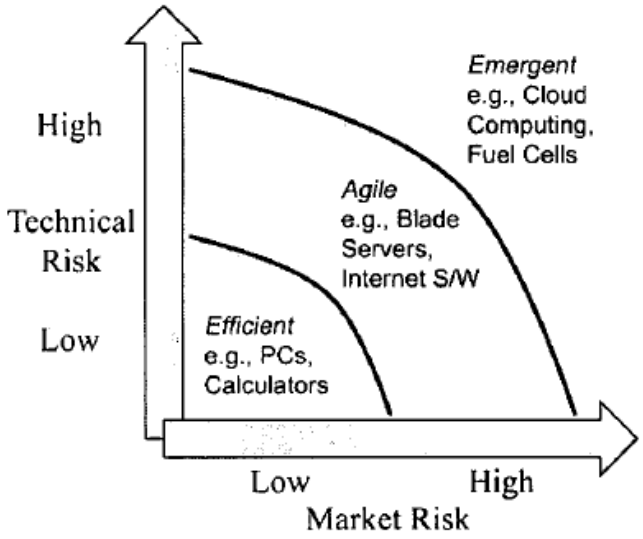

Figure 3: Product development methods influences by technical risk and market risk (MacCormack et al., 2012)

Changing the product development methodology is very difficult because people inside of the organizations do not recognize the need of it. (MacCormack et al., 2012)

The produce development methods that will be described further in this thesis are the stage-gate method, agile product development en lean product development. The stage-gate NPD is a traditional method on the R&D spectrum. The agile method is logically on the left side of the spectrum. The Lean methodology can be found between the traditional and agile NPD project.

A very often used and cited reference from Brown and Eisenhardt (1995) combined an enormous amount of literature into their research. Figure 4 illustrates the result of this research. The main idea behind figure 3 is that there are several players whose actions are influencing the product performance: (Brown & Eisenhardt, 1995)

1. The project team, leader, senior management, and suppliers affect the *process performance* (speed and productivity of product development)
2. The project leader, customers, and senior management affect *product effectiveness* (the fit of the product with firm competencies and market needs)
3. The combination of an efficient process, effective product, and munificent market shapes the *financial success of the product* (revenue, profitability, and market share)

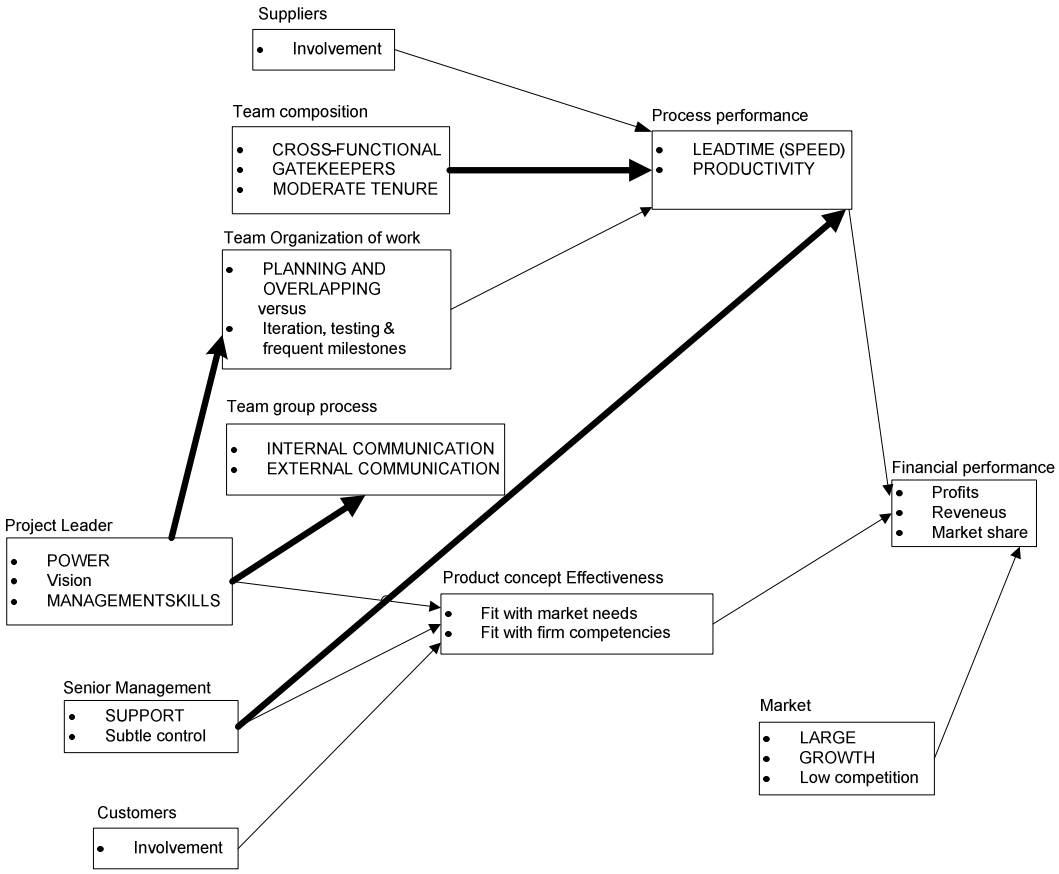

Figure 4: Factors affecting the success of Product Development Projects (Brown & Eisenhardt, 1995)

6.1. Cooper stage-gate product development

In 1985 Cooper and Lybrand did a survey that showed that companies in the United States of America are counting heavily on new products on their desire to grow and become more profitable. A study done by Hopkins in 1980 however showed that the success rate of NPD project is extremely low. The study shows that 63 percent of managers feel that the NPD success rate is disappointingly or unacceptably low. (Cooper, 1990)

Cooper (1990) concluded that the solution for these problems is that inside NPD project the management should better conceive, develop and launch new products, rather than extend and incrementally improve existing products. Launching new product however, requires management of the innovation process. A framework which considers innovation to be a process and therefore manageable is the solution to this, the framework is known as the state-gate model. (Cooper, 1990)

The stage gate model is a framework that channelizes the product development process of moving from product ideas to a successful developed new product. Nowadays the stage gate model is a popular system for managing risks in product development. (Van Oorschot et al., 2010)

The model is presented in figure 4. The Stage gate model consists of sets of information-gathering stages. Each stage is followed by a GO/Kill/Hold/Recycle decision gate (Cooper, 2008).

In each stage the uncertainties and risks are reduced, while the costs increase. This allows risk mitigation and management. By using the stages, the stage gate model makes the size of an investment inversely proportional to the uncertainty related to the investment. For example, at the beginning of the NPD project there are still a lot of uncertainties and therefore the costs are low. When the NPD project becomes more mature, investments have to be made and the cost of the project will rise, but the uncertainties, in turn, decrease. (Summers & Scherpereel, 2008)

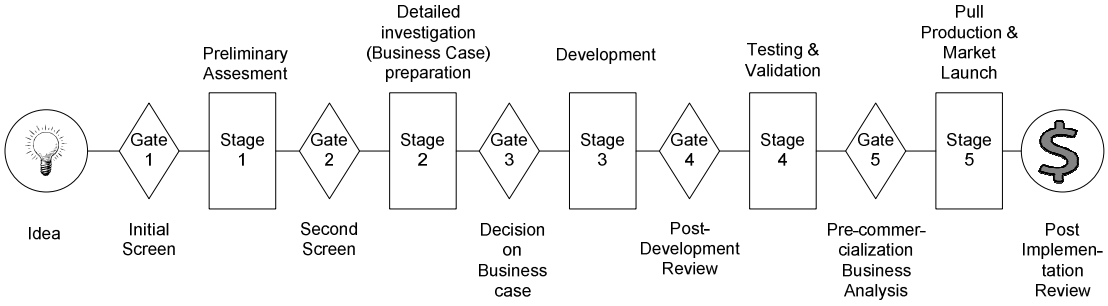

Figure 5: Figure 5: Stage-gate model for product development (Cooper, 1990)

In figure 5 is shown how the NPD process is divided into different stages. Between each stage there is a quality control checkpoint or gate. At each gate there will be a GO/Kill/Hold/Recycle decision and a review of the action plan for the next stage. The decision in the gate is based on certain requirements which differ for every gate. The project manager is responsible to deliver the requirements that will be reviewed at the checkpoint. The gates are controlled by senior managers who will be the 'gatekeepers' during the process. The gatekeepers group is usually a multidisciplinary group of managers. The roles of the gatekeepers are: (Cooper, 1990)

- Review the quality of the deliverables provided by the project owner.
- Review the quality of the project in an economical and business perspective, which will result in an GO/Kill/Hold/Recycle decision
- In case of GO decision, approve the action plan for the next stage

Stage-gate systems usually involve four to seven stages, it depends on the organization or division. Usually each stage is more expensive than the previous stage, this is how risk is managed. (Cooper, 1990)

Even though the main idea of the stage-gate model is to continue from one the next stage after all requirements are met. However, the concept of time to market is nowadays a very important factor in NPD and therefore it should be possible to make stages overlap. Long lead time activities can be brought forward from one to an earlier stage. This means that project can proceed to the next stage, even though the previous stage has not been completed. (Owens & Cooper, 2001)

There are also other variations of the stage-gate model, where certain stages are divided into sub phases. After every sub-phase there will be a review, but not a gate. This means that the ‘gatekeepers’ can monitor the progress, but cannot stop the project. The sub-phases highlight the organization emphasis. This means that the division of sub-phases in the stage-gate model should vary per organization, depended on what their emphasis is. In figure 6, for example, the organizational focus is on the validation of the product to evaluate if the product meets the customers demand. However, at this phase most of the costs have already been incurred. This means that this organization is recommended to put more sub-phases in stage 2, which would enable the organization to monitor the project during an earlier phase in order to operate with the lowest costs. (Phillips et al., 1999)

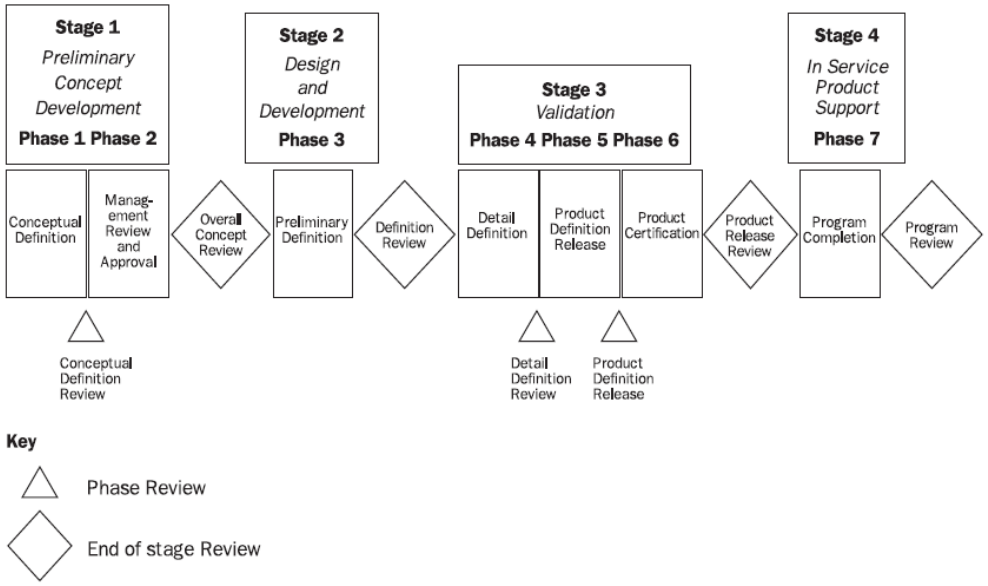

Figure 6: Stage-gate model with sub-phases (Phillips at al., 1999)

Nowadays there is not only positive criticism anymore about the stage-gate model. Recent negative comments about the stage-gate model concern the fact that project manager do not have enough authority. The project managers become errand-boys for gates rather than real leaders with time to market and efficiency as priority. This creates a culture where taking the right actions is hindered. Also the kind of steering used in the stage-gate model can have negative effect on the project performance. Criticism also arises from the decision making in state-gate model. While quick decisions are vital for every organization, in the stage-gate model the important decisions cannot be made when needed but only at the gate meetings. Another comment is that the gates are slowing down the development. When a problem occurs during stage 3, the project should go back to gate 3 while earlier was decided that the project already passed this gate. (Holmdahl, 2010)

One more negative point about the stage-gate model is that the focus in the model is on the time between one and the next gate, but there is no measurement for the quality. (Van Oorschot et al., 2010)

6.2. Agile product development

Conboy (2009) defines agile product development as *"continued readiness to rapidly or inherent create change, proactively or reactively respond on change, and learn from the change while contributing to perceived customer value, through its collective components*

and relationships with its environment." Agile product development is mainly used in software development. But many of the agile principles are also used in the manufacturing business. When agile product development is applied in more than just software development the results can be spectacular. (Denning, 2013)

One example of product development that is used in agile product development trainings is Wikispeed. Wikispeed is a non-profit automotive-prototyping company that is using agile product development in their NPD projects. (Wikispeed, 2013)

One main source in agile product development (APD) is the Manifesto for Agile Software Development. In 2001 the agile manifesto was published and this led to a breakthrough in the software engineering field (Dingsøyr et al., 2012). The agile manifesto is a website where the 12 principles of agile development are introduced. These 12 principles are compiled by 14 experts on the software development field: (Agile manifesto, 2001)

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity--the art of maximizing the amount of work not done--is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.

12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

These principles are applicable to all software development project. On the website of the agile manifesto can be seen that hundreds of people agree with the authors about these principles.

