CHALMERS

Product development workshop
Workshop för produktutveckling

Examensarbete inom produktutveckling

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Preface

The following report is a Candidate thesis (15HP) in mechanical engineering (180HP) at the university of Chalmers. The report includes a case study at Husqvarna Construction Division (HCD).

A special thanks to: All employees at Husqvarna who have been part of the case study; Martin T Huber, the initiator and our contact person at HCD during this project. Thanks to Jakob Müller for mentoring us during this report and asking a lot of “why’s”. Thanks to Massimo Panarotto for valuable input as our examiner.

Summary

The product development process is becoming increasingly complex, which leads to a higher rate of delayed projects. This can be counteracted using structured methods; however, many companies have problems following these. This problem has been observed at Husqvarna Construction Division (HCD). To examine the problem a case study was conducted.

The aim of this project is to increase the understanding for the importance of structured methods and thereby get more product development projects to achieve their set time-goals.

To succeed with the aim, the following questions were answered: Does HCD have trouble meeting their product development time goals? Where and how do these problems arise and what are the reasons? How should a tool be designed to visualize and encourage change towards an ideal workflow?

Changing the structured method used by HCD is not part of this work.

The results from the interview study that was conducted indicates that there are problems with reaching the time goals and that the understanding of the red thread can be improved. The key factors for a successful project were identified as: A well formulated requirement specification, validation of functions, following the Product Creation Process (PCP) and early involvement of manufacturers/suppliers for exchange of information.

The tool that was developed is a workshop where the player gets to experience the first stages of the PCP, through a simulated product development projects with the help of Lego. The activities in the workshop are focused on the key factors that were found in the interviews.

Using this workshop, the understanding of the red thread and the importance of structured methods is supposed to increase. This will hopefully lead to less problems with reaching set time-goals.

Sammanfattning

Produktutvecklingsprocessen blir allt mer komplex, vilket leder till att projekt allt mer drar över i tid och kostnad. Detta går att motverka med hjälp av strukturerade metoder, dock har många företag problem med att följa dessa. Detta problem har även observerats på Husqvarna Construction Division (HCD), därför används en fallstudie hos dem som underlag för studien. Målet med detta arbetet är att öka förståelsen för vikten av att följa strukturerade metoder i sin produktutvecklingsprocess.

För att lyckas nå upp till målen med detta arbete, behöver följande frågor besvaras: Har HCD problem med att nå upp till sina tidsmål? Var och hur uppkommer dessa problem och vad ligger till grund? Hur bör en workshop vara designad för att visualisera och uppmana till förändring mot ett idealt arbetssätt?

Att förändra den strukturerade metoden som används av HCD är inte en del av detta arbete.

Resultaten från intervjustudien som utfördes visar på att det finns problem med att nå upp till tidsmålen och att förståelsen för den röda tråden kan förbättras. Nyckelfaktorer för ett lyckat projekt är: En välformulerad kravspecifikation, funktionsvalidering, att följa sin ”Product Creation Process” (PCP) och tidig inblandning av tillverkare/leverantör för informationsutbyte.

För att illustrera något bör en workshop vara uppbyggd på ett sätt som låter spelaren få uppleva det själv och då med hjälp av det tänkta arbetssättet lösa problemet. En workshop var utformad enligt dessa principer.

Genom användande av denna workshop kommer förståelsen för den röda-tråden och vikten av strukturerade metoden att öka, vilket kommer leda till mindre problem med att nå upp till tidsmålen.

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1 Introduction

1.1 Background

The product development process in general, is becoming increasingly complex ("something consisting of many interdependent parts that are connected in a way that is hard to overview" (Nationalencyklopedin, 2018)) due to more advanced product structure, ambiguous goals and cross functional teamwork (Chucholowski, Lehmer, Rebentisch and Lindemann, 2016). Negele, Finkel, Schmidt and Wenzel (2006) state that the increased complexity in product development in engineering industry can be derived from an increased international competition and more diversified products.

According to Ulrich and Eppinger (2012) the development of complex products, including many subsystems and components, causes certain employees to be assigned a specific task. This leads to the development process being carried out in parallel with different team members working at the same time with different parts that interact with each other. Because of this an important part of the development becomes managing the network of interactions or also referred to as "synchronization". Chucholowski, et al. (2016) agree on this and states that the increase in complexity leads to challenges in coordinating and aligning interdependent activities within product development projects. Further on Chucholowski et al. (2016) present a study conducted in 2006, where a survey about challenges in the mechatronic (products including a mix of mechanic and electronic components (Rouse, 2017)) development process was carried out. The study stated that 68% of 140 companies expressed that synchronization of activities is a big challenge.

The sections above describe that companies within the technology sector are experiencing problems with increased complexity especially related to synchronization. This thesis will report from a case study on the Swedish company Husqvarna, which is experiencing similar problems. The company is divided into separate divisions, the case study focuses on the Husqvarna Construction Division (HCD). The construction division develops, manufactures and sells machinery and diamond tools for stonemasonry and the construction industry. The product range stretches from light hand-held tools to more advanced demolition robots.

The product range of the construction division include products with a high degree of technology and mechatronics. This makes it a relevant case for the study about challenges in the development process deriving from an increased product complexity.

The origin of this study are concerns expressed by the company, regarding the increased product complexity with new market demands of integrated software and new technical solutions. Chucholowski et al. (2016) state that a key factor in coordinating interdisciplinary activities is the management of complex and dependent tasks. Further on, Ulrich and Eppinger (2012) state that an effective way of creating synchronization and allowing everyone on the team to understand the key points of the process, is the use of structured methods.

HCD applies a structured method for how a product development project should be carried out, called the Product Creation Process (PCP). However, the initiator for the case study at HCD thinks that not all employees understand how and why they should follow this process. According to the initiator this could be the reason for delay, unnecessary rework late in the process and repetition of mistakes that have already been made in former projects.

The idea that deviations from the intended method leads to problems or difficulties reaching goals is supported by Cooper and Kleinschmidt (1986), they present a study that shows that in most cases where the quality is lacking, the process is poorly executed.

1.2 Purpose

As stated by Cooper and Kleinschmidt (1986). Companies that have problems implementing structured methods, more frequently run product development projects that result in bad quality.

The aim of this project is to get more product development projects to achieve their set goals. This is intended to be achieved by broadening knowledge and understanding of the product development methodology among the engineers working with the PCP. This will be done by developing a workshop that illustrates the importance of following the intended product development method.

1.3 Precision of the aim

To be able to reach the aim, the following questions will be treated.

- Is there a problem with reaching time goals?
- What's the cause of these problems?
- Which aspects in this specific product development process, used by HCD are considered as key factors for a successful product development project?

Before designing the workshop, the following question had to be answered.

- How should a workshop be designed to visualize and encourage implementation of an ideal workflow?

1.4 Delimitations

The study will focus on providing a better understanding of the product development process and the methodology of HCD. To improve already existing methods for the product development process is not part of the goal.

Due to the initial request from HCD asking for a workshop to implement change and the fact that a workshop is a suiting way, other game based learning methods will not be investigated further.

Furthermore, the case study is conducted only at one company, HCD.

2 Theoretical reference frame

2.1 The importance of structured methods

There are three main reasons for why a company which conduct product development should use structured methods. First, the decision making becomes clear, a project cannot proceed without decisions being made and supported. Second, using some sort of checklist for the key parts of the process makes sure that no important steps are missed. Third, a structured process is often self-documenting. The documentation of what decisions have been made and why they were made is simplified. Even if methods are important they shouldn't be followed blindly, but thoroughly contemplated and well suited after the company needs (Ulrich and Eppinger, 2012).

Furthermore, a study conducted by Cooper and Kleinschmidt (1986) showed that the chances of a successful project increases the closer to the process you follow. For each activity or step that is deviated from, the chance of failure increases. It was also shown that the first few steps in the project, such as market research and preliminary studies have a significant role to play in the success of the product.

According to *Cooper (1990)* following structured methods is a key factor of successful projects. Projects that succeed in product development do follow the intended process and often spend twice as much money and 1.75 times as many man-hours on preliminary studies, compared to failed projects.

Further on following the intended process will produce a clear overall picture of how economically justifiable it would be to commit to the project. If it will generate sufficient market demands and thereby revenue, who the target group is and how they are to be captured. What makes our product the winning one and can this product be manufactured at the right price? These questions must be answered before the project has even begun ensuring that time and money is put on the right projects (*Cooper, 1990)*.

2.2 The Product Development Process

The product development process is many activities with purpose to develop new products (something sold to a customer by a company) for the customer's needs. Containing everything from estimation of market opportunity to production, sale and delivery (Ulrich and Eppinger, 2012).

A way of measuring the successfulness of a product development process in a for-profit enterprise are products that can be produced and sold profitably (Ulrich and Eppinger, 2012). Further on Ulrich and Eppinger (2012) present the following five dimensions to determine if a process have been profitable and to facilitate the assessment of product development performance.

- Product quality. This measure includes to what extent the product satisfies customer needs, how good it is and if it is robust and reliable. Quality is indicated by market shares and the price that customers are willing to pay.
- Product cost. The sum of total costs for manufacturing the product. The product cost combined with the product's sales volume and sales prices determine the eventual profit.
- Development time. A measure of how long time it takes to develop a product. This determines the responsiveness to competition on the market and the time it takes to adapt new technologies. At the same time, it is a measure of how fast the company will receive economic return.
- Development cost. The cost of developing a product, often a large part of the investment required for the new product.
- Development capability. How well did a product development project increase the ability of the team and enterprise to carry through successful projects in the future. Development capability is a resource that the company can use in future projects.

As mentioned in the section above structured methods could be a helpful in organization of the work with product development further on it was stated that well defined methods are strongly correlated with successful projects. Ulrich and Eppinger (2012) list the following advantages with having and executing a well-defined product development process.

- Quality assurance. In a structured method for the development process all phases and checkpoints that the project will pass through along the way are specified. If these checkpoints and phases are chosen in a good way and the project is carried out accordingly, the method itself becomes a way to assure good quality of the resulting product.
- Coordination. A distinct and clear description of the development process works as a general plan that defines the role of each member of the development team. The description also informs the members with whom they will exchange information and data and when their contributions will be needed.
- Planning. A well-defined development process contains checkpoint that describes when each phase should be completed. These checkpoints help to create an overall schedule for the development project.
- Management. The process can be used as a comparison to the actual process to identify possible problem areas.
- Improvement. A well-defined development process usually encourages careful documentation and simplifies improvement of how work should be carried out.

Why product development processes are important

Kahn, Kay, Slotegraaf and Uban (2012) states that the number one driver of corporate growth and prosperity today is enhanced innovation abilities, and that it was "cost cutting" a decade

ago. Further on they present that in a study conducted in the US, 53.2 percent of businesses' new product development project achieve their financial objectives and 44,4 percent are launched on time.

Kahn et al. (2012) mean that the top 25% of new product development firms have 12 times as much productivity as the bottom 25%.

Adler, Mandelbaum, Nguyen and Schwerer (1996) states that process management has already revolutionized the manufacturing process with principles such as those used in the lean process. A way of work that have been successfully implemented by different companies around the world. Further on they mean that the product development process can be streamlined in a similar way.

Different product development processes

Today most companies conducting product development use some sort of product development process. The next section describes two different types of product development processes used in companies today, Lean product development and the stage gate model. A variant of the stage gate model is used by the case study company HCD, their variant is referred to as the PCP.