Even though the agile manifesto has been written in 2001, already earlier there were developments in the agile direction. In the middle of the 1990's some so-called "lightweight methods" were developed in reaction to the "heavyweight methods" such as the waterfall model or the stage gate model. The main issues with the "heavyweight methods" are the strong documentation, formal processes and control. The authors of the manifesto saw a strong need for this non- document driven methods. Some examples of the "lightweight methods" are eXtreme programming (XP), Scrum, extreme manufacturing, and Lean software development. (Grimheden, 2013)

The Scrum methodology - one of the "lightweight methods"- was originally developed for managing the product development project, but is nowadays mainly used for software development. Scrum, is a set of management practices that facilitate agility. The scrum process is based on a few main principles, all principles are related to fast customer feedback, self-organizing teams and constant improvements. (Denning, 2013)

In Scrum the product development team is also known as a scrum team and consists around 10 members. One of the members is selected as the scrum master. The scrum master is to keep the scum team focussed on their task and remove any disturbing influences. The product owner is the representative of the product that has to be developed. The product owner can be an external customer or someone with a special interest to the final product (Schwaber & Sutherland, 2013; Grimheden, 2013)

The project work is organized in short cycles, which are known as sprints. These sprints span a period of a couple of weeks to a month. Each sprint starts with a preparatory task to define the tasks that have to be undertaken. Each sprint ends with a delivery to the customer or product owner that will be followed with a sprint reflection. The sprint reflection is a meeting where the progress of the last sprint will be discussed with the scrum team, project owner or customer. (Schwaber & Sutherland, 2013; Grimheden, 2013)

The product is defined in a product backlog. It is the product owners' responsibility to make sure that the customers' expectations are reflected in the product backlog (Kettunen, 2009). This product backlog is made in cooperation with scrum team and the product owner. At the beginning of each sprint a new sprint backlog is made. The sprint backlog is made as subset of the product backlog by the product owner, the scrum master and the scrum team. In the creation of the sprint backlog, most stress will be put on the features that create the most value to the customer. During sprints there are daily scrum meetings. In these the daily scrum meetings all team members will tell what they did the day before, what they are going to do on the current day and tell what may be an obstacle in the foreseeable future. (Grimheden, 2013) This scrum methodology is simplified shown in figure 7.

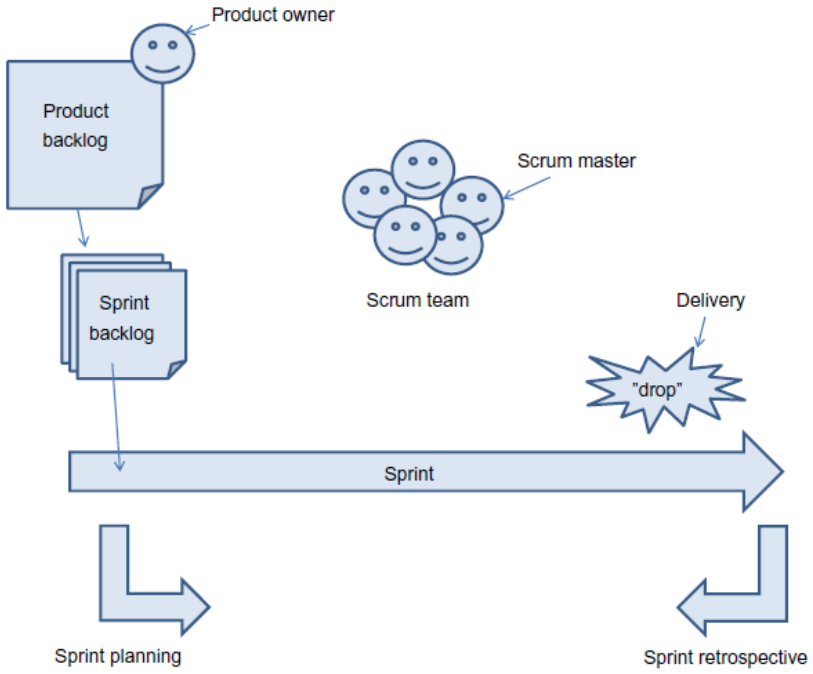

Figure 7: Scrum illustration (Grimheden, 2013)

Scrum is a customer driven methodology. This can be seen from the product backlog that is governed by the product owner and initiated during the planning phase. This product backlog is continuously iterated throughout the project and will record the current features to be developed. The product owner should ensure that the customers' needs are represented in the product backlog all the time. (Grimheden, 2013)

Factors that are critical for success in Agile product development projects are: customer satisfaction, customer collaboration, customer commitment, decision time, corporate culture, control, personal characteristics, societal culture, and training and learning (Misra at al, 2009). Control has been recognized as one of the main critial factors. In the agile product development project control is possible during the daily scrum meetings and weekly progress showcases to the customers (Misra at al., 2009).

Another important factor is customer commitment. One of the principles of Agile development is to give the highest priority achieve customer satisfaction through early and continuous delivery of valuable products (Kettunen, 2009). This means that the customer should not only be available when needed, but should also be committed in the NPD project. Recruitment of employees should not only be concentrated on experience but also focus on the characteristics like honesty, willingness to work with others together, collaborative attitude, willingness to learn and a sense of responsibility. (Misra at al., 2009)

There are many advantages of APD compared to other product development methods: (Petersen & Wholin, 2009)

- *Transparency and control.* Control and transparency is achieved by having small and manageable tasks. It is also clear who assigned to each task, this results in transparency and high quality deliverable as the team members feel personally attached to their tasks.
- *Learning, understanding, and other benefits of face-to-face communication.* In Agile development there is a lot of face to face contact. This brings makes different functions understand each other and makes communication lines shorter.
- *Frequent feedback for each iteration.* After every iteration there is a feedback moment. During these moments knowledge can be transferred and feedback can be given on everyone's work.
- *Low requirements volatility.* Small requirements packages are prioritized and can go quickly into development due to their limited scope. The main advantage of this short implementation period is that there are small chances that the customers demand has changed between the development and the release

- *Work started is always completed.* Once the task has started, the work has to be finished in order to continue to the next task. The main requirement for this advantage is that the tasks are well prioritized.

Like any other product development methods, APD also has its disadvantages and critical issues: (Petersen and Wholin 2009)

- *Testing lead times and maintenance.* The realization of continues testing with a wide variety of platforms and test environments is challenging and requires much effort. Also the release of several different versions of the product makes it harder to reproduce the fault and solve the problem.
- *Management overhead and coordination*. Working in small teams, requires a lot of management effort. Coordination is needed to keep all teams working towards the same goal.
- *Little focus on architecture*. The company is planning different project on the timeline. However dependencies between the projects are not covered. When one project is implementing a specific component, it has no control over other projects that are implementing another component in the same product.
- *Requirements prioritization and handover*. In for example scrum the product backlog is showing the highest priority always at the top of the backlog. Getting the priority list right is a challenge as the requirements list is changing according to the demand of the customer.
- *Test coverage reduction of basic test.* Teams have to conduct unit testing and test their overall package before delivering the latest version. This leads to developers and testers working closely together. In that case the developers are able to influence the testers
- *Increased configuration management effort*. Configuration management has to coordinate a high number of internal releases, as each internal release is a potential market release. (only valid in software developments projects)

6.3. Lean product development

In 1990 the automobile industry realized that Japanese automakers were simply better than their European and U.S. competitors. In 1991 Jim Womack, Dan Jones and Dan Roos introduced the term lean manufacturing in their book, *The Machine that Changed the*

World. The book described the production system from Toyota that was better, faster and cheaper (Womack at al., 1991).

The book was the start of a revolution in manufacturing. But the authors pointed out quickly that only one chapter of the book was focussed on lean manufacturing. The book is concerning the whole enterprise, which also includes other departments like marketing, logistics and product development. Toyota's product development methodology was lean product development (LPD). This system was of interest for many researchers as it was shown to result in lower cost, quicker development times, and higher quality than the product development practices that were used at the time by Western and U.S. competitors in the automotive market. (Morgan & Liker, 2006)

Nowadays LPD concepts are not only composed of the Toyota LPD principles, current LPD also incorporates other improvement techniques that help to develop products and services faster with less effort and fewer errors. (León & Farris, 2011)

León and Farris (2011) define LPD as*: the cross-functional design practices (techniques and tools) that are governed by philosophical underpinnings of lean thinking – value, value stream, flow, pull and perfection – and can be used to maximize value and eliminate waste in product development.*

There are many different opinions by authors of books and journals about the LPD principles (Radeka & Sutton, 2007; León & Farris 2011). Some authors apply the principles from manufacturing to product development, while other authors claim that manufacturing needs different principles than the product development. León and Farris (2011) wrote in an article about the literature available on LPD and the different principles that govern LPD. In their article they published a table with the main LPD authors and their opinion about the LPD principles. In table 1, this is shown.

Table 1: Main principles in lean product development (Léon & Farros, 2011)

Authors	LPD principles
Haque and James-Moore, 2002	Specify value; Identify the value stream and eliminate waste; Make the value flow; Let the customer pull; and Pursue perfection

Oppenheim, 2004	Define value (by delivering a robust product design in minimum time and costs through waste removal); Define the value streams; Make the work flow; pull ("by doing the right work right"), pursuit perfection (in both, perfect planning and perfect first-time execution of the flow).
Morgan 2002; Liker and Morgan, 2006)	Understand value from the customer's perspective; Gentchi Gembutsu (go to the source); Eliminate the non-essential; Minimize hand-offs and build in accountability by developing Chief Engineer; Examine multiple alternative solutions; Integrate suppliers into PD system; Apply lean manufacturing principles and create flow in tool and die making; Set very specific, measurable goals; Practice very early, detailed scheduling; Use flexible capacity strategies; Employ rigorous standardization to create flexibility and reduce variation; Front load PD process; Build-in-learning and continuous improvement
Ward, 2007	Value focus; Knowledge and operational value stream; Entrepreneur system designer; Set-based concurrent engineering; Teams of responsible experts; Cadence flow and pull
Cusumano and Nobeoka, 1998	Prefer heavyweight project managers to lead projects; Overlap PD phases; Work with cross-functional teams; Involve suppliers with high-level engineering; Use rapid model replacements techniques; Design for team and project manager continuity; Develop good communication mechanism; Frequently expand model-lines; and Modle incremental product development.

There are certain topics that can be found in most of the authors' principles: value creation, eliminate waste, flow, pursue perfection, and pull. These topics will now be discussed further.

6.3.1. Value

In LPD, value is what the customers actually want. In order to create successful products developers should focus on what the customer is willing to pay for. Lean companies have to focus on value streams to eliminate non value adding activities. Inside the organization there are several value streams. The operational value stream includes the activities that are transforming raw material into a product that is bought by customers. The development value stream includes all the activities between recognizing an opportunity and the manufacturing. The development value stream itself does not create any value to the customer, but the development value stream creates the operational value stream. (Ward, 2009)

Ward (2009) presented in his book instruments to measure the value of product development. The first instrument is the Return on Investment (ROI), with the ROI calculation people can see the effect of their work. The ROI calculation is a simple equation: (earnings – investment) / (the total life time of the product * the investment). The ROI calculation can show a low investment rate at the beginning of the NPD project, which means that the product development project needs more investigation on the profitability. (Ward, 2009)

The second instrument presented is the project defects rates. This instrument is measuring the defects in the product development project. The organization can gain profitability by eliminating the possible project defects before the NPD project starts. The defects should not be eliminated by adding more test, gates, signatures, etcetera, but by making the process understandable and simple for everyone. This instrument can be used before the project starts but can also be used during the project. In this case the instrument will estimate the probability of failure and success. By calculating the probability of success per subsystem, the probability of success for the full systems can be calculated. (Ward, 2009)

The third instrument is the focussing on creation of knowledge value. Almost all defective projects result from not having the knowledge in the right place at the right time. Therefore it is important that usable knowledge in basic value that will be created during development. In general engineers in U.S. spend 10 to 30% of their time creating value. Managers spend about 5% of their time on the creation of value. By reducing administrative work employees can focus on true value creation. This instrument means

that the developers and managers will be asked how much time they spend on true value creation and think about how much this could be increased. (Ward, 2009)

The fourth instrument is the cycling time. All organizations want to speed up their product development, but development is hard to measure. This instrument is focussing on the cycling time to come from a concept to model to simulation tests or from concept to prototype to test. This instrument can be applied by determining the basic learning cycle in the organization. After this the organization can aim to reduce the learning cycle time. (Ward, 2009)

The fifth instrument is the knowledge grade and rate of exchange. With this instrument employees should grade the company's ability to learn in each phase of the product development. The company should try to get similar information from a lean competitor's organization and evaluate itself. (Ward, 2009)

The last instrument is the lead time measurements. There are inside the product development process several points were lead time could be measured. The reaction time is the time between the opportunity appearing and the company's decision to invest in the opportunity. The exploration time, the time needed to explore the several alternative solutions and implementations. The lock in time, the time needed to decide on a single solution. The fix-up time, during this time the company tries to deal with the problems related to the solution. This instrument can be applied by the organization by measuring the lead times in the own organization and compare this to a lean company in the same industry. (Ward, 2009)

6.3.2. Eliminate waste

The element of waste in lean product development has raised a lot of discussion. Some authors on emphasise the waste elimination in lean product development, while other authors emphasize on the creation of flow (Radeka&Sutton, 2007; Reinsertsen, 2007). In the lean terminology waste is known as muda. Waste or muda are activities that use resources but do not add value for the customer (Morgan & Liker, 2006). There are seven waste categories. These are originally coming from the lean manufacturing, but can be also applied in product development. In table 2 these 7 waste categories are shown and

explained. In the third column is shown how the categories can be applied in product development.