Lean product development

Johansson, Persson, Pettersson (2013) present an overall picture of the Lean product development process as follows. Product Development according to lean-philosophy is a resource- effective/cheap, way of work which derives from Japan, specifically the company Toyota. The describing word lean was coined by American researchers.

Toyotas keynote is to put as much focus as possible on value adding work, and avoiding non-value adding, described as waste. Another cornerstone is to understand the customer and the customers' demands, with a focus on satisfying needs. The quality of a product is as also mentioned above, measured in terms of how the customer receives the product. Product-characteristics regarded as good by the customer is an indication of good quality, while characteristics regarded as bad indicates bad quality. Further cornerstones are knowledge generating and learning, all learning is value-adding and all knowledge generated is of value, regarded as a resource which will be used. This has consequences such as resources used for developing alternative solutions that does not make the final cut, is regarded as an investment instead of waste.

All product development projects deliver two results: The intended result, the product and the increased knowledge or value stream.

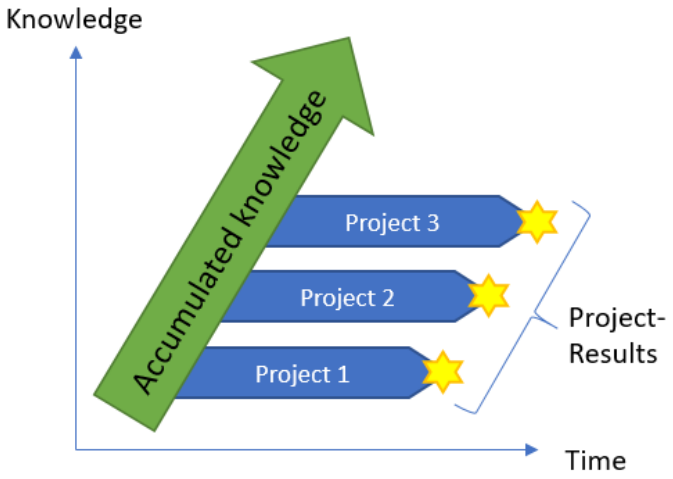


Figure 2.1 Product development projects according to lean gives both gives results, but also adds to the company's knowledge value stream (Johansson et al., 2013).

In this context three different kinds of waste are regarded:

- Scatter. Interfering organizational change and other communication barriers, unfitting or bad product development methods and tools.
- Hand-off. An unfitting way of distinguishing between these in charge, they with knowledge, those who do, and those who gives feedback.
- Wishful thinking. Decision making that is not supported by data, ignoring knowledge, testing with a sole purpose of fulfilling specifications.

All this adds to the risk of later fault, and failure. It's crucial that all decisions are based on knowledge, which means that knowledge is needed before a decision is made. A consequence of this is that much work is put in in an early part of the process, analyzing problems and testing many different solutions. When testing it's important to do that in a way that tests for not only if demands are met, but also taking the solution to its limit, gathering knowledge about the solutions disabilities.

Different solutions are being tested to gather data for generating trade off curves between conflicting requirements. Further this is used to determine how to balance choice of partial solutions in a chained product solution, to make sure these fit the requirements. One important principle is to perform early testing, before bigger resources are used to develop details, thus gain a clear picture on if the concept idea will work. First after positive response on the testing, further investments are suitable.

Another important cornerstone in the lean-philosophy is applying set-based-design (SBD), or set-based-concurrent-engineering (SBCE), the main principle with this is to work for multiple alternative solutions in every aspect of the product development process. Alternatives that do not fulfill the requirements are progressively being reduced from the amount of possible solutions. With help from analysis and experiments, creating information of how well the solutions fit current requirements.

Product development based on lean philosophy is based on three cornerstones, a process with the characteristics described above, knowledgeable people as well as tools and technologies to be used by the knowledgeable people in the process. Toyota describes its product development process as follows. "*Product development is not about developing cars, it is about developing knowledge about cars. Great cars will emerge from the interaction." (Johansson et al, 2013).*

Stage gate process

The stage gate process is based on a model where the user has different steps to get through under the process. To pass by each step there are many variables to check of, when they are completed the project can proceed to the next stage. Usually, a stage gate model has about four to seven gates, depending on company and department (Cooper, 1990).

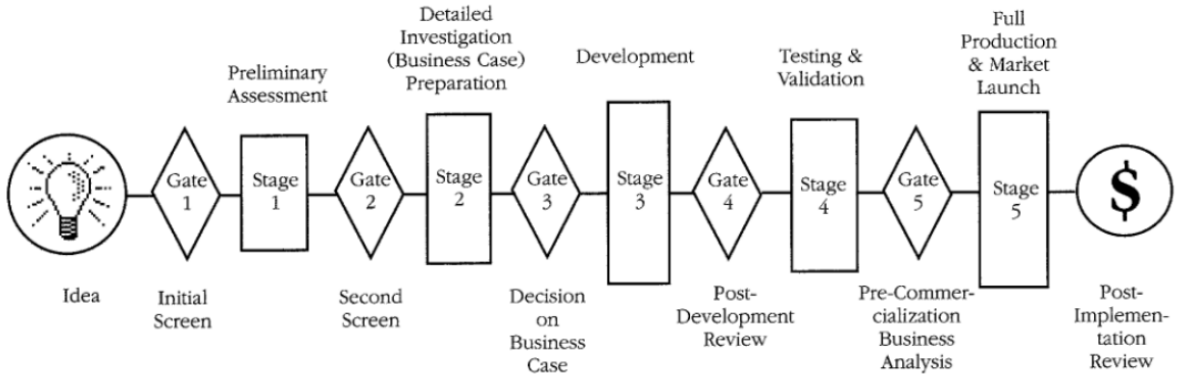


Figure (2.2) An overview of the stage gate process by Cooper (1990).

When the user moves to a new step in the process, a gate must be passed. Where a form of entry criteria must be included. These are then evaluated by the project manager and the project is assessed based on how well these criteria are achieved. Each gate also has an output, typically: Continue / End / Wait / Recycle. Examples on entrance criteria at a gate are: Customer requirements, market adjustment, competitive power and financial overview.

At each gate there is a gatekeeper, superior to the project leaders. The gatekeeper has the authority to decide what to do with the project at each gate by assessing the quality of the entry criteria, deliverables and the action plan for the next step.

It is the project leader's role to ensure that the projects go on, the project leader is aware of the criteria that will be evaluated at the next gate, and what the team must achieve to complete the process, the project manager will then see that this happens.

When working according to the Stage Gate model, you may need to make a few changes within the company, as according to this model you do not hand over parts of the process to different apartments in the company. According to stage gate, you have a team and team leader who conducts each process from start to finish. In addition to this, you also need to

work with supervisors and managers in the process, as gatekeepers. Not only for guarding the gates and ensuring that all steps are included in the process, but also because a successful project often places great demands on resources and commitment by top management. Further this involvement of top management keeps them included in the loop, avoiding concerns such as “where are we with this project”, “how many projects are ready to launch by next quarter”.

The different gates in a typical stage gate system is described in the paragraphs below.

Gate one. Initial Screen. At this point, the project is born, if the project moves forward resources will be committed to the project. Gate one is a gentle screening of the project, assessing a handful of key criteria, such as: strategic alignment, project feasibility, magnitude of opportunity, synergies with the company’s business and resources, different advantages and market attractiveness. “Must meet” criteria are checked of a list and “should meet” criteria are used to rank and focus discussions of the project. Financial criteria are not part of screen one.

Stage one: Preliminary assessment. The objective of this first stage is to determine marketplace and technical merits of the project. One part of stage one is a preliminary market assessment, other parts is relatively inexpensive activities such as: library search, focus groups and contacts with key users. A handful of potential customers gets a first test at an early concept. The purpose is to assess the potential market size, potential and acceptance. At the same time, a quick and preliminary technical assessment of the product is done, involving a in-house estimation of the proposed product. The purpose with this is to assess possible costs and times to execute, involving development and manufacturing feasibility. The point with this is gathering both technical and market information, in short time at a low cost. The project will be more thoroughly evaluated at gate two.

Gate two. Second screen. Evaluating the project by the new information that has been obtained in stage one, in addition to the data from gate one that will also be re-evaluated. At gate two a quick and simple financial assessment is done, regarding aspects such as payback period. Moving forward from this point, the project will move on to the heavier spending stage two.

Stage two. Definition. Verify that the project is attractive and worth putting in resources to, before going on to furthermore heavy spending stages of product development. Define the project clearly, conduct market researches to understand the customer needs, wants and wishes, to come up with a winning new product. Analyze the competition and test concepts against the market, appreciate how likely it is that the customers want this new product. At stage two there must be a detailed technical appraisal, focused on the do-ability of the project. Customer demands and wishes must be understood and translated into a list with technical and economically reasonable solutions, can involve a preliminary design, or laboratory work. If it is appropriate, work such as copyright, patents and other legal activities is undertaken. A detailed financial analysis of the project is conducted, and used as input to gate 3.

Gate 3. Decision on business case. This is the final gate before the development stage, as this is the last chance to stop the project before substantial financial commitments a financial analysis for the project is made. “Must meet” and “should meet” criteria from stage two are checked off. The second part of gate three is that key items for the project is decided before moving on, including parts such as market definition, specification of product strategy, deciding important functions of the product and definition of product concepts.

Stage 3. Development. This stage contains product development, and concurrently testing, marketing and operations plan. Financial analysis is updated and legal documents such as patents and copyright are resolved.

Gate 4. Post development review. The project and product are being checked for continued attractiveness, development work is reviewed as well. Financial data is updated and reviewed, test and implementation plans for upcoming stage are approved and the marketing and operations plans are reviewed.

Stage 4. Validation. Viability of the project is being tested: product, production process, customer acceptance and the economics of the projects. A couple of activities are undertaken in stage four:

- In-house product testing, ensuring product quality and performance.
- User and field testing to validate that functions work in real circumstances, together with estimating customers attitude towards the product.
- Trials and pilot production to test and improve the production process, production rate and cost is defined.
- Trial sell to estimate customers reactions and assessment of possible business opportunity.
- Financial analysis updated.

Gate 5. Pre-commercialization decision. Final gate before full commercialization, last chance to kill the project. Focus in this gate is the quality of stage four and the results of the validations. The financial projections determine if the project should move ahead or not. Plans for marketing and operations are reviewed, if all results are approved it’s time for implementation at stage five.

Stage 5. Commercialization. Marketing and operation plans for the launch is implemented.

Success factors in product development

Clark and Fujimoto (1990) states that the reason that some companies are successful in their development of new products and other companies are not, is the product integrity. The product integrity is achieved by having the entire team aware of what the concept of the product is, with a team trying to achieve their own small parts, without consideration of the

product as whole, there will be collisions in the process. This was a big part of Honda's success developing their Accord, with issues such as the space in the motor room being too small. With motor-constructors having full understanding for the concept of making the car spacious, which required the motor-room being small, they developed a motor fitting the car. What makes every conflict, in the product development process constructive instead of being destructive, is that every member of the team having a common goal. Working towards the concept instead of their own vision of a small part.

Making a serious effort of involving customers is an important part of the process, it is easy to develop technically advanced products that provide good value, but if it doesn't match the customer falls short with the market (Clark and Fujimoto, 1990).

Clark and Fujimoto (1990) mean that another important part for successful projects is having a good and clear leadership, without it democracy in the process is easily reduced. It's the leaders job to make sure that the engineers working on the project remember the concept, which easily is forgotten during a product development process that takes years to complete. The project leader listens to all parts of the team, taking part of their knowledge and ideas, but never compromises the concept. The concept is the soul of the product, it cannot be bargained with. Further to truly improve and make big changes to a team, it's very important to see to what impact the team leader have on the team.

Striving for faster processes is another important key to success, not only because of the faster process time, but because of when trying to achieve a faster process time everyone is challenged to improve their part of their process. Reducing work in process inventory is good, but understanding and attacking the root causes of excess inventory is truly a success (Clark and Fujimoto, 1990).

Clark and Fujimoto (1990) states that the reason to why companies have similar problems, often recurring in different projects, is so usual, is because they don't learn from previous project. This is because when a project is done it's always a rush to get on the next one. Companies working clearly with evaluating and progressively improvements after each project learn from their mistakes. This gives a strong competitive edge.

Adler et al. (1996) argue that general managers need to understand how many projects their organization can handle, however, it's important that they see each project for a complex operation and not as a simple list of parts that needs to be checked off. Even though every project involves unique challenges that require their own solutions, many parts of the project development process that is similar across different projects. Process management exploits these similarities by standardization and continuous improvement, this can be done in the project development process as well, without killing creativity.

During a period of eight years, a dozen of different companies were studied by Adler et al. (1996) which lead to three important discoveries. First, that projects are finished faster if the

company undertakes fewer at a time. Second, investments made to remove bottlenecks have unproportioned big return relative investments. Third, eliminating unnecessary variation in workload removing distractions and delays, giving the organization freedom to focus on the project. When implementing these findings, the average product development process times decreased with 30% to 50%.

In the study conducted by Adler et al. (1996) it was discovered that management created cross-functional concurrent-engineering teams to identify and solve problems fast and early. Unfortunately, this led to that the organization face too many different problems at the same time, making key persons in the process working on five to ten projects at the same time. This was made even worse with the managers commandeering resources to give their project priority, creating unnecessary breaks and further delays in other projects. This resulted in key persons working 60-hours weeks and still not having time to finish their work, and most projects ran late.

Further on the study by Adler et al. (1996) showed that at every stage of the product development process engineers needs to wait for technicians to finish crucial tests on the prototype, even though having sufficient resources, technicians often had long back-logs due to uneven workloads. Adler et al. (1996) means that uneven workload usually arises due to companies jumping on to new projects as soon as a good market or technical opportunity arises. A pattern creating backlogs at important parts of the product development process.

Adler et al. (1996) have by numerous instances seen that managers think they are smart when they plan for a 90% workload, which would have been good if, it wouldn't have created fluctuations in the workload from 80% to 150%, due to variations in the work. If they reduced the workload to 80%, this fluctuation is reduced enough to make the time spent on developing a product reduced by 30% or more.

In a brainstorming session with the companies that was part of the study conducted by Adler et al. (1996) an array of possible ways to reduce the time for the product development process was generated. The generated solutions being:

- Increase resources.
- Reduce the number of ongoing projects.
- Teaching employees in less burdened departments performed tasks of heavy burdened departments.
- Remove unnecessary parts of the process.
- Reduce mental and physical stress by improving the project documentation and make the content available. Further on the organizations can reduce time it takes to perform tasks by creating best-practice templates, which employees in the studied companies were encouraged to take part in and further improve and update. These templates were also mentioned to be a good help for newcomer to come up to speed with the process.

When the participating companies were asked to come up with ways to lower the workload in general. They came up with that the most important factor was to reduce the number of ongoing projects and possibly work according to a pull-system, which would allow a new project to start only once another has finished. The results from the study made it clear to the participants that they had to rethink how they handled urgent projects, expediting a project by interrupting work in process, resulted in an increase in both general workload and variation in workload. They came up with two possible solutions for this, either reducing the number of expediting projects, or increasing capacity.

When technicians in the participating companies were teached to help the engineers to even the workload, and simultaneously reducing the number of ongoing projects. The product development time for both new projects and extensions were reduced by nearly 40% (Adler et al., 1996).

One company in the study conducted by Adler et al. (1996) tested to reduce the project portfolio from 32 to 22 ongoing projects, which lead to the completion of projects over year increased with 30%. They also introduced a first in first out approach to overcome issues with expediting projects incurring too much resources and creating variations in the workload. But this way of work was too rigid, not providing a solution to projects that really did have to be accelerated. This was solved by letting senior managers only, commandeering special treatment.

Success factors at project level

Kahn et al. (2012) present the following eight success factors at project level in product development.

1. Striving for unique superior products

The most important factor in separating top performers from others is the ability to produce products with unique benefits and real value to customers and/or users. These products have five times the success rate, four times the market share. The special attributes shared by these products is:

- Good value for the money for the customer.
- Provide excellent product quality compared to competing companies.

2. Creating market-driven products and building in the voice of the customer (VoC)

Another important factor of why new products fail is the lack of understanding of the customers' needs and wants. A strong customer focus improves success rates and profitability but it also leads to reduced time to market. The most successful companies keep this focus through the hole process, including: idea generation, design of the product and before the final stage of development.

3. Pre-development work

The more successful firms spend twice as much time and money on front-end activities as unsuccessful firms. These front-end activities include:

- Initial screening, the basis for the first decision to start a project.
- Preliminary market assessment, the first market study.
- Preliminary technical assessment.
- Detailed market study and VoC research.
- Business and financial analysis that are the basis for the decision for starting up the development

4. Sharp, early, stable, fact-based project and product definition.

A major success factor is the quality project and product definitions before the development stage begins. This can decrease time waste because of elimination of scope creeps, that means that the definition of the project constantly changes. And time waste that comes from constantly changing product requirements and specifications. A well performed product and project definition includes the following steps:

- definition of the project's scope, for example deciding if it will be used domestically or internationally, if the project will use line extension, a new product or platform development.
- specification of the target market
- definition of concept and the benefits for the user
- outline of the positioning strategy, for example the target price
- a prioritized list with "must have" versus "would like to have" criteria, concerning: Features, attributes, requirements and specifications

5. Spiral development - build, test, feedback and revise

The conditions and terms set in the front load stage of the project can change during the development stage. Therefore, a series of iterative loops should be used during the project. this is done to test ideas against customers and try the definition created, but as important competitive firms could have developed a similar product with outstanding customer value that the team must take in account.

6. The world product - a global orientation

Multinational companies that design products with a global approach outperform firms that design products for the home market and later adjust them to neighboring markets. The firms that perform best on the global market brings in the aspect on an early stage of the process.

7. Planning and resourcing the launch

Profitability of a new product is strongly correlated to a high-quality launch with effective after-sales service. The development of a good launch must begin early in the project and be an integrated part of the product development. The launch must also be properly resourced in terms of financial support and people.

8. Speed, but not at the expense of quality of execution

The competitiveness of the firm increases as the time from idea to launch is decreased. This is a direct result from being first on the market with less probability that the market or competitive situation has changed and a quicker realization of profits. The following principles are used by project teams to increase project speed:

- Front loading the project as discussed in point 3 and early and stable product and project definitions.
- Execution of every stage of the project with good quality, having to cycle back and redo stages consumes valuable time.
- The use of parallel processing.
- The use of spiral development as described in point 5.
- Focus and prioritizing, by concentrating resources on a few high-value and truly deserving projects will create higher quality and save time.

Success factors at company level

Below the nine factors creating successful product development on company level presented by Kahn et al. are listed.

1. A product innovation and technology strategy for the business

Positive performance in business is strongly linked to product strategy. The strategies with the highest positive impact on performance include the following parts:

- Clearly defined long term-goals and objectives for product innovation. For example, determine the percentage of business´s sales that will come from product innovation the coming three years.
- Clear statement of the contribution from product innovation to the overall business goals.
- Focus the product innovation efforts on strategic arenas. places that are rich on opportunities for innovation. For example, different markets, product arenas, industry sectors or technologies.
- Strategic buckets. dedicating buckets of resources such as funds or personnel at different project types or strategic arenas makes it easier to create strategic alignment and balance in development projects.
- A product roadmap is an effective way to map out a series of initiatives oriented on product development to decide a plan of actions for the coming five to seven years.
- Most best performers have a long-term product strategy.

2. Focus and sharp project selection decisions-portfolio management

Kahn et al. (2012) state that most companies take on too many projects at the same time and in addition often the wrong projects, without the right amount of resources. This results in bad conditions to perform in any of them. In other words, valuable resources are wasted on projects with poor potential and projects with great potential don’t receive the resources

needed. Companies that have been proven to have a good strategy for choosing the right projects and focusing their resources in a good way have one thing in common, they are using a funneling process. A process that eliminates the poor projects along the way this is done with help of decision points in the form of tough gates. These go or kill decisions are effectively managed with the help of visible criteria that can be used in a scoring model that rates the project and gives support to the decision. The following criteria have been identified as especially important: strategic, competitive and product advantage, market attractiveness, leverage, technical feasibility and risk and return.

3. Leveraging core competencies-synergy and familiarity

The best performing companies have a clear connection between the new product development projects and the core competencies, experiences and resources in the company.

4. Targeting attractive markets

There is a strong correlation between successful products and attractive markets, therefore the intended market is an important part in decisions about a product development project. Attractive markets can be divided in the following two dimensions.

- Market potential: markets with high potential are large and growing, the customer needs for the intended product is high and purchase is important for the customer in addition the possible profit margins are big.
- competitive situation: markets with negative characteristics contain: intense competition, competition based on price, high quality and strong competitive products.

5. The necessary resources

The rate of failure increases as the resources in the terms of time and financial resources decreases. Limited resources have been a greater problem as the competition on the market have increased and companies have tried to do more with less. This together with the fact that many companies take on too many projects at the same time leads to: lack of VoC and market input; poor front loading of projects; ineffective launches; and an excessive focus on fast, simple projects.

6. The way teams are organized

Most projects today consist of separate functional areas doing their own part of the project, with little communication with other functions in the line. However, product development is a team effort and the way that teams are organized have a great influence on the outcome of the project. The best performers use the following set of rules to create a good team organization:

- The team should be clearly assigned to the specific new product development project. The team members should be part of the team and work with it. The team should be cross-functional containing members from all parts of the product chain, for example: technology, sales, marketing and operations. The important part is that team members

should not just be representatives of their function but “true members of the team” (only 61 percent of companies use this method).
- The project leader should be clearly identified and be responsible for the project from idea to launch not only in some stages.
- The team have a central shared-information system where every part of the team can share and work on the same documents simultaneously. This should work independent of function, location and country.
- The team is responsible for the projects result, for example making sure that it meets profit target and time target.

7. The right environment, climate and culture

A positive climate for innovation is a strong driver of success in product development projects. A positive climate can consist of different parts depending on who you ask but the following attributes have been identified in high performing companies.

- Entrepreneurial and risk-taking behavior are encouraged.
- New investments are occasionally risky.
- Successes in new product development projects are recognized and rewarded but failures are not punished.
- The focus is centered on the team rather than on the individual.
- Senior managers do not take over control of the projects or try to second-guess team members.
- The project review meetings involve the entire team and are open.

8. Top management support

Another factor of success is support from the top management. The top management develop a vision, objectives and a strategy for product innovation. They also make sure the necessary resources are available and importantly review projects and make go/kill decisions.

9. Multistage, disciplined idea-to-launch system

Well performing firms are using systematic idea-to-launch methodologies. These are roadmaps for how to go from idea to launch efficiently.

Case study Husqvarna

At Husqvarna the PCP is a Stage gate process, with seven stages. The names and objectives of each stage are not further explained in this report, due to NDA.