Table 2: Seven wastes of product development (Morgan & Liker, 2006)

Seven wastes	What is it	Example's in product development
Overproduction	Producing more or earlier than the next process needs	Batching, unsynchronized concurrent tasks
Waiting	Waiting for materials, information, or decisions	Waiting for decisions, information distribution
Conveyance	Moving material or information from one place to place	Hand-offs/excessive information distribution
Processing	Doing unnecessary processing on a task or an unnecessary task	Stop-and-go tasks, redundant tasks, reinvention, process variation, process variation – lack of standardization
Inventory	A build-up of material or information that is not being used	Batching, system overutilization, arrival variation
Motion	Excess motion or activity during task execution	Long travel distances/ redundant meetings/ superficial reviews
Correction	Inspection to catch quality problems or fixing an error already made	External quality enforcement, correction and rework

When companies start to apply lean, many look at their processes wildly and start to eliminate waste. But when they step back and let the processes run, the people become overburdened, sick or the equipment will break down. This leads to management deciding that lean does not work. These companies forget that lean thinking has made it easy to identify waste and pull it out of system, but it takes much more effort to create an evenly balanced flow of work. (Ward, 2009)

6.3.3. Flow

Ward (2009) defines flow as: "*Flow means that knowledge and material are available when needed, in bite-sized chunks that can be handles easily*." Flow can be visualized by mapping the value creation process in the product development. The ideal LPD flow is a steady progress of the value stream through all takt periods with minimum waste and each

period terminating in an integrative event. Figure 8 gives a schematic illustration of the flow in an idealized timeline. (Oppenheimer, 2004)

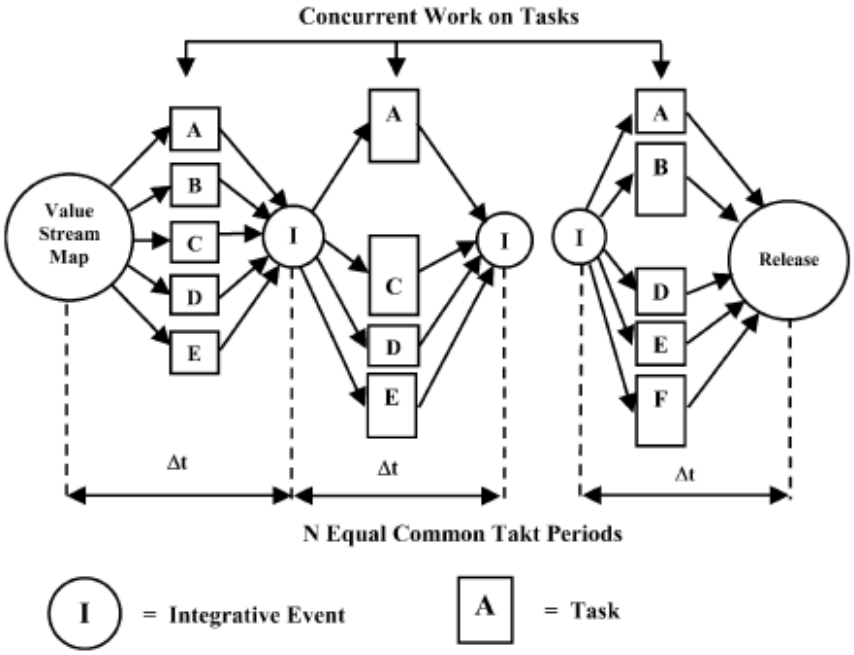

Figure 8: Lean product development flow (Oppenheimer, 2004)

The flow begins with the value definition and planning, captured in a value stream map and ends with the release of the deliverable. Between the beginning and the end, the flow proceeds at a steady speed. The flow consists of a large number of equal work periods called takt periods. All the takt periods have equal and short duration. The role of the takt periods is to provide a constant, common, and frequent rhythm for the whole team. The takt periods all have the same deadlines, but do not necessarily have equal efforts or team composition. (Oppenheimer, 2004)

6.3.4. Pursue perfection

As product development project are very expensive, it is important that the project succeeds at the first attempt. Therefore this lean principle can be interpreted in two ways. First of all, it can be interpreted as perfect planning of the lean product development flow. A detailed and well-made value stream map is necessary for perfection, but is not enough alone. The fast flow of the value stream makes the LPD flow very sensitive to instabilities. It would be naïve to think that there would occur any problems in the LPD flow. Thus this principle can be also understood as perfect first-time execution of the flow. The problems

that are occurring require special mitigating methods and tactics. These tactics can be divided into three enablers. (Oppenheimer, 2004)

The first enabler is the program Leadership and Management. Good leadership is essential and cannot be delegated. The Chief Engineer should lead the entire LPD flow programme and he or she should be the sole “owner” of the programme and therefore totally responsible for the programme. In addition the Chief Engineer should have authority over only a small direct staff. The Chief Engineer should only be responsible for delivering the product value, directly focusing on product integrity and good engineering work. The programme manager who is reporting to the Chief Engineer should handle all the administrational tasks besides the main work flow or as a parallel flow. (Oppenheimer, 2004)

The second enabler is Team Training. The LPD flow is very different from the more traditional product development methods. Therefore all participants should receive a proper training on LPD. The participants should understand the value stream mapping and the importance of the takt periods. Furthermore, the participants should be trained to identify and understands the wastes in the product development process. Also, roles inside the project ought to be clear to all participants, one important aspect here is that all participants should also be aware that bringing concerns and issues to the attention of the core team is appreciated and welcomed. Further communication and coordination needs should also be addresses in the training. (Oppenheimer, 2004)

The third enabler is the Mitigation of uncertainties and unexpected events. As product development uncertainties can vary in scope, efficient strategic and tactical mitigation of uncertainties is critical to the LPD flow success. Uncertainties can be classified into: lack of knowledge, lack of definition/specification, lack of statistical characterization, known unknowns and unknown unknowns. There are several mitigation actions possible. The best mitigation action is mostly depending on the classified uncertainty. All project members should become familiar with the uncertainties and know the mitigations needed. (Oppenheimer, 2004)

6.3.5. Pull

Morgan and Liker (2006) explain in their book that customers pull what they want from the store shelves and store owners replenish the shelves when needed, the store owners is restocking what customers have purchased. In manufacturing this principle is also clear. There is a direct link between the customer and the supplier of the material in a pull system. The smaller batch sizes the producer makes, the closer the operation is. In one-piece batch sized the factory has to fully streamlined with the workflow of the customer.

Oppenheimer (2004) defines pull as: "*the concept of each process "pulling" the incoming work from the upstream process when needed and in the amount needed."*

In LPD the projects participants store the release of product and manufacturing data so that the data can be pulled as required by the next/other functional organization. Cross-functional teams maximize the utility of the available data and the participants strive to work with stable data. For example, in earlier phase of the NPD, the development team can seek out data that seems to be related to the project but does not concern it yet. This data can be stored and used later in the project. (Morgan and Liker, 2006)

6.3.6. Lean product development conclusions

Lean has shown to have many advantages in manufacturing. When lean is applied to product development, there are some observable advantages there (Womack at al, 1991; Ward 2009). Advantages named in literature are: shorter time-to-market, improved productivity, better collaboration, lower product costs and fewer changes at the end of the development (Radeka & Sutton, 2007). Unfortunately there are not that many success stories about LPD known yet, but many companies are currently experimenting with lean and in the trends can be seen that more literature should become available in the future (León & Farris, 2011).

Currently there are many different opinions and believes about LPD. LPD has a different meaning inside companies and also authors and consultants differ on the detailed definition of LPD (Radeka & Sutton, 2007). At the moment there is not one key model that can be used, when a company decided to go in the LPD direction. This makes implementation very complicated and requires a lot of research.

7. COLLABORATION

Collaboration is critical for any organization's success. It can help companies create competitive advantage by utilizing the dispersed resources and expertise of their departments. Successful collaboration can help company increase its profits, improve decision making and reduce cost trough cross departmental sharing of insights, expertise and best practises. Sharing ideas can lead to innovation and working together might help departments pursue goals involving whole organization. (Patel et al., 2011; Bruns, 2013)

Bedwell et al. (2012) conducted a research concerning the conceptualization of collaboration. This research is combining literature from different fields and perspectives. The definition created in this research and used in this thesis is that collaboration is: "*an evolving process whereby two or more social entities actively and reciprocally engage in joint activities aimed at achieving at least one shared goal* (Bedwell et al., 2012) ". However, Pater at al. (2012) notified the need of including the notion of time into the definition of collaboration. The paper is adding to the above cited definition that collaboration occurs within a single episode or series of episodes.

As mentioned in the above citation collaboration is an evolving process. This means that that people are interacting with each other and that the process is dynamic and of evolving nature. This shows that collaboration is a process that can evolve, improve and change over its life cycle. (Bedwell et al., 2012)

Collaboration is an interaction between entities. These entities refer to individuals, teams, units, departments, functional areas and organizations. These interactions can occur on many levels, or even across levels. In fact, collaborative processes at lower level may affect the higher level and vice versa. This means that the definition of collaboration shows that collaboration can occur beyond just individuals and teams and across levels of analysis and involve combinations of entities. (Bedwell et al., 2012)

Bedwell at al. (2012) also mentions that collaboration is reciprocal. In practice this means that collaboration requires active, mutual engagement from all the involved parties. To give an example, a party dictating and controlling another party cannot be seen as collaboration but work delegating. However, collaboration does not require equal

participation or engagement, instead it is critical that all entities are involved and work interdependently and contribute sufficiently towards reaching their joint aims.

One main element that is separating collaboration from other forms of shared work – terms such as co-work, cooperation and teamwork - is a shared goal. The process of collaboration can only occur if all the involved entities share at least one mutual goal. Without any shared goal there would be no reason for the entities to work together. It is also possible that the collaborating entities have conflicting goals. In fact it often happens that both collaborating partners have conflicting goals. This means that the collaborating partners must work through their conflicts to achieve their shared goal at the endpoint. (Bedwell et al., 2012)

Patel et al. (2012) defined 7 different types of barriers that hinder or prevent collaboration: non-supportive organization, inadequate partnering arrangements, weak management, poorly conceived/planned/managed projects, technology orientation, inadequate knowledge management and unacceptable costs. These barriers and their root causes are shown in appendix 3.

In order to create a stable and good collaboration between the project members there are several general factors that managers should take into consideration. William (2013) lists the following:

- Establish a common vision and goals – the goals can be general but should be compatible to all parties.

- Foster trust – Beginning a collaborate activity with organizations and individuals that already have a trusting relationship is more likely to succeed.

- Provide value – The different partners all have to put an effort into the collaboration. The partners should find support or measurable results that support their distinctive missions.

- Communication – Communication is important for building trust and creating a common vision and goals. In most cases, meeting are the main and important resource in collaboration. Meetings should be long enough to give all parties the

chance to share their issues and ideas. When there is a good relationship, the communication atmosphere will be safe, allowing honesty and openness.

- Recognize power and conflict – Common vision and goals, trust, and good communication will decrease the negative impacts of power struggles and other conflicts.

- Create structure and administrative support – Administrative support is one of the critical factors for success. Administrators are able to create structure for communication, coordination of services, guidelines, roles, minutes, leadership and management of agenda's.

- Provide the medium leadership – A collaborative project is composed out of several individuals which are linked through each other by common goals. As leader building consensus is needed, use open communication and have alternative ways to create harmony. In successful collaboration projects the leadership is often dispersed and unrecognizable.

7.1. Collaboration in NPD

There is a clear relationship between collaboration and improved new product development processes. Several researchers have concluded that collaboration accelerates product development. However, how multiple groups come together and interact in order to create a successful new product still remains poorly understood. (Jassawalla & Sashittal, 2000)

Jassawalla and Sashittal (1998) define NPD related cross-functional collaboration as a type of cross-functional linkage, which in addition to high levels of integration, is characterized by participants who achieve high levels of , at-stakeness, transparency, mindfulness and synergies from their interactions.

One of the most common problems in collaboration in product development are addressed by Jassawalla and Sashittal (2000). In product development most of the decisions concerning the product development are made by the development team. This leads to supporting functions not feeling connected to the NPD project and they will prioritize their daily operations above the NPD projects. According to their research supportive functions

gave more priority to the NPD projects in companies where the supportive functions had more power in the decision making in the NPD projects.

Appendix 4 lists the effective and ineffective technology transfers in new product development process recognized by Jassawalla and Sashittal (2000). This table shows how different groups should come together in order to create successful complex new products.

7.2. Collaboration project management

There are several frameworks for collaborative projects. There is for example the Forming, storming, norming, performing, and adjourning framework from Ellen Gottesdiener (2003), whereby the collaborative projects are divided into 5 different stages. Here the collaborative session or workshop is the main tool for successful collaborative projects. One, more recently published, collaborative framework is the Collaboration life cycle (CLC), developed by Hilda Tellioğlu (2008)

According to the CLC framework there are typically 4 different phases of collaboration inside the collaboration process. These four phases are Initiation, Formation, Decomposition and Operation. These phases form a cycle through which the collaborative project runs. The CLC framework is visualised in figure 9. (Tellioğlu, 2008)

In addition to different phases there are also different roles active in the CLC framework. Each of the team members has one or more of these roles, but all roles have to be present within the project team. These roles can be done by different by the same person: (Tellioğlu, 2008)

- Members – The members of the group are working together, they can discuss and exchange knowledge with each other.
- Initiator – This person is the founder and organizer of the group
- Experts – The experts bring knowledge and competence to the project. Experts are in most cases key personnel of the organization
- Moderator – This person is in most cases a key person of the organization and is needed to organize the group

- Sponsor – The sponsor has the hierarchical power to promote the group. This person is interested in the result of the project.