2.3 How to implement change

Workshop - Serious Game

There are different ways of introducing information or knowledge in a more interesting way than the traditional way. These are given similar terms such as “Simulation game”, Game-based Learning” and “Educational game”. This term can be summarized in the term “Serious

game", defined as an activity where people learn about serious contexts through playing (Kerga, Rossi, Taisch and Terzi, 2014).

In the game developed by Kerga et al. (2014) the players are meant to understand the differences between using a 'Set-Based Concurrent Engineering (SBCE)' approach versus a 'Point-Based Concurrent Engineering (PBCE)'. SBCE is defined as "when design engineers and product designers reason, develop and communicate about sets of solutions in parallel and relatively independent" Sobek (1997) and PBCE is when you search for a feasible solution by using a series of iterative loops to modify and select completely different solutions.

In this SBCE game the players are meant to design a simplified aircraft, using different pieces of Lego. The players define different parameters to fulfill customer demands and technical requirements, the aircraft have four subsystems which is represented with a department of one player each. The game has two main stages, stage one is based on a PBCE approach toward a given a list of demands, in stage two they have sufficient tools to use a SBCE type of approach. When the prototypes have been designed players must pass a controlling stage ensuring that they have met all the demands.

After they have tested both stages the players are given time to discuss the differences in using PBCE and SBCE processes.

In the game the players must meet five customer demands, the number of passengers, plane length, weight (both weight of aircraft and passengers), wing-span and tail-span. Customers' demands are made vague intentionally, for example the number of passengers are set to 91-110 and wingspan is set to 7-15 distance units. Setting vague units of length is in line with reality, as customers often give imprecise information of what they need, forcing developers to explore different conceptual solutions.

In the game these demands are handled in different ways, where in stage one the players choose one concept and start working toward this, which leads to compatibility problems and feasibility issues in the process. The players also have bad visibility in what the other departments are up to. At stage two, where players are encouraged to use a SBCE process where they test different concepts, and have a better outcome. This gives the players an understanding of how a SBCE-process is a better approach to meet customer demands and requirement specification without costly rework.

The Game design is meant to give the players penalties and time-punishments if they do not meet customer demands, in addition to having the players go back and change their design to meet all the demands. This round end when all demands are met, or in this case when two hours have passed.

The point of game based learning is that players are given an opportunity to try and use different work-methods and learn from them, in a smaller much faster stage then in the real

world. These models have built in pitfalls and success factors to illustrate the necessity of using a certain process.

Discussion

The SBCE Game have been played by more than 60 design and management engineers working with product development. According to the participants the effectiveness of the game to educate certain processes can be summarized as follows.

Differences in results using a PBCE or SBCE- process is clear, which is something this game wanted to illustrate. They realized that following a SBCE process when developing process gives ensures that you gain visibility earlier, and don't have to do as costly reworks because of failures. The players also saw benefits in trying the different processes together, giving them a opportunity to discuss the differences and what was good about each one of them, which is a rewarding discussion in itself.

To further validate the games effectiveness, it would have been good to prepare some sort of measurement plan, such as questionnaire or participants feedback.

Effectiveness of Serious Games to educate

In the report about serious games by Kerga et al. (2014) six characteristics about the effective mechanism of using a SG to introduce complex practices were found. In this case the SBCE-method was the complex practices being introduced. The following list is presented by Kerga et al. (2014):

1. *Internalize knowledge without interfering in an actual practice.* SGs put boundaries between actions in games and consequences, but players acquire new skills and knowledge transferable to actual practices (Prensky (2001)).
2. *Improve communication.* Gaming creates a means to support effective communication and structures debates between stakeholders. (Geurts and Joldersma (2001)).
3. *Create consensus.* Beyond communication, gaming creates means reaching consensus, conflict mediation and collaboration between actors' perceptions about a subject matter (Duke and Geurts (2004)).
4. *Commitment to action.* Gaming is used to introduce and test new concepts, to convince industrial players of the need for intervention, to introduce approaches to the intervention and to introduce the roles of the participants in the intervention process (Mayer (2009).
5. *Stimulate creativity.* Gaming allows players to leave their routines and provides settings to experiment new ideas (Duke and Geurts (2004)).
6. *Understand complexity.* reality is much more complex than any attribution in gaming. For example, PD involves problems in a dynamic situation, with many variables, actors, objectives and uncertain outcomes. However, gaming creates a simulated and holistic environment to show how to make better decisions (Duke and Geurts (2004)).

3 METHOD

The end goal is getting more product development projects to reach their set goals. This will be done by developing an illustration tool.

To achieve this, the following steps will be worked through: First an understanding of the product development process in general is required. Therefore, a pre-study on how the general product development process work was conducted. To be able to communicate information about the changes that must be done to improve the process, a study on how to implement change will be conducted. After the initial pre-study, the case study at HCD was carried out. This is made to create a picture of the present situation of the specific product development process at HCD. The case study was mainly executed by interviewing selected personnel but also by analyzing existing documentation about their workflow. When the key elements of the product development process at the case study company was identified, the work focused on creating the illustration tool.

3.1 Prestudy

The product development process

To illustrate how the product development process in general is carried out, first an understanding for the general workflow in the product development process is needed. Therefore, a literature study (a critical review of fact-based scientific publications, such as dissertations and scientific articles Håman, Prell and Lindgren. (2015) is considered appropriate. The literature study was conducted mainly during the first three weeks of the project.

How to implement change

To be able decide how to develop a workshop to implement change, the article Serious games by Kerga et al. (2014) were studied.

Case study

With the aim of improving the product development process at a company, an awareness and understanding of how the process is performed at present in that company is required. Therefore, the process at the company will be investigated with help of those who work with the projects. As it is a limited target group whose opinions are asked for, it is considered appropriate to conduct interviews.

Types of interviews

According to Gill, Stewart, Treasure and Chadwic (2008) there are three main types of research interviews. These are: structured, semi-structured and unstructured. In a structured

interview a list of predetermined questions with little or no variation are used. They are well suited when there are numerous respondents. Because of the lack of follow-up questions, they are of less use in studies where more depth is required. Semi-structured interviews consist of a few predefined questions that define the subject but gives room for supplementary questions. Compared to a structured interview this method gives more flexibility and thereby a larger probability of finding information that have not been thought of by the research team. An unstructured interview does not include any predefined questions and is performed with little organization. This kind of method is well suited when significant depth is desired, or when very little is known about the subject.

Moving forward with this a semi-structured type of interview was used. Personnel from different sections of the product development groups, 12 persons were interviewed.

Interview design

Lantz (2007) means that there are three requirements that must be met to carry through an interview with good quality:

- The method must give reliable results.
- The results must be valid.
- It must be possible for others to critically review the conclusion.

Further on Lantz (2007) believes that the following four steps are helpful in the preparations of an interview study:

- Clarify why the subject and the problem is important and interesting.
- Decide the aim of the study.
- Choose a theory or model that highlights the problem.
- Clarify the aim or the problem.

Gill et al. (2008) present the following guidelines to create an interview that produce new knowledge that have not been anticipated by the researchers.

To be able to generate as much information as possible the questions should be open-ended, they should require more than a yes/no answer. The Interview should start with easy questions and the proceed to more difficult and specific questions. It is important to listen attentively to acquire more knowledge about the intended topic.

Before an interview takes place, the participants should be informed about the study and given assurance about anonymity and confidentiality. This increase the chance of good quality and honest answers because respondents are given an idea of what to expect.

Lantz (2007) state that the respondent also should be informed about how the results will be used and how the respondent will get access to the results. Further on Lantz (2007) describes

that it is the respondents right to finish the interview at any time. In addition, it should be clear why the participant is interesting, if the person is interesting or as a representative for a group.

The interview should be conducted in an area free from distractions and at times that are most suitable for the participant. Interviews should be tape recorded and typed in text word by word, this is done to provide a permanent record and create a fair image of what was said. Field notes is also helpful which could help the data analysis process (Gill et al. 2008). Lantz (2007) ads that in an interview where it is enough with less nuances to meet the aim, it is suitable to take notes during the interview and at the same time make a tape record. After the interview the notes can be supplemented with help from the recording.

According to Lantz (2007) a way of meeting the first requirement of reliability is to summarize what the respondent have answered. This gives an opportunity to test the ability to mirror what the respondent really wanted to say.

At the end, thank participant and ask if there is anything they would like to add. This should be done because it can lead to unanticipated information (Gill et al. 2007).

The interviews at Husqvarna were conducted mainly among people working in the PCP at Husqvarna, with the addition of a higher-level manager at Husqvarna Brand Division and a production project leader.

The interviews were conducted according to a pre-defined template (appendix 2). The interviewees were chosen based on their position in the product development process and to give balance between the represented groups. The interviews were recorded, transcribed and summarized, then the results were compared in a matrix to distinguish similarities and differences. The summarized interviews were mailed out to each respective interview candidate to ensure quality, that nothing was taken out of context and misinterpreted.

The interviews were conducted at location and via skype as a second alternative. The questions were built up based on the guidelines presented by Lantz (2007). The interviews were approximately 45 minutes long, and based on the research questions:

- Is there a problem with reaching time-based goals?
- Where are these problems
- What's the cause of these problems?

Analyzing interview data

Lantz (2007) gives the following steps for analyzing the collected data from the interview. The first step is to reduce the amount of data to what will be used in the coming steps. Here things that won't help to answer the question or aim is taken away. This is done by defining a principle for what should be analyzed. This principle should then be the base of the selection

of parts that are retrieved from the data material. To control the data reduction the selected parts should be read for themselves, the picture this creates should be compared with the picture that comes up when the raw data is read.

The principle used when reducing the initial interview data was that content that did not concern the PCP or current work situation was removed in the initial step.

The next step is to create dimensions that mirrors the content. The content is divided into groups of answers on the same theme, this dimension is given names that summarize the content in the dimension (Lantz, 2007).

When analyzing the interview data, in addition to the research-question, the following questions were answered:

- Is there a problem with understanding the red-thread and following the PCP?
- Where do these problems occur and what key factors can be identified in their PCP?

A matrix was created where content on the same theme from different interviewees was put in specific dimensions. After that, the answers were printed and put up on a large paper to create an overview of all answers at the same time (appendix 3).

The next step is to find connections between answers from different participants that treat the same subject. When connections between answers and patterns that can describe a phenomenon are found a conclusion that are more general can be made (Lantz, 2007).

To categorize the answers and make general conclusions, the answers on different subjects were color-coded and summarized in diagrams that are shown in the result chapter. To further decide which parts of the process that should be focused on in the continuous work key factors of performance were identified. Here factors from different dimensions could be placed in the same group. When collecting these key factors, the number of mentions was considered as well as the number of unique candidates mentioning the same factor. Accordingly, one candidate could mention one factor in different aspects resulting in more mentions, but one aspects was only counted once (appendix 7).

When the key factors were identified they were reduced into four main factors to be focused on in the workshop.

3.2 Illustration method - Workshop

Workshop development

The part of this project which involves creating a workshop was started after the case study, where interviews were conducted. The results gave insight in what key points the interview candidates considered important, illustrating these would then give a better understanding for

the PCP and a better understanding for the red-thread. Classic brainstorming, which according to (Johannesson, Persson, Pettersson, 2013) is regarded as well tested and thoroughly described method for generating many ideas together within the project group. This method was used to generate ideas about how to prove a point about a specific topic in the workshop.

With the interviews as a base a project for the workshop was created, building a case-specific prototype to keep it relevant. In this case it's a floor grinder. The actual process used by HCD were analyzed and used when creating templates for the workshop (appendix 8).

Pilot - Testing the workshop

To test the illustrating method, a pilot version of the solution was introduced to three students at Chalmers. This led to a few changes that was implemented, and a second run-through of the workshop was executed together with two project leaders at HCD. Because they have good insight in the process and can help further develop the workshop and make sure that it illustrates their process.

Evaluation of the workshop

Based on the run-through an evaluation of the workshop was done. From this, an outline of possible future improvements was derived.

4 Results

The result chapter is structured by subchapters, where each subchapter deals with a specific subject. The first paragraphs are a summary of the subject, followed by quotes that illustrate different answers. Accompanied with an interpretation to illustrate what the summary and the figures are based on. The figures represent the data that was achieved.

4.1 Interview Results

In the interviews there were 10 candidates from HCD participating, representing: design, project-management, production, product owners, testing and quality. In addition, there were a Higher-level manager and a Production leader from Husqvarna Brand Division. In specific questions concerning the work situation at the Construction Division, only the answers from employees at this division were regarded.

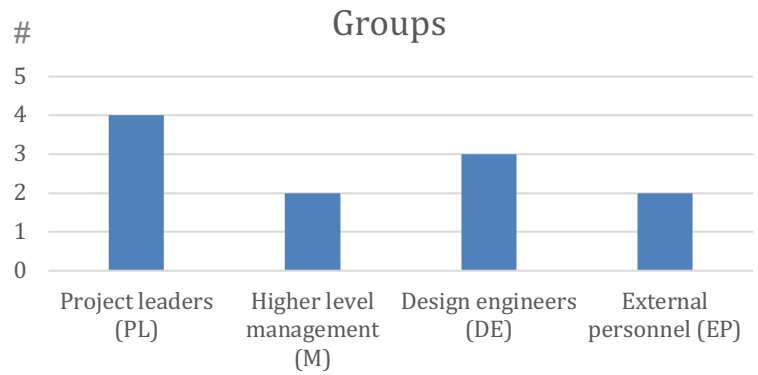


Figure 4.1 The interview candidates represented in corresponding groups.

Is there a problem with reaching pre-defined time goals?

The interview results show that the initial question, "is there a problem with reaching the pre-defined time goals?" is relevant. Half of the interviewed candidates meant that there are difficulties reaching pre-defined time-based goals. Answers to this question also indicated that there is an uncertainty about time-goal achievements. None of the candidates had a clear opinion on to what extent that they achieve set goals, but most had a feeling of if they managed or not. The uncertainty about the goals makes it hard to identify where and why problems exist. A cause of uncertainty about time goals is that goals are adjusted during the projects, which makes it hard to measure at the end. In this question only HCD internal personnel's answers are considered relevant. Because the external personnel have a lack of insight in how well HCD reach their goals.

- **Yes.** A design engineer thinks that it's common that they do not reach the pre-defined time-goals. *"It's common that you do not reach the goals, preliminary time goals are often optimistic."* (group DE)

- **Yes.** A higher-level manager does not feel that they have a track record of reaching set goals. *"Concerning time goals, we have no track record of reaching our goals. We usually miss our preliminary time goal"* (group M)
- **Goals are adjusted during the project.** A project leader does not think that it's important to reach pre-defined goals, rather that goals are being iterated to better match the current situation. *"As much as possible is measured during the projects, then it's being iterated if goals have to be changed."* (group PL)
- **Functions are removed to reach time to market.** A project leader think that time-goals are being reached by removing functions. *"[...] a discussion with the control groups about if the cost can increase or if we can remove functions to reach time goals." (group PL)*

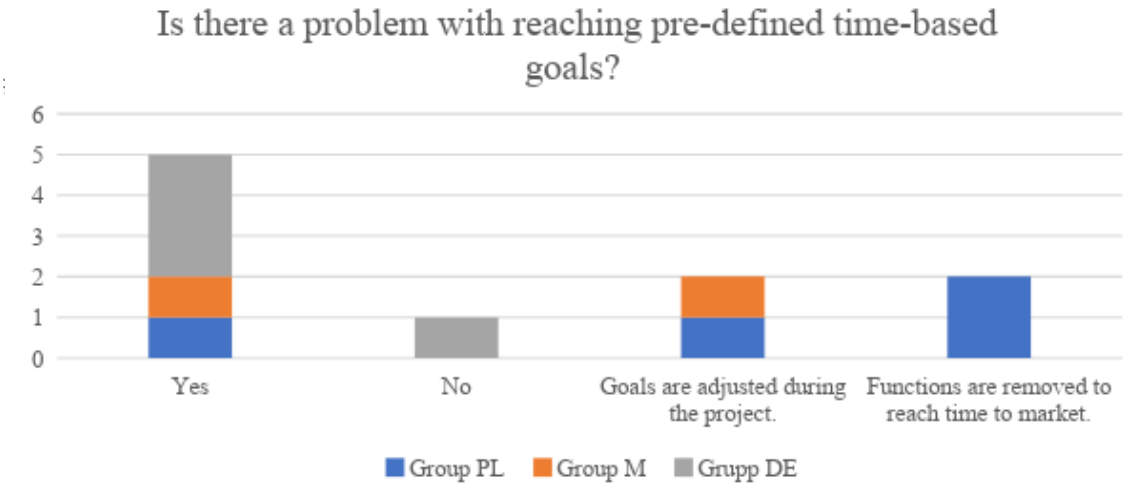


Figure 4.2 The interview candidates' different answers to how well they reach pre-defined time goals.

Do you work according to the PCP?

When asked if they work according to the PCP, most of the project leaders and only a few of the other candidates answered yes. How they answer indicated that there is a common understanding that the PCP is intended to be used more for project organization than as a support for daily work. Which is a misunderstanding since the original intention is that the PCP should be used as a supporting tool in the daily work as well as for project organization. All employees have their own responsibilities described in the PCP template. The view that the PCP should be used by project leaders and not all team members leads to a lack of insight in the overall process or the rest of the team.

Further on this leads to a lesser understanding of the red-thread and a more task specific work way, rather than working wholehearted in the project. Which is the case when everyone understands why each task is important (Clark and Fujimoto. 1990).

A project leader stated that this "gets better" referring to that all team members use and feel a responsibility for the PCP. Which confirms the thought that it would be better if all employees were included in the work with the PCP.

On the question, "do you work according to the PCP?" a design engineer answered that the PCP is poorly adjusted for their projects. This indicates that it could be better adjusted during each project. The intention is that the team makes active choices at each stage about which parts are relevant for their project. Further on the design engineer stated that the PCP can't be used directly and that it increases the workload. This indicates that if the PCP is not adjusted with active choices, there is an increased risk that engineers start skipping parts because it doesn't seem relevant for their project, leading to unnecessary deviations. Further on a design engineer stated that success factor is to follow the PCP more, that project leaders should emphasize the PCP more and that it should be present in all parts of the projects. The design engineer also concludes with that there is a big difference between making active choices and skipping steps. The answers from all groups indicates that there is a common understanding that the PCP is not used to the same extent across all groups but that an increase of involvement in the PCP would increase overall performance.

- **YES.** A project leader think that project leaders are responsible for all the deliverables, and that the engineers don't work actively with the PCP. Stating that it's getting better indicates that he thinks that they should do that more. *"I work actively with all the parts of the PCP, we are responsible for all the deliverables. The engineers don't work actively with the PCP, but mainly the project leaders. But it's getting better." (group PL)*
- **Not actively.** A design engineer state that design engineers doesn't use the PCP because they are not project leaders. *"I don't use the PCP that much, mainly because I am not a project leader…" (Group DE)*
- **No.** A design engineer don't feel any use of the PCP, the engineer expresses that it's overwhelming and increases the workload. That it's not very well suited for all the projects and can't be used directly indicates that it's poorly adjusted to the project. *"It's not very well suited for all the projects, can't be used directly. It's a little too detailed, increases the workload. The intent is that it should be guiding, but I don't feel any use of it." (group DE)*
- **No.** A project leader states that it was several years since he used the PCP the last time. This indicates that the PCP is not always being used. *"I don't use the PCP directly in many projects. Several years since the last time I used it." (group PL)*
- **External group.** An external personnel states that Husqvarna Construction have distanced themselves from the PCP, and that it's been expressively said. This indicates that there might be uncertainties about if the PCP should be followed at Husqvarna Construction. *"The Construction division have distanced themselves from the PCP and expressively said that they don't fully work according to it." (group EP)*

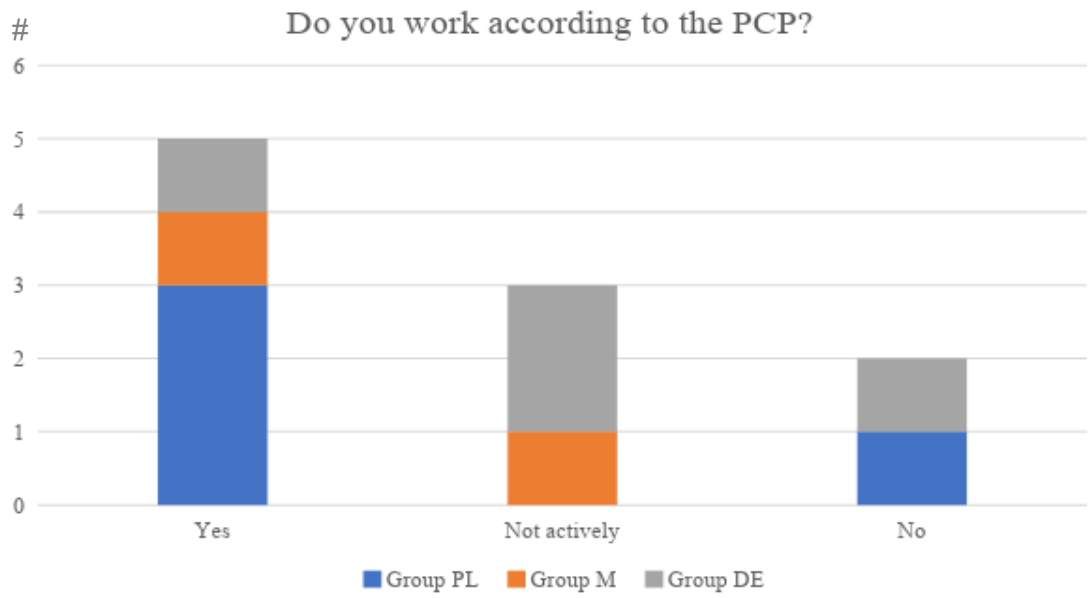


Figure 4.3 The interview candidates' different answers to if they work according to the PCP.

What is the cause of problems in the product development projects?

Answers concerning the subject, "what is the cause of problems in the projects?" indicates that deviations from the PCP is one cause. Other than that lack of resources and new technologies were mentioned. The subjects "lack of resources" and "new technologies" are problems that could be minimized by following the PCP as intended. The PCP suggests a thorough pre-study and that projects should not start unless they have the right resources, or knowledge about the level of technical maturity. Some of the candidates expressed that the lack of resources came from losing knowledge when experienced personnel left the company. The solution to this problem presented in the PCP is a lessons-learned database where important knowledge and important teachings from former projects are collected. The fact that the two latest subjects could be minimized through correct use of the PCP, it is considered likely that problems arise due to deviations from the PCP.