- Boundary spanner – This person is only needed when there are several groups working and information exchange between them is needed.

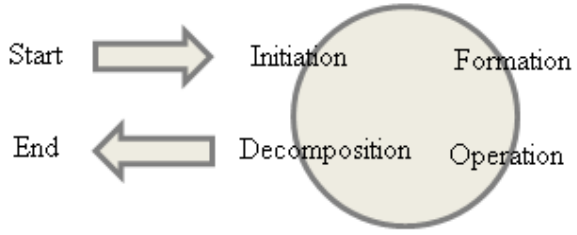

Figure 9: Collaborative Life Cycle framework (Tellioğlu, 2008)

The collaborative project will start with an initiation, then a formation, which will be pursued by operation and the project will close with the decomposition.

In the initiation phase, which starts the collaboration, the need for the collaborative workgroup is defined by the initiator or multiple initiators. This means that the initiators have to decide if the collaboration is needed in order to reach the common goal. In this phase the complexity of the work, the duration of the work and experience with similar projects should be considered. There also has to be a decision if the collaboration is needed in order to reach the goal. If the collaboration is needed for the specific project, the workgroup can be built. Before the workgroup can be created, the reason for the project should be identified and clarified by the initiator. The reason behind the goal should be understandable for all future team members. After this the initiator can start identifying the potential team members and when all the team members are selected the identifier can start inviting the desired team members. The result of this phase is a final list of project members. (Tellioğlu, 2008)

The second phase of CLC is the formation. This phase starts by defining common goals. This list of common goals should be made with the entire group. People can also define their personal goals and discuss them with the other team members. After all the goals are defined, the group should negotiate about the project goal. The goal should be refined after the negotiation by the initiator. When all team members understand and agree on the goal, the roles for the collaborating members should be identified. It is good to have some

negotiation about the different roles, so that all team members understand the importance of each role. When all the roles are defined, the roles can be assigned to the team members. The final task is to set up the working environment. This means specifying the information technology structure and defining the deadlines and work agreements. (Tellioğlu, 2008)

The third phase of CLC model is the operation phase. In this phase the team members start with their work and the actual communication and coordination is performed. One of the main underestimated issues in collaboration is the change management. It is important to discuss changes in the project goals, scope, roles or organizational structures. (Tellioğlu, 2008)

The last phase of the project is the decomposition. This phase starts when the project goals are reached and it starts with publishing the results of the project. After the results are published it is important that the group members keep in contact. Like this the group members have a chance to create a network and next collaborative projects can be easier. Also the coordinated work environment and workgroup are decomposed in this phase. (Tellioğlu, 2008)

8. COLLABORATION BETWEEN SUPPLY CHAIN AND RESEARCH AND DEVELPOMENT

The relationship between the Research and Development department and the supply chain is an important but complicated relationship. Both functions are able to affect each other performance in a positive and negative way. First of all the Research and development department is creating the products that have to be manufactured and distributed within the supply chain. This means that the research and development department is determining a large portion of the supply chain costs. At the same time, the outcome of the research and development department depends on the supply chain. This is due to the fact that decisions made in the supply chain are contributing to the success of the product development. Decisions like supply chain structure, positioning of the production sites and warehouses and outsourcing concepts are influencing the outcome of the product development. (Pero et al., 2010).

As mentioned before in this thesis, it is proven that there is a clear relationship between collaboration and improved new product development processes. Several researchers have concluded that collaboration enables product development to accelerate. When focussing on the collaboration between research and development and supply chain there are several advantaged for the NPD project team. (Hilletofth & Eriksson, 2010)

NPD requires an overview from strategy to commercialization. This leads to incorporation of several functions like, marketing, sales, product development, manufacturing and distribution. In this case the supply chain management is able to provide feedback from for example the logistics and distribution perspective in the different stages of the NPD project. Another advantage of the collaboration is that the supply chain design can be created parallel to the NPD process. (Hilletofth & Eriksson, 2010)

The NPD project should be driven by the customer's needs, rather than by technological improvements alone. This requires knowledge about what the customers actually want. This means that the company should not only question what kind of the product the customer wants, but should also be interested in information regarding the customer's service needs. The supply chain solution can be adapted to the customer service wishes. (Hilletofth & Eriksson, 2010)

In order to have a successful market release, the product should be segmented, as customer demands can vary a lot. The connections to supply chain management are that customers demand different lead times and service levels as well as the preferred supply chain solution. Moreover it can be discussed that operations should be focussed on the same customers segmentation in order to develop a truly customer driven product development. (Hilletofth & Eriksson, 2010)

One more advantage is that NPD is creating continuously new products, which does not bring the customers only a physical new product. The customer will also purchase a package and services. These issues should already be considered in NPD project but will be part of the supply chain solutions. By involving the supply chain management in the early phases of the development, information exchange can be optimal and the development process can be parallel. (Hilletofth & Eriksson, 2010)

NPD is focussing on developing new products. This means over the timeline several new products are released. Decisions about how and when to properly phase out older products should be made together with the supply chain management. (Hilletofth & Eriksson, 2010)

PART III: EMPERICAL STUDY

In this third part of the thesis the current situation of the case company is described. The first part of the chapter describes the current product development process and the second part describes the supply chain and the processes within the supply chain function. In the following part the product implementation process is described. The last part of this chapter presents results and analysis of the interviews that are conducted for this research.

9. The product development process

The case company has defined 5 core processes that describe how the organization is operating. These core processes that are globally the same are: Customer (sales and marketing related processes), Delivery (sourcing, delivery chain and installation), Maintenance (maintenance operations and spare parts management), Solution creation (research and development related processes) and Management support (company and management and supported processes). The 5 core processes are shown in Figure 10.

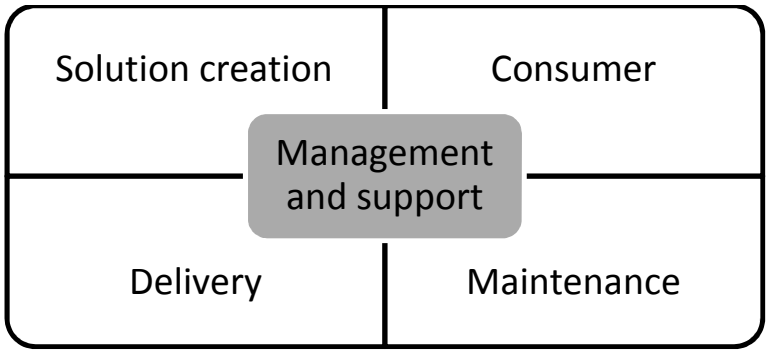

Figure 10: The case company's 5 core processes

The new product development process belongs under the Solution creation core process under which there are four phases of product development. These four phases are not only dividing the NPD process, but also determine the structure of the research and development department inside the case company since each phase has its own department. These four phases are shown in figure 11.

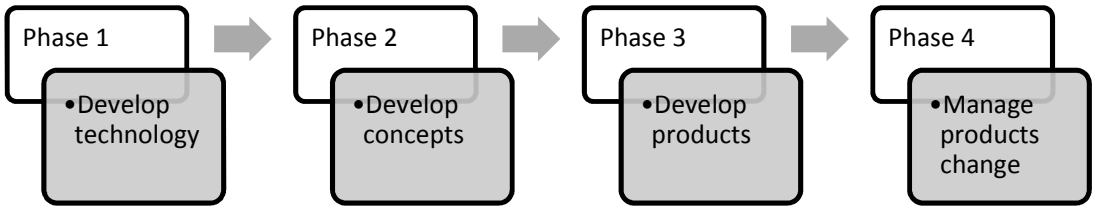

Figure 11: The solution creation process

The "Develop technology" is the first phase of the new product development process. In this phase basic research is performed in the research department. The research process aims to find concept and process ideas and enabling technologies for the next phase, the Concept Development. The average time span for a research project is 3 to 6 years.

Data that is used as input in the research is collected from research institutes and innovators, Innovation Tool (tool used inside the organization), Expert Forum and marketing feedback. The employees of the case company are also able to contribute to the innovations with the innovation tool in the company intranet. The ideas posted in the innovation tool are studied further by an expert. Employees with a patentable idea can also contribute by filling in an invention closure form and sending this to the patent office for further investigation.

The main tasks of the research department are:

- Maintains Strategic Research Areas (SRA)
- Maintains Research Portfolio
- Negotiates contracts (partners / consortiums)
- Evaluates invention disclosures
- Facilitates IPR-trade
- Follows patents (Patenting landscape)
- Runs patenting process
- Supports/facilitates public funding
- Participates in code/standard coordination

After the first phase is fully conducted, the second phase of the product development can start. In figure 12 there is a schematic drawing of the different stages of the product

development. The product development process phases are further divided into smaller parts; this will be explained later in this chapter.

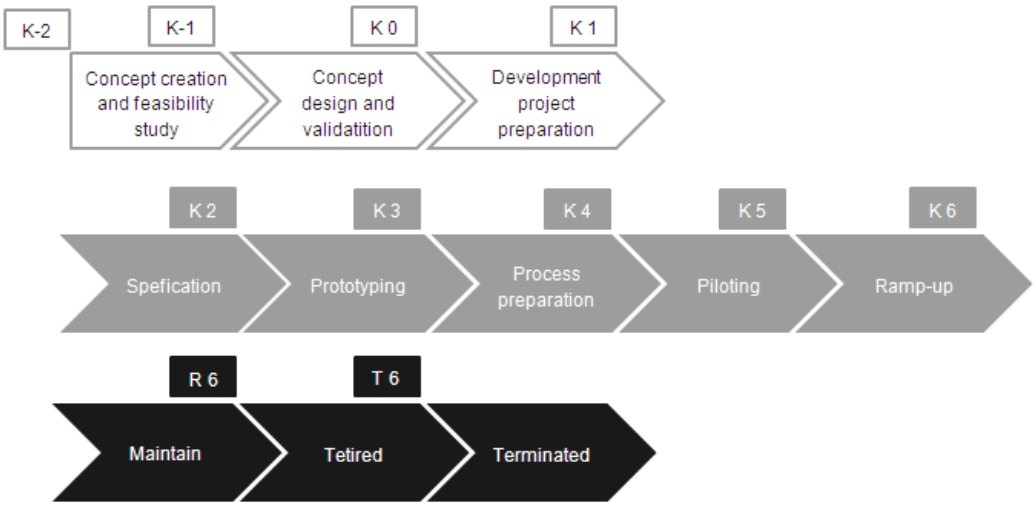

Figure 12: The product development stages

After the idea of the new product comes out of the first phase, the idea will be forwarded to the second phase of the R&D department. The first phase department is in charge of developing the concept. The main phases in concept development are:

- Concept creation and feasibility study
- Concept design and validation
- Development project preparation

The main objective in the second phase process is to reduce uncertainty. This means in practice that the second phase is testing relevant uncertainties. The biggest thinkable uncertainty will be tested first in order to stop non-potential research as soon as possible. The milestones the concept has to pass, span from K-2 until K-0.

After the product concept is developed, the product development process will continue and proceed in the third phase of the proces. The third phase process is developing the new product and the related processes (tools, instructions and processes for supply chain and front lines). This means that the technology and concepts are commercialized. The main inputs for the this phase are:

- Verified and described concept

- Business case
- Preliminary definition
- Definition of the concurrent project organization and steering group

At the moment there are two methodologies used in the third phase to develop new products. The most used and well developed methodology is the stage-gate model. The company is, however, currently testing lean and Agile product development methods. The case company is planning to implement this methodology in the future. However, lean and agile product development is still under development and the tools and processes needed for this new product development method are still being developed. Currently a few lean and agile NPD project have been run. The feedback so far is positive and promising.

9.1. The third phase of product development with stage gate model

Most of the product development in the third phase is done following the concurrent engineering model. This model consists of several parallel and interconnected activities. The overall product development process is described in the Product Development (PD) matrix where the different concurrent activities are represented as rows. The main phases and milestones in the product development are represented in the columns.

During the third phase a stage gate model is used to keep track of the projects process. Every milestone includes criteria that have to be fulfilled. After all criteria from the stage are fulfilled, the Milestone is granted to the project. Part of this state gate model is shown in the figure 13. The criteria used to determine in which stage the project is, cannot be shown for confidentiality reasons.

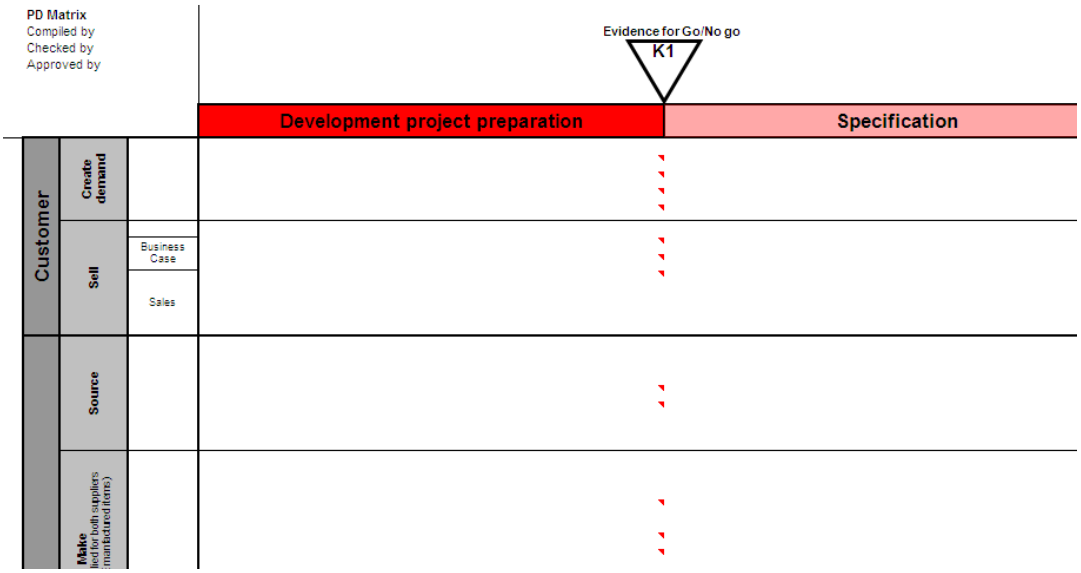

Figure 13: The stage gate model

The stage gate model is consists out of the following phases:

- Development project preparation
- Specification
- Prototyping
- Process preparation
- Piloting
- Ramp-up

In the development project preparation stage (K1) the main goal is to validate the business case of the developed concept, and create detailed requirements specification that defines the performance and features to meet the market and customer needs. In the specification stage (K2) the main tasks are to validate the cost targets and the product design, and create technical specification and project plan with the corresponding implementation and piloting plans. In (K3) the prototyping takes place. This means that the technical specification will be broken down into a detailed specification and a technical design has to be developed.