- **Deviations from the PCP.** External personnel think that deviating from the process and letting projects get forced ahead by the steering committee and market powers creates a backpack of problems. *"Not following the process, letting projects be forced ahead by the steering committee and market powers. This creates a backpack with problems" (group EP)*
- **Deviations from the PCP.** A higher-level manager feel that projects sometimes carry on without reaching the requirement specification without changing the specification. This indicates that there might exist validation issues. *"We carry on without reaching requirement specifications without changing the requirements." (group M)*
- **Lack of resources.** A design engineer feel that key persons take knowledge with them if they leave. This indicates that the knowledge loss decreases with a better lessons-learned database. *"If someone with key competence leaves, we lose a lot of important knowledge […]"* (group DE)

- **Lack of resources.** A Project leader states that they lost key competence when a key person disappeared. This adds to the previous point about the lessons learned database. *"Core competence disappeared when we lost a key person" (group PL)*

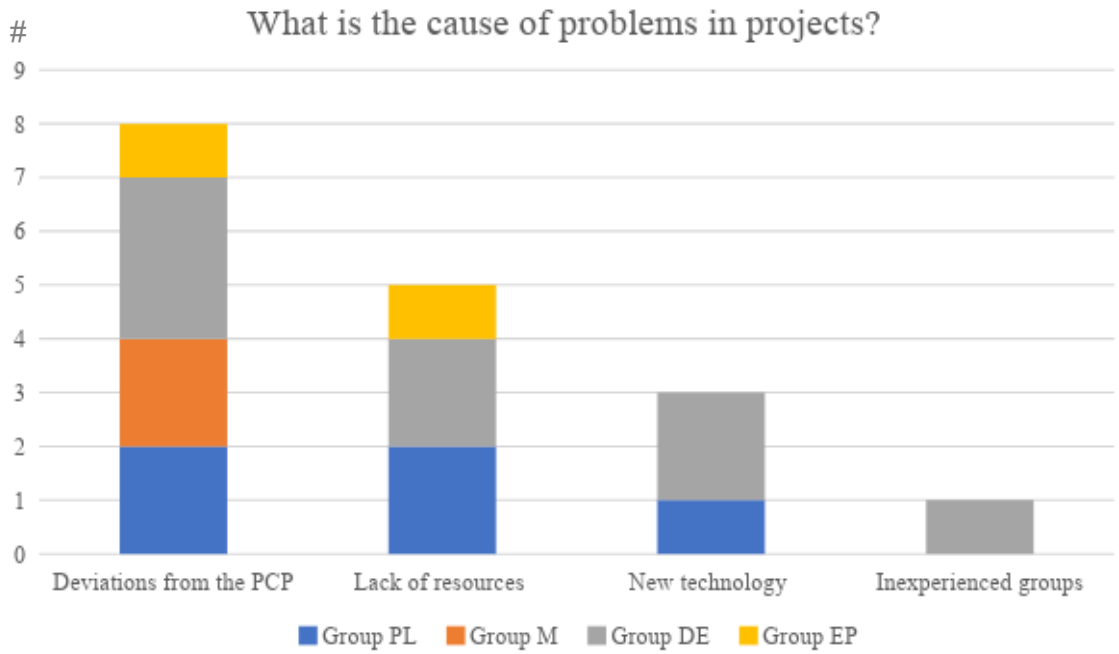


Figure 4.4 The interview candidates' different answers to what causes problems in projects.

Thoughts about the PCP.

When asked what they think about the PCP, a design engineer stated that it should be followed more and that steps shouldn't be skipped. A higher-level manager thinks that it should be followed better and that the PCP is something they must fight for at HCD. A project leader stated that the engineers think that the PCP is burdening, but that's only because the PCP is frontloading projects and making sure that all tasks are done from the start at the stage where it's supposed to be. A project leader also stated that a reason for not following the PCP is laziness and ignorance. This indicates that there is room for improvements, interview candidates across different levels think that the PCP is good, but should be followed more and that there is a lack of understanding of the red-thread.

- **The PCP should be followed more.** A design engineer states that following the PCP is a success factor. *"A success factor is to follow the PCP more, emphasize it more and don't skip steps" (group DE)*
- **The PCP should be followed more.** A higher-level manager feels that they must work hard for the PCP at construction, this indicates that there is room for improvement in how and if the PCP is followed. *"It should be followed more. I would say that we have to fight hard for it on the Construction." (group M)*
- **It's good.** A project leader think that the PCP might give a feeling of being burdening, but it makes sure that all the necessary steps is done in the beginning of the project instead of at the end. *"it might give a feeling that it's a little too much and*

burdening, but the difference is that you do all the steps in the beginning instead of having to do them in the end." (group PL)

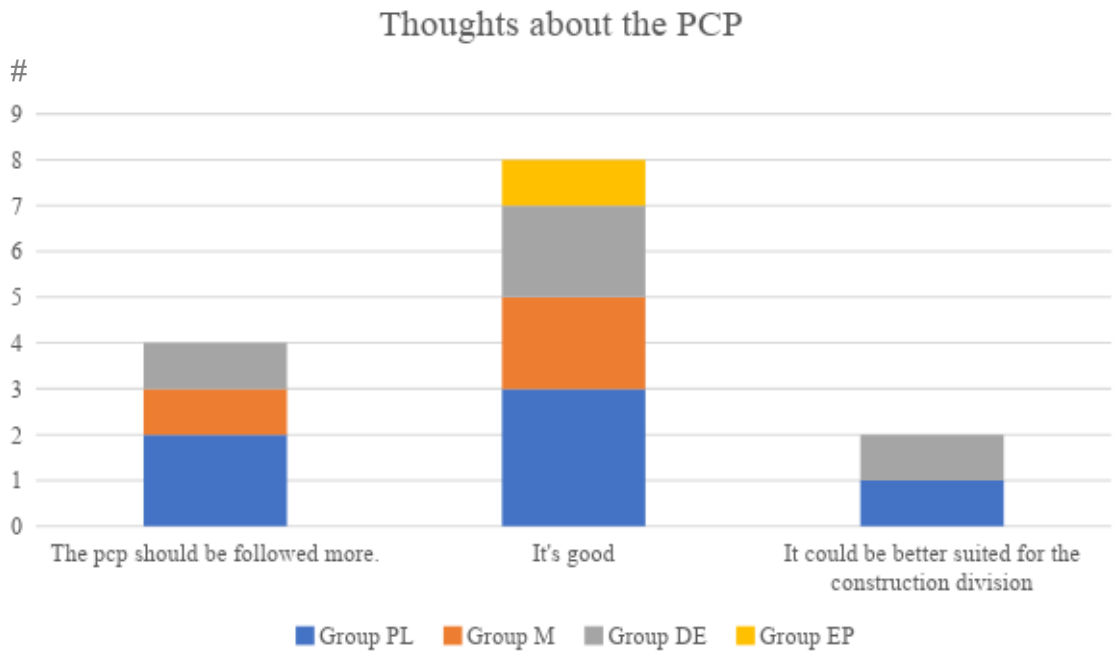


Figure 4.5 The interview candidates' different answers to what they think about the PCP.

Why is the process diverted from?

The answer on the subject "why do engineers deviate from the process?" from a project leader indicates that they sometimes skim through a couple of paragraphs, what leads to that important steps are missed. This confirms that steps are skipped without making well documented active choices and that it is a problem. This problem shows that the process i diverted from due to lack of understanding of the original thought of the PCP. Where instead all steps should have been considered by the team and a common decision about what to do and what to skip should have been made.

Another reason for deviations that was pointed out is that projects are forced to proceed due to tight time and cost goals. A project leader stated that a reason that this happens is that there is a need of promising too much to get a project started. The project leader expresses that this is a common thought among other project leaders. The project leader mentioned that if it took three years and cost 15 million the last time, don't expect it to take two years and cost 10 million this time. This statement describes one of three major wastes according to the lean principle. Wishful thinking that means making decisions that is not supported by data and ignoring knowledge (Johansson, Persson and Pettersson. 2013). This leads to a time- and cost pressure being put on the projects from start. Which leads to unnecessary pressure being put on the engineers and a rush to finish the projects and as mentioned above, deviations from the process.

Another factor to why the process is deviated from is that it isn't clear that it should be followed. A design engineer expresses that it's unclear that the PCP should be followed and a project leader mentions that it was several years since the team worked according to the PCP. This is backed up by an external source mentioning that HCD expressively say that they don't work according to the PCP.

When asked what they think about the PCP and why it's deviated from, it's confirmed that the interview candidates think that a lack of understanding, a push forward (forcing) and uncertainty that it should be used, is reasons to why the PCP is deviated from.

- **Failure to understand red-thread.** A project leader states that they have reached the end of projects without having a proper manual, this shouldn't be possible if you follow the process correctly. Further he continues that they skip a couple of to do's because they seem irrelevant. This indicates that they instead of making active choices in which steps are relevant for each stage at the gate, skip steps during the stage. *"It shouldn't be possible to reach the end of the project without a manual, for example. This has happened more than once […] Now it's possible that you skip a whole paragraph, because it seems irrelevant. But amongst these ten things you read through there was a manual that you missed […]" (group PL)*
- **Forced projects from management.** A project leader state that you often must put too tight time and cost goals to be allowed to start with a project. Further the project leader state that most of the project leaders have understood this. This indicates that it is a common practice and that this might be an important reason to why the process is diverted from. *"You often put too tight time and cost goals to be allowed to start with a project. Most of us have understood this, that if you promise that the project takes two years and cost ten million you get to start with the project. It's easier to be forgiven than gain permission." (group PL)*
- **Unclear if the PCP needs to be followed.** A design engineer thinks that it's unclear if they should follow the PCP. *"I don't think that we need to change the PCP to make it work better, rather make it clearer that it should be followed" (group DE)*

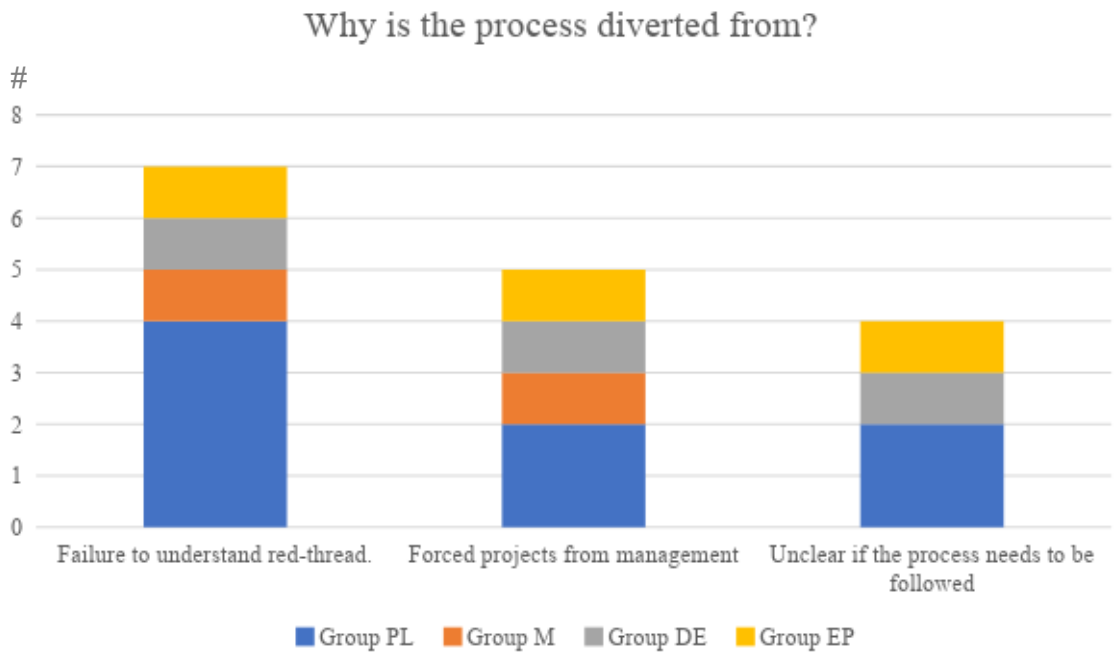
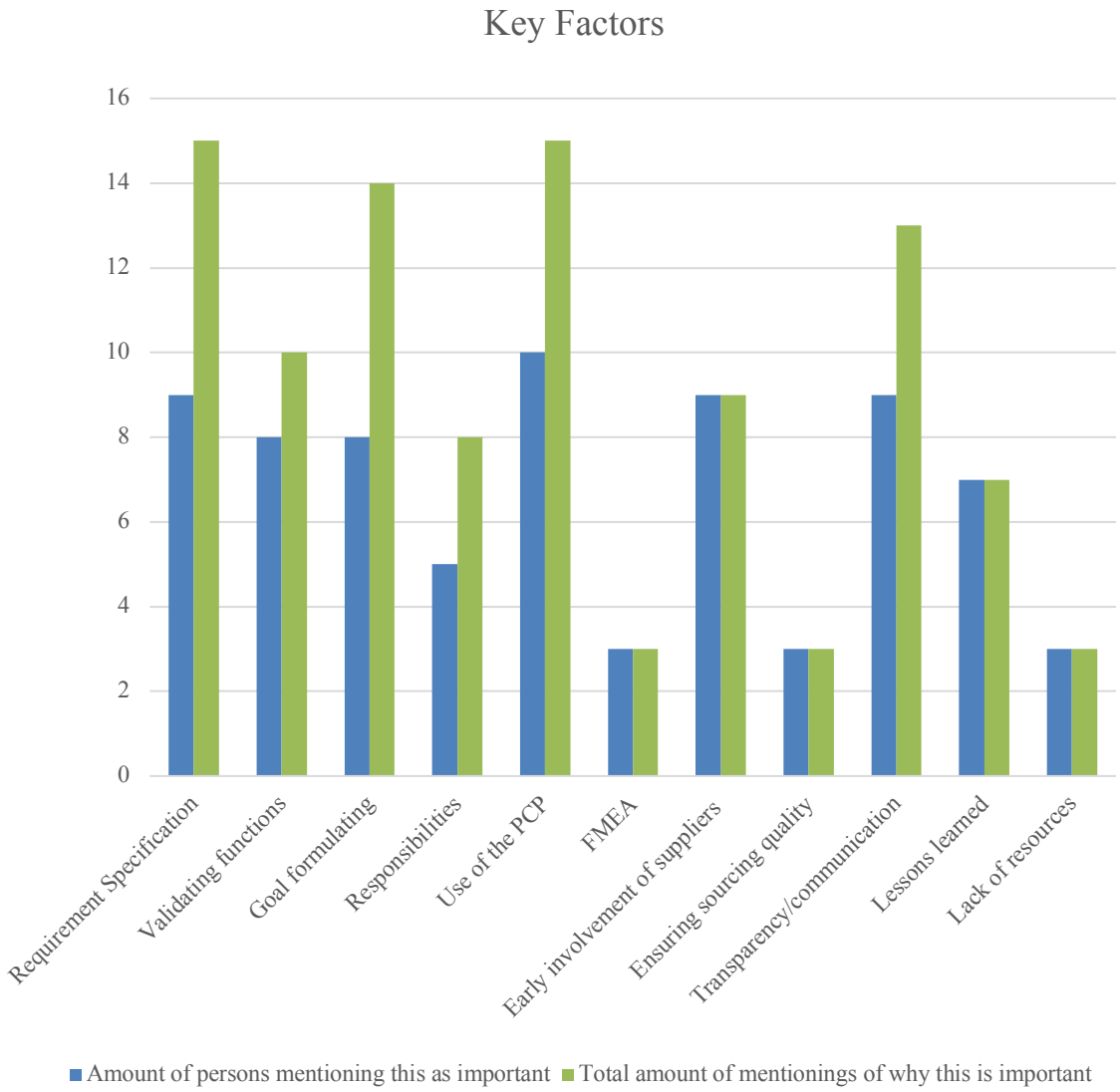


Figure 4.6 The interview candidates' different answers why the process is diverted from.

4.2 Key factors in the product development process

The key factors represented in the following figure (4.7) are found in the interview study conducted at Husqvarna. The key factors are subjects that the employees think are important parts of the process. The subjects can include factors that lead to success or factors that must be considered to avoid problems. The factors are collected in categories that express a common theme linking them together. The key factors are formulated as the following list, with the key factor in bold and a short explanation of what it concerns:

- **A well formulated requirement specification.** The requirement specifications must be set before projects start. What do we want to achieve? What numbers do certain specifications need to reach? What level of maturity do we have in this technology? *What do we need to achieve and what do we want to achieve?*
- **Validating functions.** The prototype must reach set specifications before project moves forward. Involvement of customers, quality assurance, set based approach.
- **Well formulated goals.** It's important with a common goal of what's meant to be achieved. Honest goals, if a goal is set it's meant to be plausible. Quality goals are often missing, measurable goals are needed to do improvements.
- **A clear distribution of responsibilities.** It's important that everyone feel a common responsibility for the project, understanding of RACI (Responsible Accountable Consulted Informed) - diagrams to know who's responsible for each deliverable. Otherwise hard to address issues.
- **Following the PCP.** The PCP is important for the quality of the process. Adjustments can be done before a stage, but it is important that adjustments are documented and based on active choices. Forcing projects ahead creates problems.
- **FMEA (Failure Mode Effect Analysis).** It is important with a good pre-study and to map out possible risks in the project. This gives conditions to take good decisions, saves time and money.
- **Early involvement of suppliers and exchange of information.** It is important with good communications and exchange of information, it's important to be humble and realize that we don't know everything. Time and money is saved by changes early in the process, therefore production and suppliers must be able to give their opinion on the design early so that we don't design something that they cannot produce.
- **Ensuring quality from suppliers.** It's important to control what the supplier can manufacture as well as what they can mass-produce.
- **Transparency of communications for consensus.** It is important with transparent information, common goals and good communications create good teamwork and employees that work with their heart.
- **Lessons learned.** Lessons learned documentation are good for collecting common information and ensuring that the knowledge is safe in the building in case of loss of personnel.
- **Lack of resources.** It is important to give projects proper resources, lack of resources leads to hunches and inferior performance.



The list of key factors that was derived from the interviews, corresponds well with key factors that can be derived from the theory studies (appendix 4). When ranking the key factors, both the amount of different people mentioning something as an important part of the project and how many unique points were made for why something is important were counted. This is because it illustrates different aspects, both that it's a general opinion that something is a key factor, and that one key factor can be important for several different reasons. The most important key factors are presented below:

- A well formulated requirement specification.
- Validating functions.
- Formulating plausible goals.
- Following the PCP.
- Early involvement of suppliers and exchange of information.
- Transparent information, common goals and good communications.

Figure 4.7 The different key factors mentioned in interviews.

Goal formulating and transparency/communication are considered out of scope for the workshop. It's considered to be outside of the main goal with getting HCD to work more according to the PCP and improving the understanding of the red-thread. This is because the pre-defined goals are formulated before the projects start and the measurement of them is done after the projects end. Transparency/communications is more correlated to the internal information logistics of the company.

4.3 Workshop

The results from the interview showed that the intended process, sometimes is deviated from and that this is regarded to create problems with reaching time goals. Further on the results show that project performance could be increased through a better use of the PCP. As the results from the interviews indicate that it could be followed better and that it's regarded as a success factor when it's followed properly.

The main goal of the workshop is to increase the use of the PCP. Which is intended to be done through an increased understanding of interdependent activities. Therefore, the players will have to complete important parts of the process, to finish the project. To be able to focus the workshop on the most important parts of the process the result answers were analyzed and key factors were identified. As seen in the result chapter the three most important factors after ranking and elimination were: Requirement specification, Validating functions and early involvement of suppliers for exchange of information.

The theory studies on how to implement a process or a way of work, showed that a good way to introduce knowledge, is by making it interesting. To make it interesting serious games or workshops are suitable. This way the participant gets to experience what the game designer wants to educate. A workshop was considered to be a good method in this project because Kerga et al. (2014) mean that it includes the following three important advantages: Even if there are boundaries between action and consequences in serious games, players acquire skills and knowledge that are transferable to actual practices; in Serious games players are allowed to leave their routines and gives the opportunity to experiment new ideas; serious games creates an understanding of that a product development process is complex and involve many variables, objectives and uncertain outcomes. However, the serious game can create an understanding that leads to better decisions.

The two findings, that HCD needs a better implementation of the PCP and that a workshop is a suiting method resulted in a workshop in form of a mini-project. In this workshop the players will work through the first three stages of the PCP.

The intended players are all persons involved in product development, with focus on Research and Development (R&D). The players will be divided into teams of 5-7 employees. The different players will have the same positions and responsibilities, developing the workshop-product together.

Due to NDA the method-templates used in the workshop have been excluded from this report, but the instructions for the game leader (appendix 5), Project proposal (appendix 6), Existing concepts (appendix 7) and Player guide – PCP short (appendix 8) are included.

4.4 Workshop design

The players will be given a project proposal, including information that's needed to start the project. The information includes initial customer demands, available time, project goals and practical information about how the workshop will work.

Following a description of what times, the players are supposed to meet, and what they are supposed to do at each stage is given:

08:30 – Introduction

The project start with a short introduction about how and why the project should be run.

09:00 – Start specification stage

Purpose

Generating a product specification and developing product concepts that meet the set market- and user-demands from the project proposal.

Description

Project proposal is analyzed and important demands are compiled, evaluated and specified in a product specification.

A structured development method will be used, for example set-based concurrent-engineering. Sketches of prototypes can be used to validate that the concept meets the demands. Potential suppliers and manufacturers are identified and evaluated based on if they meet set demands on quality etc.

Input

Project proposal with initial Market and User requirements.

09:45 – Development gate

Check stage objectives:

- Product Specification. From Requirements defined for the project from stakeholders like manufacturing & suppliers (appendix 1), market & users (appendix 2), in addition to product compliance requirements.
- Product Concept. Including Bill of Material and Design direction with the possibility to fulfill the Product Specification and the agreed parts of Requirements.

- Preliminary Design Verification and Validation plans. Covering each of the development steps (appendix 3).
- Identified approved potential suppliers. And their possibility to fulfil requirements (appendix 2).
- Go to Development Gate
- A recommendation if and how the project shall proceed.

09:50 – Development stage 1

Purpose

Improving the product development project to a level that makes a stable assumption about the business proposal for investment request.

Description

An industrial and technical design for the chosen concept is developed. With start on a system level, decomposed into part-systems and component level. This means development and affirming of an industrial design model and preliminary blueprints of critical elements.

A stable software architecture is developed. Viability must be secured by concurrent product- and process construction as well as contribution by stakeholders, (suppliers, production and customers.) FMEA, risk assessment.

10:30 – Investment gate

Check the stage objectives:

- A matured Product and Brand Design meeting all requirements agreed. Includes the whole scope of the product and product software.
- Design risk analysis, D-FMEA.
- Design Verification plan is set for all development stages, from Prototype to Manufacturing Pilot status.
- Stage report and recommendations how to continue project.

10:35 – Development stage 2

Purpose

Verification and validation of design. Make sure that the product design, functions and production concept meet set demands.