When the prototypes are ready and approved the process preparation stage (K4) can start. In this stage the implementation of the product into the delivery chain starts. The delivery chain consists of selling, ordering, sourcing, manufacturing, delivery and other processes. Also documents related to the piloting of the product have to be prepared at this stage. In the next stage, Piloting stage (K5), the piloting will start. Piloting tests the delivery chain.

The main purpose is to validate and finalize the processes and tools for the production ramp-up. The products that are produced in the piloting stage will already be installed at the customer. In the last stage, also known as the Ramp-up stage or K6, the product will be released to the market. This leads to ramping up the sales, deliver volumes, finalizing the product and making sure that the processes perform according to the requirements.

When the project has gone through the second phase, a project manager will be appointed to continue the project in the third phase. This project manager will coordinate the project throughout the whole third phase. The project manager will have to get resources (result providers) through contacting the stakeholders of each respective function. The stakeholders are usually the heads or directors of the different functions. The stakeholder will give a result provider to the project manager to help the project manager with the tasks that have to be fulfilled concerning the function.

In a special tool, the stakeholders have to keep track of progress of the project. In this tool all the criteria of the milestone are described. The result provider has to fulfil these requirements and the stakeholder can colour the criteria green, yellow or red according to the progress of the project. When the task has no progress and it is not ready yet the criteria is red. When the task has been completely fulfilled the criteria is coloured green. When the task is partly ready, but has considerably low risks on the project success, the stakeholder can colour the criteria yellow.

9.2. The third phase product development with lean and agile approach

Inside the case company the lean and agile methodology is a mixture of lean thinking and the agile way of working. Scrum is used during the daily work. Currently the case company is experimenting with lean and agile product development. Research has been done inside the organization concerning the lean and agile product development and at the moment the methodology is tested by running a few pilot NPD projects. The first project that used the lean and agile product development method has successfully launched the product on the market. The feedback from the product development team and project manager is positive and promising. Also the supportive functions that had to participate in the lean and agile NPD project have been very positive. The functions mainly enjoyed monitoring the progress of the other functions instead of only being focused on their own.

The next NPD project that has been chosen to use lean and agile product development has started recently. This project has been able to improve certain issues that were not solved the previous project.

The lean and agile NPD project start with the same step as the NPD with the stage gate model, by nominating the project manager for the NPD project. The project manager then meets with the chief designer, the third phase process owner and a quality representative to define the stakeholders, vision and the backlog item list.

After this the project manager contacts the stakeholders. The stakeholders define the items for the backlog and make a rough schedule together with the project manager. The stakeholders also nominate the result provider of the function. The result provider will be part of the project team and is expected to be 100% available for the NPD project.

When the third phase NPD starts the team comes together and gets a short introduction about the lean and Agile methodology and practices. Further learning about the lean and agile methodology will happen in the project during the work. It is also important that the project team members know each other and can function well as a team. Consequently there is a “kick-off” meeting at the beginning of the project where the project members will get familiar with the project and each other.

The project is works in sprints of 2 to 4 weeks long. In general the project is starts with 2 week sprints, but when the project starts to become more mature the sprints can be prolonged up to 4 weeks. During the sprints, the project members will meet daily in their daily stand up meetings. At the daily stand up meeting everyone is expected to be at the “project room” or at “project wall”. Team members that are at a different geographical location can attend the meeting by teleconference or similar tools. A “Project board” – a visualization tool- is shown in the project room or on project wall.

As lean and agile methods emphasize on making the projects as visual as possible, a project board, containing tools for showing the progress, schedule and backlog, is used. Figure 14 shows an example of a project board. On top of the project board the projects

vision is clearly marked. Project backlog is shown under the vision. The project backlog always contains four boxes: To do, in progress, verify and done. The project can mark the tasks in the right box and move this during the daily stand up meeting when the needed progress has been made. The risk chart shows where the main risks of the project are at the moment. The product roadmap is showing the release plan of the product. It contains the information about which releases and in which order and with what content will happen.

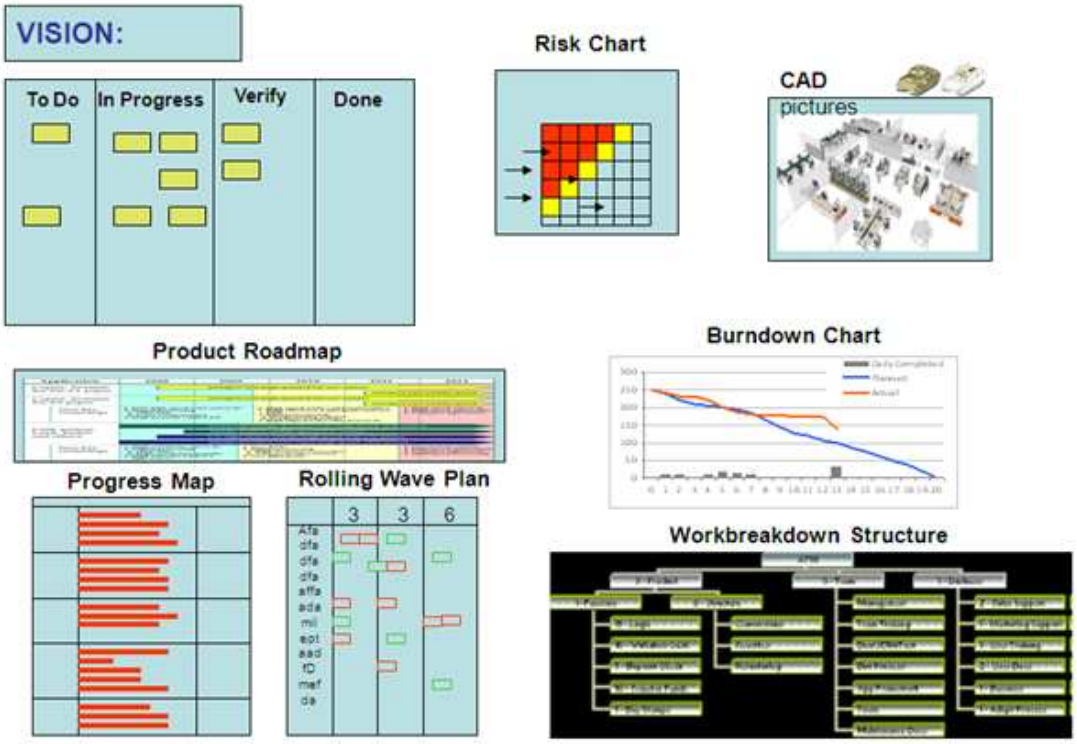

Figure 14: Example of the project board

The burn down chart shows the amount of work done in comparison with the estimate of total work. Further, the progress map shows how much progress has been made per function. The rolling wave plans shows the planning for the coming 3 sprints, the next 3 sprints and the 6 sprints after that. The work breakdown structure chart is showing the amount of work ready in comparison with the total amount of work. The last visualization is the CAD drawings.

After every sprint, there is a sprint review where the sprint goal is reviewed. At this meeting there will also be a demonstration, drawing or prototype shown. This

demonstration, drawing or prototype shown helps visualizing progress of the project and to show how far the project is in the development of the product. All team members have the opportunity to comment on the demonstration, drawing or prototype. In the sprint review the project manager and the project team will also set the new goal for the next sprint. Stakeholders attend every second sprint review. These sprint reviews allow stakeholders to comment and influence the project. The stakeholders will only attend the meeting when their function has been active in the project during the last four to six weeks. After the sprint reviews the stakeholders did not attend, an A3 (A lean tool whereby all information is shown on one A3 paper) newsletter will be send to them by the project manager to keep the stakeholders informed.

The project manager and the project team members also meet regularly to discuss the new user story that the project members are going to do. As the project manager does not always have enough knowledge about the item, the project team members can explain the project manager what the main complications are and how many working hours he or she needs per user story or task.

As the organization is still experimenting and piloting the lean and agile methodology there are still a few challenges that have to be overcome. The first challenge is the measurement of the project progress. The project progress is in the current product development method shown by the last granted milestone. As there are no milestones in the lean/agile method, the project progress cannot be easily shown. The product readiness is visible with the demonstration, drawing or prototype shown during the sprint review, but this does not show the progress of the NPD project.

Another challenge that the lean/agile methodology is facing is the resource allocation. The organization is used to resource one person in several NPD project. In the lean/agile methodology the resources should be 100% available for one project at a time. In the current organizational structure the supporting functions do not yet have enough resources for these resourcing requests.

Team members have no or very limited knowledge about lean/agile methodology. Before the lean/agile NPD project is started the team members will get an introduction about the

methodology and its principles from an internal lean/agile coach. After this the team members have to manage on their own. During the project the team members can contact the lean/agile coach when some aspects of the methodology are unclear. The last challenge is the geographical location of the team members as the lean/agile methodology requires physical presence during the meetings. Because the organization is operating and developing products worldwide, some of the team member are not able to attend a meeting physically. The current tools and videoconference possibilities available in the organization are not sufficient to replace the physical presence.

Currently the main advantages of the lean/agile NPD project have been discussed by the project team and the main advantages were recognized by all the team members. The first advantage they identified was the good collaboration between the team members, the different units and between the organization and the supplier. This improved collaboration has brought speed and better quality to the project. The next advantaged recognized is the transparency the methodology brings. The project members are able to see what is happening in the different functions and problems can be prevented and solved quickly and easily. The last advantage that was mentioned by the project manager was the commitment of the team members. Because the team members are 100% available for the project, the team members are much more involved in the project.

10. THE SUPPLY CHAIN

About 2800 people are working in the supply chain worldwide. About 80 percent of the raw materials needed for the products and parts are bought from approximately 100 different suppliers. Main targets in the supply chain are ensuring timely, quality and cost competitive supplies.

The supply chain has a clear structure. The supply chain embodies of suppliers, distribution centers and customers. The direct suppliers are also known as first tier supplier. The supplier of the first supplier is known as the second tier supplier. The third tier supplier is the supplier of the second tier.

Suppliers are selected by the sourcing department. Sourcing is responsible of making the contracts and agreements with the suppliers. The supplier quality management (SQM) function inside the sourcing department is ensuring the quality output from the supplier. SQM is certifying suppliers with the color codes bronze, silver, gold and platinum. The better the color, the better and preferable is the supplier. SQM employees will also visit the supplier on a regular basis and make improvement plans together with the supplier to strive for a continuous improvement of quality. Quality is very important for the case company, as suppliers are delivering their components or raw materials direct to the distribution center. Products will be assembled for the first time at the customer's location.

The distribution centers are not managed by the case company but by logistic partners. The logistic partner can differ per location. In total there are 6 distributions centers around the world, 3 in Europe, 2 in America and 1 in Asia. The distribution centers are delivering their components to the customer. In some cases the supplier can also deliver the component directly to the customer. The product is assembled and installed by the installation department at the customer site. The components are assembled for the first time together at the customer site, this requires high quality standards from the case companies own factory and suppliers. For the spare part supply there is one distribution center that is only handling spare parts.

The case company customers are located all over the world, as this company is operating global. Products can differ per continent and sometimes even per country. The supply chain is illustrated in the figure 15.

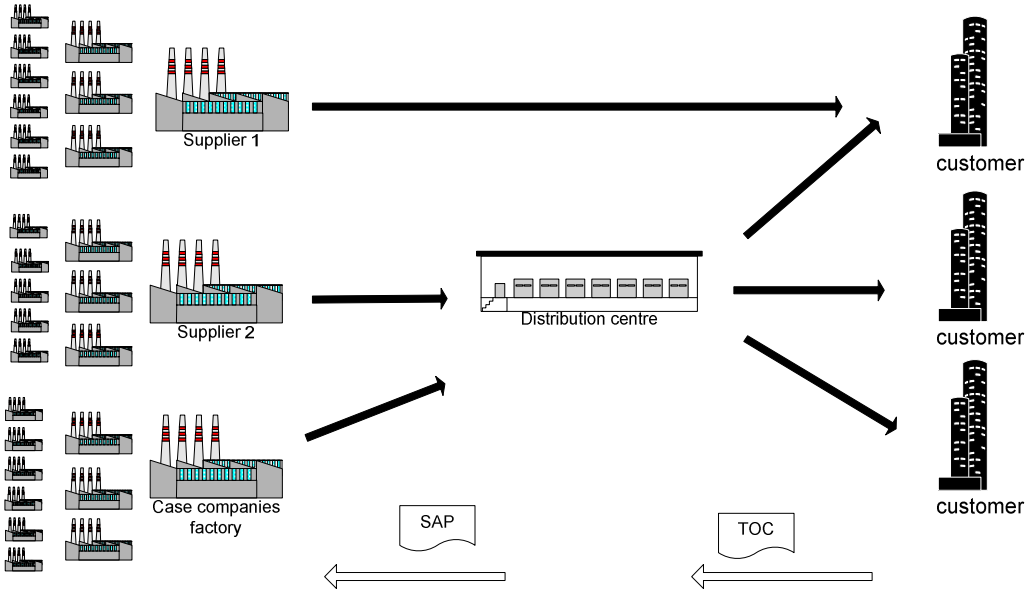

Figure 15: The supply chain from the case company

The data flow is going in the opposite direction as the goods flow. The data flow starts from the customer. When the customer orders a product, the order is recorded in the tendering tool. This tendering software is making the order official. In the order all the agreements with the customer are visible. The tendering software order is then transferred to the Enterprise Resource Planning system. In the Enterprise Resource Planning system the order will be transferred into product components and materials so the product can be compiled and manufactured.

The supply chain process is part of the Delivery core process. This core process is split-up into 5 different processes: source, make, fulfill and install, plan and return.

The main purpose of the Plan process, which is done on a monthly basis, is to balance the supply and demand for the coming 12 months. This process is performed monthly because of anticipation on any possible changes in future demand, and especially to support growth, balancing the supply in order to satisfy the demand.

The Source process is completely handled by the sourcing department. In the Source process strategic sourcing is done with the BENIM method (Baseline, Evaluate, Negotiate, Implement and Manage). With the BENIM method the best supplier is selected and the contracts signed and managed. One other important part of the sourcing process is the

supplier quality management (SQM) processes. This process ensures the continuous flow of high quality products from the suppliers. The SQM process is tightly linked with other processes, especially the BENIM process. The SQM process exists out of three phases: Qualification and Preparation of Suppliers, Measuring and Monitoring of Suppliers, Improvement and Development of Suppliers.

The Make process is mainly handled by the Supply Unit (SU)). SU is manufacturing the critical components of the products. All critical components for the new products are always manufactured by the case company itself. The manufacturing operations are in seven locations worldwide.

The Fulfill and Install process aims to optimize the delivery towards the customers. The process begins at the moment the front line receives an order and ends when all payments have been received. The Fulfill and Install process is managed through a stage-gate model. The stage gate model is operating as a backbone in every Fulfill and Install project. The main goal of the stage-gate model is to increase productivity and speed in operations and to harmonize the operations. Figure 16 shows the stage-gate model schematically. The criteria used to determine in which stage the project is, cannot be shown because of confidentiality reasons.

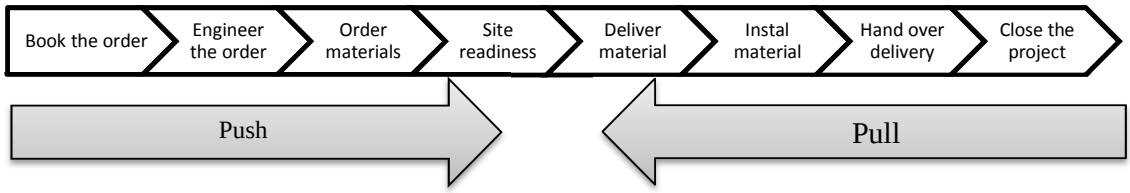

Figure 16: Fulfill and install stage-gate model

The stage-gate model includes a push and pull site. The push stream involves reaching approved specifications and a total cost overview as soon as possible. In the pull stream the manufacturing and installation of the necessary equipment is started as late as possible respecting the agreed handover date to the customer.

The logistics process is also part of the Fulfill and Install process. Logistics is managing the delivery network through focused management of the real time information and material flows. In addition to that logistics is also optimizing the information and material flows to support the global operations. The packaging of the products is also under the responsibilities of logistics.

The last process inside the Delivery core process is the Return process, which is used when the front line is sending products to the supply line or when products are sent from the case company to an external supplier. The Return process is covering three scenarios where products have to be returned: return of defective products, return a product for maintenance or repair and return excess products.

10.1. The preparation for ramp-up process

The preparation for ramp-up process is inside the case company known as the new product implementation process (NPI). The NPI process is part of the NPD process. The NPI process is implementing the new product into the supply chain. The NPI process is part of the third phase of product development process in the case organization.

The main goal of this process is to get the product implemented into the supply chain, so the products can be sold and delivered to the customer. The NPI process is driven by the project manager. The project manager has to activate and manage the other functions when they are needed in the process.

Every NPI process should start with a kick-off meeting. In this meeting all the involved people come together and discuss the scope and schedule of the project. After this meeting all the involved functions should act as agreed. The active parties in the NPI process are: Sourcing, Variant configuration, Logistics, Quality, Manufacturing and Design.

The sourcing function is selecting the right supplier and negotiating about the price and quality conditions with the selected suppliers. Furthermore sourcing is making and signing the contracts with the supplier. The supplier quality management is also a task inside the sourcing function. To be certain that the supplier can fulfil the needs of the case company, some audits will be done by SQM. After the audits an agreement will be made with the supplier on how the supplier can improve their capabilities. All suppliers will also be

graded. There are 4 different grades possible. The most preferred suppliers are the suppliers with the highest grading.

The variant configuration function is responsible for creating the product structures in the ERP system and other IT tools that are used during the product implementation and later when the products are released.

The logistics function has three tasks in the new product implementation process. The first task is to organize the logistic outlook and process. In practice this means selecting the right logistic partner, selecting and preparing the distribution centre and calculating the transportation times and costs. The second task that the logistic function has is the task of creating the materials in the ERP system. The third task is to create packaging for the new products

The quality function is assuring that the quality of the product is going to be sufficient. This means that quality is agreeing on the quality levels that have to be reached during the production of the product. Quality is working closely together with other functions.

The manufacturing function has several tasks in the new product implementation process. In the beginning of the third NPD phase the factory management is helping the project with the manufacturability of the product. As the final result of NPD project is the new product in mass production, it is important to design products that are manufacturable. Another task that the manufacturing and souring are doing together is the Make or Buy decision. Here the functions will decide together with the project manager which components are going to be bought and which components are going to be made. After this decision the production plans can be made. Production plans contain practical information about how the product is going to be produced and financial information about the costs of the production and the investments needed.

Design is making the actual product. The design team forms the actual project team together with the project manager or project owner. The design team draws a 3d model of the product in 3d drawing software and is responsible for the product design. Design is also involved in the product testing.

All the tasks that the functions have to fulfil are done by the result provider. The result provider is a person that is named by the stake holder. The stake holder has to approve the tasks done by the result provider. Some smaller functions have stake holders who are also acting as result providers.

11. RESULT OF THE INTERVIEWS

Interviews were held to map the current state of collaboration between the research and development department and the supply chain functions. These interviews are the main input for this research. Multiple people from the different departments recognized the need for improvement. In the earlier chapter is a summary of the interviews. The interviewees' positions range from managers to directors and heads of departments. From every department a same amount of people have been interviewed, the size of the text per function is only varying. This is due to the fact that some participants did not have so much input as others. Also some departments give collaboration a higher prioritization than others. An overview of the people who were interviewed can be seen in Appendix 2.

The goal was to find out interviewees' perception of the state of current collaboration between the research and development department and supporting supply chain functions. Also their opinion about collaboration in general and how they are currently working on better collaboration was pointed out. Furthermore did the interview try to address possible improvement proposals from the interviewee. The questions that were used in the interviews can be found in Appendix 1.

Project management

In total there are five project managers interviewed for this research. There are two senior project managers and three middle level project managers. All project managers agree that the collaboration between the R&D and supply chain could be improved. The average grade given by the project managers is 5 out of 10.

The project managers have a common understanding of what collaboration is. They all agree on that collaboration is several parties working together in order to reach the same goal. One project manager added also that trust and transparency are very important factors for him. The reasons given for the bad collaboration differ among the interviewed project manager. Some project managers claim that there is no clear understanding of who is responsible for what. Other project managers claim that the supply chain functions have too little resources to fully support the R&D projects. One project manager gave as reason that the supply chain is giving high enough priority to R&D projects high enough and therefore there is no commitment from the function.

On the question concerning what the project managers themselves do in order to improve the collaboration the answers varied a lot. The project managers answered that they tried to communicate more often by mail/phone, update the result providers or simply don't do anything extra.

Sourcing

From the sourcing function seven different people were interviewed. The interviewed people represent different levels on the sourcing organization. All of them recognized the need of better collaboration between the research and development department and the sourcing department in the new product implementation process. Some examples came up where the project team had made a contract with a supplier but the sourcing had not been involved. When the sourcing department found out about the contracts there was no correction to the contract possible anymore.

The sourcing function notified that the collaboration of the NPD project depends a lot on the project manager. There are projects where the collaboration is working, but there are also projects where collaboration is hardly or not seen at all. This can also be seen from the grades that the different employees from the sourcing function gave on the collaboration. One interviewee gave a 7, while another gave 3 out of 10.

The sourcing manager that was interviewed had also been involved in one of the lean and agile piloting projects. This sourcing manager was very positive about the methodology and he felt that the collaboration was improved during the project. According to the sourcing manager the main reasons for the improvements are the obligatory stand up meetings where the whole team is meeting every day and the sprint reviews after every sprint.

Logistics

When it comes to packaging function there is still a lot to improve according to the packaging manager. The product designers do not know much about the packaging solutions, this leads often to components or products that are hard or impossible to be packaged. The packaging manager is aware, that the packaging function could do something in order to improve the collaboration. He started some clarifications regarding

the packaging process by making a clear picture of who is responsible for what He has also made a presentation about the packaging process that can be used to introduce new project managers. The packaging manager is not that negative about the collaboration, as he knows that both departments are doing their best. When grading the collaboration on a scale from 1 to 10, the manager would give a 6.

The logistics department is also responsible for the logistics process. The representatives of this function admitted that there is still a lot to improve on the collaboration with the research and development department. The logistics representatives pointed out a few things that they consider very problematic. Firstly is the project “kick-off” meeting. The logistics representatives said that the project kick-of is unstructured and are sometimes not taking place. Another problem that was pointed out is the different behaviours of the project managers. The project managers are having different communication methods and different ways of working. Some of the project managers involve the logistics department on too short notice, which is causing frustration and chaos on their side. Others do involve the logistics on time, but the communication is bad.

One of the logistics representatives had been involved in the lean and agile NPD piloting project. This representative was optimistic about the project, but pointed out that this might be possible because it is a new methodology. The representative thinks that the targets and idea setting behind the methodology is good, but that the organization should use lean and agile for product development and not too much for emphasizing creativity. Another issue that the representative pointed out was the physical presence in the lean and agile projects. If more R&D projects used the lean and agile methodology, there would not be enough resources available in the logistics department. The manager also noted that more training on lean and agile would be necessary as it was sometimes difficult to follow and understand the structure of the methodology.

The last task of the logistics function in the NPD projects is the material management. This task has caused some difficulties in some previous project. The representative for this task also claimed that there is still a lot to improve on the collaboration aspect. He mentioned that there is still a lot to improve on the communication, since there is not enough contact between the project team and the supporting functions. He would also like to see that the supportive functions can give feedback on decisions that are made during the project. Last

point mentioned is that he would like to see a more standardized way of working in the NPD projects. Currently it is hard to handle the different working styles.

Manufacturing

The manufacturing representative in Finland thinks that the collaboration depends a lot on the project and the project manager in charge. The manufacturing prefers the project manager to come to the factory and discuss the project, schedule and other needed information in a face-to-face meeting. Also when there are changes made or things have to happen in a different manner than earlier discussed they prefer the project manager to come to their office and discuss. Two of the three manufacturing interviewees think that the project manager often asks too late for involvement or results. The members of the manufacturing process would also like to be more involved in the product development. One of the interviewees felt that he does not have any influence on the NPD project, but that the product is just “pushed” to his manufacturing process. The grade that the manufacturing function would give on the collaboration from 1 to 10 is a 6.

12. ANALYSIS OF QUALITATIVE RESEARCH

In the new product implementation process the supply chain functions and R&D are required to work closely together in order to make the new product implementation successful. As mentioned in the literature (Hilletofth & Eriksson, 2010) there are many advantages for a collaborative NPD process. Also in practice it can be seen that the time to market is heavily depending on the collaboration between the R&D and the supply chain functions.

Almost all interviewees agree that the collaboration between the R&D and supply chain functions is not optimal and that could be improved. They all agree that both departments are well willing to collaborate but there are certain aspects that prevent them from collaborating at an optimal level. When it comes to the goal setting in the collaboration, all departments agree on the same goal during the NPI projects; to bring the new product as fast and well to the market as possible.

The new lean/agile product development has a positive effect on the collaboration between the R&D and supply chain. The interviewees who have worked in a lean/agile NPD pilot project are all positive and enthusiastic about this methodology. The main reason for this optimism was that the team members felt more involved in the project and felt that they had a real impact on decisions that were made during the project.

It should be noted, however, that this optimism and high interest might be due to the fact that the methodology is new and the project differs from the “usual” NPD project. People might be more willing to spend time and interest on it. Therefore the results of the first piloting project can be different than future lean/agile NPD projects. It should be noted, that the lean and agile methods implementation is not going to happen soon. The lean/agile implementation is a long term project. The second piloting project has only just started and there are still issues (project control and the physical attendance in global projects) that have to be solved. Another problem during the pilot projects is the resourcing and training in the supply chain functions. When lean\agile product development will be implemented, it also means that resources from the supply chain functions have to be fully committed to the project and cannot participate in many projects at the same time, as it is in the current situation. The stake holders have to attend the sprint reviews every 4-6 weeks, which can be demanding for these people as they have also daily operations to attend to.

At this point the lean/agile methodology seems to solve many of the collaboration issues, but as the full implementation is not scheduled yet, this thesis will focus on the stage-gate methodology that is currently in use for most of NPD projects. Also the factors that are affecting the relationship between R&D and supply chain are only focussed on the current projects that are using the stage-gate methodology. The data gathered through the interviews about the lean/agile methodology is not representative yet.

The main factors that are affecting the relationship between the R&D and supply chain negatively within the case company are:

- Communication

  Communication is one of the factors impacting the success of NPD (Brown & Eisenhardt, 1995). In the qualitative research the functions inside the supply chain all agree on the fact that there is no or bad communications between the R&D and supply chain. The functions also commented that the communication mainly goes through email, while they prefer to have a direct conversation by phone or face-to-face meetings. Further do employees not know when to communicate to each other.

- Product development methodologies

  During the qualitative research became evident that the methodology used during the NPD project has a lot of effect on the collaboration between the supply chain and the R&D. In the lean/agile methodology all interviewees felt that the collaboration was better. Main participants gave as main reason the daily stand up meetings and the sprint reviews that is are organized more regularly than the gate meetings. The participants also felt that the stakeholders were more involved in the NPD project than in the stage-gate methodology.

- Project manager capabilities, personality and working style

  The project manager has influence on the product development process performance and product effectiveness (Brown & Eisenhardt, 1995). In the interviews the participants from the supply chain functions agreed on the fact that the project managers have different capabilities, personalities and different working

styles. This causes problems as some project managers would like to get feedback and involve the supply chain functions in the NPD project. Other project managers tend to do more work themselves and ask the supply chain functions for help only when they need approval or have a problem. This makes it hard for functions to schedule resources and to create a standard working method on their side.

- No standardized working practice

  In the interviews the interviewees' from R&D and the supply chain, mentioned this point as an important factor in the collaboration. The project managers do not have standard directives on the way they should work, some of the project managers told that this is one of the main reasons that they do not know how to collaborate. They do not know if the supply chain function or the project team is responsible of the action or activity needed in the NPD project. Also the functions in the supply chain are confused on their responsibility. Some functions told that some of the task or activities are sometimes done by the project team, but in other cases the project teams expects the supportive function to do the task or activity. In literature also Jassawalla and Sashittal (2000) agree on the fact that a standardized working practice is needed for efficient knowledge transfer.

- "Kick-off" meeting

  In the qualitative research became clear that the kick off meeting forms a good basis for collaboration. Even though the kick off meeting should happen currently in every NPD project, the supply chain functions noted that this is not the case at the moment. When there is a kick-off meeting at the start of the NPD project, the kick-off meeting is many times messy and/or unorganized. The supply chain functions would prefer to see a well-organized kick-off meeting where all functions are attending and where the agenda is made before the meeting. In addition to that the supply chain functions hope that they can expose their doubts and issues concerning the project at the "kick-off" meeting. In the kick-off meeting the general project goals should become clear and explained to all participants.

- Not enough resources on the supply chain side

  In some functions of the supply chain (sourcing and manufacturing) there are not enough resources at the moment to fully support the NPD projects. The resources at these functions have too many on-going projects to support and cannot give the needed input. The project managers named these departments and also the departments themselves realized that there is a shortage in resources.

- Lack of priority on the supply chain side

  In the qualitative research some of the project managers named that lack of priority on supply chain side is the main reason for the current collaboration level. The supply chain is very busy with daily operations and therefore does not have enough time to focus on the NPD project. Some of the interviewees on the supply chain side also agree on this fact. Lack of priority has a bad impact on the NPD successfulness. (Jassawalla and Sashittal 2000)

12.1. Collaboration with the lean/agile methodology

Literature and practice shows that the collaboration within LPD and agile product development is better than in traditional product development methodologies. When comparing the main principles of lean and agile product development with the requirements for effective technology and human interaction, which is presented in appendix 4, there many similarities. The only requirement that is missing is routinely cross-functionally trained employees. This requirement will be added as improvement proposal in the next chapter as it would improve the collaborative environment.

There are some practices that improve the collaboration in the lean and agile product development which are not present in the current stage-gate product development. These practices were identified by the participants of the qualitative research:

- Daily stand up meeting

  The daily stand up meeting is providing a daily contact between all the participants of the project. All participants can tell about their daily tasks and problems they are facing. Other team members can comment and help the participants. Through this daily task discussion team members get familiar with other processes than their own.

- Physical attendance of the meetings

The participants of the qualitative research found it very pleasant to meet other members of the project physically. The physically presence makes it easier to discuss issues and makes it easier for the participants to trust each other. Also in literature the physical presence is expressed as positive for collaboration (Patel et al., 2012).

- Sprint reviews

The sprint reviews make it possible for the team to see the product and its readiness. It allows team members to visualize the project and its product. The sprint reviews also make the senior management committed to the project. The senior management will meet the project manager every second sprint (4-8 weeks), which is much more regular than in the current product development method. Patel et al. (2012) showed in their research that commitment to the project from senior management is helping to create a collaborative working environment.

- More visualization

The visualization used in the project makes the current stage of the project and the product clear to every team member. Also the team members have the feeling that they have to spend less time on information gathering, as one picture can show many pages of text.

All these practices can be referred back to agile product development methodology. In the case company the daily way of working is dominated agile product development. The lean methodology is used as way of thinking, minimizing the waste and efficiency improvement.

PART IIII: DISCUSSION

In this last part of the thesis the improvement proposals are presents and the prioritization of these. This part is finalized with a conclusion, reliability of results and future research.

13. IMPROVEMENT PROPOSAL

As the literature is showing numerous examples of the advantages on a collaborative NPD project (Jassawalla & Sashittal, 1998), it is important that the collaboration in the NPI process is improved. This chapter presents the improvements proposed to the case company in order to optimize the collaboration between the R&D and the supply chain functions within the new product implementation process. The improvements proposed in this thesis are outcomes of the literature research and the qualitative research. The improvements proposed are presented in table 3. In this table the factors that are affecting the collaboration negatively are presented in the left column. In the middle column, the proposed actions are presented and on the right side the explanation for the proposed action is given.

Table 3: Suggested improvements to improve the collaboration

Factors that are affecting the collaboration negatively	Proposed actions	Explanation
Communication	– Communication training for the project managers and result providers of the supply chain functions – Clarification on how and in which period of time communication has to take place. (communication instructions)	The current project managers have all different way of communicating and different level of communication capabilities.
Working methodologies	– Implement best practices from the lean/agile	The lean/agile implementation into product development cannot

		methodology until lean/agile can be fully implemented	be realized in the very near future, as the supportive functions have to go through a transformation (training and resourcing). In the meantime the best practices from the agile/lean methodology can be used. These best practices would be the daily stand up meetings and the regular review with stakeholders.
Project manager capabilities, personality and working style	–	Consider collaborative aspects when hiring new project managers	New project managers should have the right skills
No standardized working practice	–	Clear process descriptions – Clear role descriptions – Clear description who is responsible for creating and doing certain tasks/activities and by who should validate this	Create work instructions for all the employees involved in the NPD project, so the know what they can expect from each other
Kick-off meeting	–	Require a kick-off meeting from every project. Make a template of the agenda for the kick-off and require the attendance of every participant in project	The kick-off meeting should make sure that the goals of the project are known among the supply chain functions and make sure there are common goals. In the kick-off meeting the scope of the project should become clear so stake holders can appoint the right result provider.
Not enough resources on the supply chain side	–	Address this problem to the head of the supply chain and the heads of the supply chain functions.	This thesis is written for the technology organization and therefore the only action that be expected from the technology

		organization is to inform the other organization
Lack of priority on the supply chain side	– Involve the supply chain functions in decision making during the NPD project	By taking part in the decision making process the supportive functions will feel more involved and give more priority to the NPD projects (Jassawalla & Sashittal , 2000)
Knowledge is not optimally used	– Collect lessons learned – Train employees cross-functional	With the collected lessons learned, best practices can be shared and discussed. Also problems that have occurred during one project can be prevented in the next project. By training the employees cross functional, the employees will get more experience in different fields and know better how to collaborate.

13.1. Prioritization of the proposed actions

Not all the proposed actions have the same impact and require the same amount of work to be implemented. Therefore it is important to prioritize the actions. There are three main actions that would require the highest priority. These actions do not require much effort but will have a big positive impact on the collaboration between the R&D and supply chain functions.

The first prioritization is the clarification of the processes and responsibilities inside these processes. By mapping the processes and responsibilities, the working methods should become more consistent and not only be dependent on the project manager. The process map will also create alignment in working methods and all parties involved in the NPI process will know other employees' responsibilities and their own responsibilities. This recommendation will create transparency and synergies in the NPD process.

The second main recommendation is the kick-off meeting in combination with the communication plan. The kick-off is a meeting at the opening of the project where project members should be able to discuss the issues at hand. One of the points that should be discussed is the communications channels and frequency. By allowing comments and feedback from the supply chain functions in the project, the supply chain functions should feel more involved and will give the NPD projects automatically a higher priority. This proposal will create commitment, improved goal setting and transparency.

The third main action is the implementation of best practices from the lean/agile methodology until lean/agile can be fully implemented. The main best practices related to the collaboration are the daily stand up meetings and the regular meetings and updates of the stakeholders. This action requires more work than the previous two actions as other functions than the R&D department have to be involved. The daily stand up meetings will improve the collaboration aspects of transparency, commitment and cross functional working. The regular meetings and updates of the stakeholders should improve the senior management engagement.

Two other recommendations that cost less in terms of work but that yield also less result are the collaborative skills and attitude addition to the project managers' recruitment process and implementation of the lessons learned. The implementation of the lessons learned should not take too much effort. There should be an agreement from all parties on how the lessons learned have to be made and where it has to be stored. The work that has to be done for the implementation is the creation of a template report or A3 template has to be made. Free access to the lesson learned from every member of NPD is primordial. The lessons learned should show where gaps in the processes are and can lead to improvement of tasks divisions. The collaborative skills and attitude addition to the project manager's recruitment process should lead to the emergence of project managers with the right collaborative skills. The collaborative aspects are described in the second chapter of this thesis.

One recommendation that requires continues work is the cross functional training of employees. This recommendation will have to be implemented as a long term project to improve the collaboration a lot. As mentioned in Appendix 4, this is one of the requirements for good collaboration. On short term this recommendation requires time and

high costs, as employees have to get experience in another than their current field. Support from the higher management to apply job rotation is a good way of training employees cross functionally. Of course also trainings can be applied, but in trainings are generally theoretically constructed, while in this case, a more practical approach would be more fruitful.

14. CONCLUSION

The aim of this research was to analyse and advice on how to improve the collaboration between the research and development department and supply chain within the new product implementation process.

In a previous research done in the case company it was shown that collaboration between the R&D department and other departments is poor. Current literature, however, points out the importance of good collaboration on NPD success. The new product implementation process is the most cross-functional part of product development in the case company.

Qualitative research formed the backbone for the empirical part of this thesis. This qualitative research was conducted in the form of semi-structured interviews inside the case company. The empirical part of this thesis answered mainly the following questions:

- What is the difference in collaboration within the current process and the LEAN/Agile product development?
- How does the current new product implementation process look like?
- What is the current state of collaboration between R&D and Supply Chain functions?

The findings of this thesis are that there are several factors that are having a negative impact on the current collaboration: communication, different working methods, project manager capabilities, personality and working style, no standardized working practice, no or bad organized kick-off meeting and not enough resources on the supply chain side, lack of priority on the supply chain side. In literature it was shown that some of these factors are connected to each other. The lean\agile NPD projects seem to have no problems with the collaboration. Main reasons for this finding is that the NPD team is meeting physically every day during the stand-up meeting, team members are fully committed to the project because of the 100% allocation to the project and the stakeholders of the NPD team are more involved.

The last part of the thesis provided proposals for improvement to eliminate some of the root causes distinguished behind the observed issues. As the literature is showing, there are many advantages on a good collaborative NPD process. Therefore it is worth for the case company to invest in collaboration and follow the recommendation.

The main recommendations are to clarify the processes and responsibilities inside these processes. By mapping the processes and responsibilities the working methods should become more consistent and not only be dependent on the project manager anymore. The process map will also create alignment in working methods, all parties involved in the NPI process will know what to do and who is doing what. The second main recommendation is the kick-off meeting in combination with the communication plan. The kick-of is a meeting at the opening of the project whereby issues can and should be discussed. One of the points that should be discussed during this meeting is the communications channels and frequency. By allowing comments and feedback to be given from the supply chain functions in the project, the supply chain functions should feel more involved and will give the NPD projects automatically more priority.

On the long term the lean product development should be implemented to maximise the improvement of collaboration. The literature and the empirical research show that the lean and agile methodologies are improving every aspect of collaboration. Lean/agile product development cannot be implemented on the short term as the methodology is not fully developed yet in the case company and also the supportive functions in NPD need to get reorganized in order to support the lean/agile NPD projects.

In general, it is always problematic for organizations to put the suggested improvement proposals into practice. Employees within an organization are used to certain ways of working and therefore feel comfortable with the way they always have been doing. By implementing the suggested proposals step-by-step, changes in the way of working are going slowly and will be easier to handle for the case company.

14.1. Reliability of results

The theoretical framework is gathered from widely accepted reference literature. Hence the theoretical framework is also applicable in other organizations than the case company. However, all organizations operate in their own way as the company culture and

environments differ per organization. This affects the chances of success of the proposed improvements gathered from the literature references. Some of the improvements in this thesis are results of the qualitative research that is done in the case company. These proposals were verified by the theoretical framework. Consequently the applicability of these proposals is dubitable in other organizations.

The effect of the proposed improvement can be different in the R&D centers in different geographical locations. This risk was mitigated by interviewing employees located in the different locations.

One factor that might have influenced the results in this thesis is the researcher bias, which means the feelings of the researcher. The influences were limited by making notes during the interview, asking same main questions in the same order in the interviews, using semi structured interviews, wearing similar clothes during the interviews and using the same meeting room for all the interviews.

However, the results from this case study cannot be generalized and results might be different in other companies in the same industry or other companies in general. This is one of the general limitations of a case study, as this research is only focussing on one company.

14.2. Future research

This research has been focussing on the collaboration in the implementation of the new product into the supply chain. Future research concerning the earlier phases of collaboration in NPD project could be very beneficial as well. In the beginning the basis of collaboration and the NPD is set. In many other companies there is not a separation of phases of NPD therefore it would also be beneficial to research in future how the separation of the different NPD phases affects the collaboration between the NPD and supporting functions. The last point that could be researched in future is the collaboration between all supportive functions and R&D in the NPD projects.

REFERENCES

Agile manifesto, 2001, http://agilemanifesto.org/, retrieved at 18-09-2013)

Barcak, Griffin and Kahn, 2009, PERSPECTIVE: Trends and Drivers of Success in NPD Practices: Results of the 2003 PDMA Best Practices Study, J PROD INNOV MANAG 2009, Volume 26, pp. 3–23

Bedwell W.L., Wildman J.L., DiazGranados D., Salazar M, Kramer W.S., Salas E., 2012, Collaboration at work: An integrative multilevel conceptualization, Human Resource Management, Volume 22, pp. 128 – 145

Brown, S.L., Eisnehardt, K.M., 1995, Product development: past research, present findings, and future directions, Academy of Management Review, Volume 20, Issue. 2, pp 343-378

Bruns, H.C., Working alone together: coordination in collaboration across domains of expertise, Acadamy of Management Journal, Volume 56, Issue. 1, pp. 62-83

Conboy K., 2009, Agility from first principles: reconstructing the concept of agility in information, Information Systems Research, Volume 20, Issue 3, pp. 329-354

Cooper, R.C., 1990, Stage-gate systems: A new tool for managing new products, Business Horizons, May-June

Cooper, R.G., 1993, Winning at New Products: Accelerating the Process from Idea to Launch (2d ed.). Cambridge, MA: Addison-Wesley

Cooper R.G., 2008, The stage-gate idea to launch process update, What's new, and NexGen Systems. Journal of product Innovation Management, Volume 25, pp. 213-232

Cusumano, M.A., Nobeoka, K., 1998, Thinking Beyond Lean: How Multi Project Management is Transforming Product Development at Toyota and Other Companies, The Free Press

Denning S., Why Agile can be a game changer for managing continuous innovation in many industries, 2013, Strategy & Leadership, Volume 41, Issue. 2, pp. 5-11

Dingsøyr T., Nerur S., Balijepally V., Moe N.B., 2012, A decade of agile methodologies: Towards explaining agile software development, The Journal of Systems and Software, Volume 85, Issue 6, pp. 1213-1221

Eisenhardt, K.M., 1989, Building Theories from Case Study Research, Academy of Management Review Oct89, Volume 14, Issue 4, pp. 532-550

Grimheden, M.E., 2013, Can agile methods enhance mechatronics design education, Mechatronics, http://dx.doi.org/10.1016/j.mechatronics.2013.01.003, to be published in the future, retrieved at 15-10-2013

Hannabuss, S., (1996) "Research interviews", New Library World, Volume 97 Issue 5, pp. 22 - 30

Haque B., and Michael James-Moore, 2002, “Characteristics of Lean Product Introduction,” International Journal of Automotive Technology and Management, Volume 2, Issue 3/4, pp. 378-401.

Hilletofth P., Eriksson D., 2010, Coordinating new product development with supply chain Management, Industrial Management & Data Systems, Volume 11, Issue 2, pp. 264-281

Hoek van, R., Chapman, P. (2006), “From tinkering around the edge to enhancing revenue growth: supply chain-new product development”, Supply Chain Management: An International Journal, Volume 11, Issue 5, pp. 385-9.

Holmdahl, L., 2010, Lean product development på Svenska, Göteburg: Digitaltrycknu

Jassawalla A.R , Sashittal H.C., 1998, An Examination of Collaboration in High-Technology New Product Development Processes, Journal of product innovation management, Volume 15, pp. 237-254

Jassawalla A.R., Sashittal H.C., 2000, Cross-functional Dynamics in New Product Development, Research Technology Management, Volume 43, Issue 1, pp. 46-49

Kettunen P., 2009, Adopting key lessons from agile manufacturing to agile software product development – A comperative study, Technovation, Volume 29, pp. 408-422

Kvalle, S., Brinkmann S., InterViews; Learning the craft of qualitative Research Interviewing, Los Angeles: SAGE publications, 354 pages

León H.C.M., Farris J.A., 2011, Lean Product Development Research: Current State and Future Directions, Engineering Management Journal, Volume 23, Issue 1, pp. 29-51

MacCormack, A.W., Crandall, P. T., Henderson P., 2012, Do You Need a New Product-Development Strategy?, Research Technology Management 55, no. 1, pp. 34–43.

Marion T.J., Friar J.H., Cullinane T., 2011, Lessons Learned from Developing and Teaching a Multi-Disciplinary New Product Development Course for Entrepreneurs, Paper presented at the NCIIA's 15th Annual Conference, paper retrieved from http://nciia.org/network/conference/2011/papers

Misra, S.C., Kumar V., Kumar U., Identifying some important success factors in adopting agile software development practices, The Journal of Systems and Software Volume 82, pp. 1869–1890

Morgan J.M., Liker J.K., 2006, The Toyota product development system, Boca Raton: productivity press,

Ogawa S., Piller, F.T., 2006, Reducing the Risks of New Product Development, MIT sloan management review, Volume 47, Issue 2, pp. 65-72

Oorschot van, K., Sengupta, K., Akkermans, H., Wassenhove van, L., 2010, Get Fat Fast: Serviving Stage-Gate in NPD, Journal Product Innovation management, Volume 27, pp. 828-839

Oppenheimer, B.W., 2004, Lean product development flow, Systems Engineering, Volume 7, Issue 4, pp. 352 – 376

Owens, J., Cooper R, 2001, The importance of a structure New Product Development (NPD) Process: A Methodology, The Institution of Electrical Engineers, IEE London

Patel H., Pettitt M., Wilson J. R., 2011, Factors of collaborative working: A framework for a collaboration model, Applied Ergonomics Volume 43, Issue 1, pp. 1-26

Pero M., Abdelkafi N., Sianesi A., Blecker T., 2010, A framework for the alignment of new product development and supply chain, Supply Chain Management, Volume 15 , Issue 2, pp. 115–128

Petersen K., Wohline C., 2009, A comparison of issues and advantages in agile and incremental development between state of the art and an industrial case, The journal of systems and software, Volume 82, Issue 9, pp. 1479–1490

Phillips R., Neailey K., Broughton T., 1999, A comperative study of six stage-gate approaches to product development, Intergrated Manufacturing Systems, Volume 10, pp. 289-297

Radeka K., Sutton T., 2007, What is “lean” about product development?, PDMA visions, Volume 31, Issue 2, pp. 11-15

Reinertsen, D, 2007, Rethinking Lean NPD, Strategic Direction, Vol. 23, No 10

Saunders, M., Lewis P., Thornhill A., 2009, Research methods for business students, 5th edition, Harlow: Pearson Education Limited, 614 pages

Schwaber K., Sutherland J., 2013, Scrum Guide, available on: https://www.scrum.org/Scrum-Guides, retrieved at: 1-10-2013

Summers, G.J., Scherpereel C.M., 2008, Decision making in product development: are you outside-in or inside-out, Management decision, Volume 46, Issue 9, pp. 1299-1312

Tellioglu, H. (2008). "Collaboration Life Cycle", Proceedings of the 2008 International Symposium on Collaborative Technologies and Systems, May 19-23, Irvine, California, USA, pp.121-126

Trott, P., 2012, Innovation management and new product development, 5th edition, Harlow: Prentice Hall, 620 pages

Ward, A.C., Lean product and process development, 2007, Cambridge: Lean Enterprise institute, 210 pages

Ward, A.C., Lean product and process development, 2009, Cambridge: Lean Enterprise institute, 210 pages

Wikispeed, www-page, http://wikispeed.org/, retreived on 30-09-2013

Williams, M., Inconvenient truths about collaboration, 2013, Public management, Volume. 95 Issue 8, pp28-29

Womack, J. P., Daniel T. Jones, and Daniel Roos, 1991, *The Machine That Changed the World: The Story of Lean Production*, HarperPerennial

Woodside A. G., Wilson E.J., 2003, Case study research methods for theory building, Journal of Business & Industrial Marketing, Volume 18, Issue 6/7, pp.493 - 508

Qu and Dumay, 2011, The qualitative research interview, Qualative research in accounting & management, Volume 8, Issue 3, pp. 238-264

Appendix 1

Questions used during the interviews

As the interviews were semi-structured, there are only the main questions in this appendix

1. What is your function inside the organization?
2. What are your main responsibilities?
3. What are you tasks inside the NPI process?
4. What do you think about the collaboration between the R&D and supply chain
5. What is collaboration for you?
6. What do you do yourself to improve the collaboration?
7. Do you think that the R&D/ Supply chain is aware of the bad/good collaboration?

Appendix 2

People interviewed for this thesis:

Sourcing (supply chain)

Global Source Process Manager

Head of DM Sourcing

Sourcing Manager

Supplier Quality Manager

Supplier Quality Manager

Quality Manager

Head of Global Supplier Quality

Manufacturing (supply chain)

Factory Manager

Operations Project Manager

Global Make Process Owner

Logistics (supply chain)

Material Management Development Manager

Manager, Packaging Solution

Global supplier Logistics Director

Manufacturing Solution Director

Logistics Process Owner

R&D (technology organization)

Senior project manager

Project manager

Senior project manager and team leader

Program manager

Appendix 3

Table 4: The 7 different types of barriers that hinder or prevent collaboration (Patel et al., 2012)

Barrier type	Root causes of the barrier
Non-supportive organization	• No culture of collaboration; systems geared to individual work • Weak senior management • No commitment of resources to collaborative working • Poor communication and low levels of trust • Non-participatory structures and processes • Lack of support through training, supervision, etcetera
Inadequate supply chain and partnering arrangements	• Mismatch or conflicts in leadership stiles, culture, performance measures and goals • Inability to see constraints faced by partners, or others' perspectives • Differences in technical support, networks, systems availability • Reduced or no face-to-face time • Poorer coordination, communication and trust • National and culture differences
Weak management	• Weak team identity and weak identification with company/project goals • SUB-optimality – prioritization of department or function performance at expense of total company performance • Concentration on technical skills rather than collaboration skills • Allowing divisions to grow and conflicts to remain unresolved; avoidance of issues • Allowing knowledge not to be shared, or people to opt out of collaboration
Poorly conceived, planed or managed project	• Lack of project goals definition

	• Rigid organizational hierarchies • Poor transfer of collaboration experiences from other projects • Poor choices in personnel mix in project team selection • Lack of care over face-to-face and especially virtual team meetings • Little organizational support for project
Technology organization	• Reliance on technology fix • Collaboration which is technology availability push-led rather than user needs pull-led • Overly optimistic views on technology capabilities • Overly pessimistic views on technology capabilities • Poor technology interfaces • Poor technology implementation
Inadequate knowledge management	• Different knowledge held by different partners without clarity • Inadequate project central knowledge store • Lack of clarity on confidentiality of knowledge for different partner organizations • Reluctance of individuals to release, or even share, their own (tacit) knowledge
Unacceptable costs	• High start-up costs including technology costs • Unknown or out of control running costs • Cut bags on technical/ communications support • Attempts to collaborate across to many business unit • No examination of costs-benefit and opportunity costs of collaboration

Appendix 4

Table 5: Effective versus ineffective technology transfer (Jassawalla & Sashittal, 2000)

Ineffective transfer of technology and human interactions in the new product development process	**Effective transfer in technology and human interactions in new product development process**
Belief that cross-functional teams are panaceas for increasing integration.	Belief that cross-functional thinking and education is critical for effective transfer of technology.
Belief that increasing involvement of functional groups will also increase cooperation between them.	Belief that commitment and joint stake in decision making, coupled with high levels of transparency and mindfulness in actions, is critical for effective NPD processes.
R&D dominates NPD activities, and production and marketing groups function as secondary players.	Senior management explicitly empowers R&D, production and marketing groups to make NPD decisions as equals.
Functional-hierarchical organizational structure, distinctive functional groups with their own unique (explicit and implicit) missions.	Employees are routinely cross-functionally trained, and cross-functional teams are routinely employed to manage complex organizational initiatives.
When cross functional teams are used, team leaders are appointed by R&D and consult others when necessary. Other participants have less of a stake in achieving NPD goals.	Cross functional teams leaders are careful selected by senior management to manage the technical and human interactions issues. They make sure that all participants are all equal stake in outcomes.
Participants are strongly affiliated with their functional groups, and withhold cooperation unless its furthers their functional group agendas. Disinterested, bystander participants, displaying "over the wall" thinking are common	Participants are aware of the reciprocal interdependencies that exist, take equal responsibility for the whole process of new product development and its outcomes, and commit to building trust and collaboration
Low levels of collaboration, low incidence of synergy interactions. Hidden agendas, convoluted communication patterns and defensive routines adversely impact technology transfer	Adoption of process that promote awareness of the diverse orientations shaping peoples' actions. High level of synergy result from open exchange of ideas and information.