Description

3D and 2D blueprints as well as specification are finalized, and released for ordering of design verification-prototypes. The prototypes are manufactured and measured according to the specifications. Design verification testing and customer demands validating is performed to ensure fulfilling of product specifications as well as user and market requirements. Software is also tested to ensure it meets the demands. In the end of development phase two the software should be 100% constructed, implemented and tested.

11:15 – Industrialization gate

Check the stage objectives:

- Engineering design is verified to Product Specification and other agreed requirements through prototyping, completed D-FMEA and simulations.
- Engineering design freeze.
- Manufacturing process and equipment designs are frozen.
- Final supplier selection is completed based on fulfillment of requirements.
- Stage report and recommendations how to continue project

11:30 – Final customer validation

Final test:

- Test run the mission.
    - Evaluate the result of the project
    - Discuss what was good and bad with the project.

In addition to the project proposal the players will receive a short-version of the PCP-template used at HCD, with associated method-templates. To be able to fill in the blanks that is needed to finish the project and do a product that is satisfying for the imagined customer. The players will need to follow the steps described in the PCP, as well as communicating with project stakeholders. Such as customer, supervisor, supplier, manufacturing and steering committee.

To aid the players in the PCP and make sure they follow the workshop accordingly, a designated game-leader will act as the projects stakeholders to answer questions and help the players get along with the project.

Equipment used in the workshop when developing the product is a set of Lego Mindstorms–Ev3 ®. Which is a Lego set with a programmable unit, three motors and a few different

sensors. The set enable the players in the workshop to develop a robot that can satisfy the initial need from the customer.

Special features have been built in into the workshop to make the participants pay extra attention to these key-factors. These special features are:

- A well formulated requirement specification: To make the participants work with the requirement specification and realize how important it is that it´s done properly, important requirements have been skipped in the project proposal. During the first stage of the project the team must complete the list of requirements and specify important values. This is simplified through the requirement specification template were the most important aspects of this project have been circled. If the players skip this step they will not be able to pass the gate, and rework must be done.

- Validating functions: To illustrate the importance of a good validation that the product satisfies customer demands and that functions really work. The team will be forced to do rework if the product fails to accomplish the mission in the final test. However, the team could be approved if they can prove that their validation was done properly and that the problems depend on other factors.

- Early involvement of suppliers for exchange of information: To avoid rework the team must talk to manufacturing in an early stage otherwise the product can be designed so that it doesn't fit the parts that manufacturing can produce.

- Using the PCP: To show that different activities affect each other, some special parts are included. The customer gives a requirement of peripheral velocity of the grinding wheel, which is dependent on what grinding wheels manufacturing could produce and what kind of gears the supplier can deliver. In addition, the team must validate that the gear and motor will work without access to the actual grinding wheel.

Doing this project is supposed to illustrate that following the PCP and the associated templates, you will be able to develop a product that is fitting to the customer. A big part of following the PCP is simply front loading the project. To make sure that all the changes of the product is done before it becomes too expensive to do them, thus lowering cost and time in the development phase.

The project goals at HCD are defined in the categories, time, cost and quality. In the workshop these are represented as: Quality, measured by the performance of the final test. This is an easy way to see if the work has been successful or not. Cost is represented by the amount of ordered parts and are there to create a more realistic feeling in the project. Time is represented by the actual time that the workshop last, and gives feedback on time loss due to rework.

4.5 Pilot - Testing the workshop

The first pilot that was carried out with help from a test group of students at Chalmers resulted in some important insights in the continuous work:

- The test group was interested and thought that the task was fun and inspiring.
- The information given in the project proposal was regarded as insufficient, and the participants thought that talking to different stakeholders was an odd part.
- The amount of information in the method templates created confusion about what information that was necessary and which that only was suited for real life projects.
- The participants were given all templates at once, which was regarded as another factor that created confusion. Because the participant had to sort information and lost focus on the actual stage and started to work on the next stage when the progress was slow.
- The confusion around the amount of information in the method templates and that all templates were introduced at once, led to that the group had problems to follow the intended process. Therefore, they got stuck in the first stage and needed guidance to continue the work.
- When the group started to use the intended templates and aids such as circled information, they managed to complete the project.

After the first run-through was held, it resulted in a few changes that was done:

- Less and simpler Lego building for the participants. Instead of building the main structure by themselves, the next pilot was given a ready structure with motors attached, with only the programmable unit, sensor, cables, tool-engine and the gearbox left to attach.
- Ready templates with instructions from customer, supplier and game leader was given when asked about, instead of the need to ask for specific points in them.
- Templates were made clearer, easier to follow by circling information and highlighting specific parts.

The second Pilot run was held at HCD, with two project leaders to further develop the workshop and make sure that it's designed accordingly to illustrate their process. The test run went well and the participants think that it's a good way of illustrating their process, and the importance of a structured method such as the PCP. The participants expressed that this was understood mainly because when they got stuck in the project they could go back to the information in the PCP and the templates and find out how to carry on. Further this run-through resulted in a short list of possible improvement:

- Further simplifying the Lego building, by using modules that can be ordered instead of building the gearbox from scratch.
- Improve the capabilities of measuring data such as time, quality and cost. Use this to add a more competitive environment in the workshop.

- Prepare questions, for discussing and evaluating the workshop together with the participants.

5 Discussion

The case study at HCD gives insight in the company and an understanding of, what aspects of the product creation projects the interview candidates considered as key factors for a successful project. These factors fit well with the theory studies. However, when reading the result chapter, it's fair to consider that the theory studies were conducted before the interviews were conducted. This might have had an impact on the questions that were asked. However, we were aware of this and intentionally asked open-ended questions.

The results from the interview study is based on the answer from relative few candidates (12) where 10 of them are based at HCD. The interview candidates represent most departments of the product development teams, ranging from project leaders, design engineers, test engineer, higher-level managers and external personnel such as a production-project leader and a higher-level manager at Husqvarna Brand Division. However, not all departments were represented. This is important to take under consideration as it might have influenced the results of the interviews.

When analyzing the interviews, a pattern of key factors for success-factors/pitfalls were seen early and not much new information was brought up by every single candidate. This leads us to assume that the information we gathered were representative at HCD. In addition to this, important aspects of a successful project that were identified in the interview results, were like those found in the theory studies:

- Following the PCP is in line with a study conducted by Cooper and Kleinschmidt (1986) which showed that the chances of a successful project increase the closer to the process you follow.
- Validating functions. When Ulrich and Eppinger (2012) list advantages with following a structured method, quality assurance is a part of that list. Which leads us to assume that validating functions is a valid factor to consider. Further on Johansson et al. (2013) state that one important principle for a successful project is to perform early testing, before bigger resources are used to develop details, thus gain a clear picture on if the concept idea will work. First after positive response on the testing, further investments are suitable.
- A well formulated requirement specification is considered relevant as Kahn et al. (2012) point out a: sharp, early, stable, fact-based project and product definition. As a success factor.
- Early involvement of manufacturing/suppliers and exchange of information is a part that wasn't found during the theory studies, but it's considered important anyway as it's included in the process at HCD. It also came up several times during the interviews, which indicates that the interview candidates regarded it as important.

When the PCP was discussed with the interview candidates, it's unclear if it was regarding the PCP or the New product development (NPD), which seems to be vaguely defined at HCD. This might have influenced the interview results regarding how well the PCP is

followed. Because the NPD is the part which the product developers should follow. However, the NPD is included in the PCP.

When doing the pilot with a test group at Chalmers they thought that the workshop was fun to do, shows that it's a suiting method when you want to introduce knowledge, in a more interesting way. At first the players tried to solve the problem without following the PCP and got stuck at the first stage. When following the PCP and the included templates, they managed to finish the project, and understood that following the PCP is important. Regarding the early involvement of suppliers, the players got information from the suppliers when they asked for it, and this led to an understanding that involving suppliers early is important when designing a product.

After the test-run they agreed that the templates were helpful, but asked why they could not be given all the information to start with instead. After discussing this they understood that it's important to put in time and effort to finalize the requirement specification.

When doing the second pilot at HCD the participants regarded the PCP as a good support for knowing how to get through with the process. When they stopped following the PCP and tried to increase speed they got stuck and had to go back to the PCP and find out how to proceed. This is exactly what the workshop is intended to show, therefore this part of the goal is considered to be met.

6 Conclusion

The interviews showed that there is a problem with reaching time-goals. The main reasons to why there is a problem with reaching time-goals were identified as deviations from the PCP, failure to understand the red-thread and a forward push from management.

The aspects of the product development process at HCD that are considered as key factors for a successful project were identified as:

- A well formulated requirement specification.
- Validating functions.
- Following the PCP.
- Early involvement of manufacturing/suppliers and exchange of information.

To visualize and encourage implementation of change a workshop should give the players an opportunity to try and use different work-methods and learn from them, in a smaller much faster stage than in the real world. It's important that the model have built in pitfalls and success factors to illustrate the necessity of using a certain process, in this case the PCP.

After completion of this workshop the players will have faced important aspects and difficulties of the product development process. By following the PCP and the included templates they will have reached success in this project and they will understand the importance of using the PCP in their future product development projects.

Using this workshop, the understanding of the red thread and the importance of structured methods is supposed to increase. This will hopefully lead to more projects reaching their set time-goals.

References

Adler, P. Mandelbaum, A. Nguyen, V. Schwerer, E. (1996). Getting the Most out of Your Product Development Process. *Harvard business review, March-April issue,* 1-24. Retrieved from *https://hbr.org/1996/03/getting-the-most-out-of-your-product-development-process*

Clark, K.B and Fujimoto, T. (1990). The Power of Product Integrity. *Harvard business review, November-December issue,* 1-26. Retrieved from https://hbr.org/1990/11/the-power-of-product-integrity.

Cooper, R.G and Kleinschmidt, E.J. (1986). An investigation into the New Product Process: Steps, Deficiencies and Impact. *Journal of Product Innovation Management,Vol 3(2),* 71-85.

Geurts JLA and Joldersma C (2001) Methodology for participatory policy analysis. *European journal of Operational Research 128(2): 300-310.*

Johannesson, H. Persson, J-G. Pettersson, D. (2013) Produktutveckling: effektiva metoder för konstruktion och design. Stockholm: Liber AB

Kahn, K. Kay, S. Slotegraaf, R. Uban, S. (2012). The PDMA Handbook of New Product Development. New York: Wiley.

Kerga, E. Rossi, M. Taisch, M. Terzi, S. (2014). A serious game for introducing set-based concurrent engineering in industrial practices. *Concurrent Engineering: Research and Applications*, *Vol.* 22(4), 334-344. DOI: 10.1177/1063293X14550104

Prensky, M (2011). Digital game-based Learning. e-book ed. New York: McGraw-Hill.

Sobek, DK. (1997) *Principles that shape product development systems: a Toyota and Chrysler comparison.* Unpublished PhD Thesis, Industrial and Operations Engineering, University of Michigan, Ann Arbor, MI.

Ulrich, KT. och Eppinger, SD. (2012). Product Design and Development. New York: McGraw-Hill Education

Appendix 1 – Intervjuinformation

Intervjuer Husqvarna

Presentation

Maskin Chalmers. Examensarbete inom produktutveckling.

Bakgrund

Många produktutvecklingsprojekt lyckas inte nu upp till sina uppsatta mål. Studie USA 2005 44% av nya produktutvecklings-uppdrag slutförda i tid.

Syfte

Syftet med studien att undersöka om det finns sätt att förbättra processen och öka konkurrenskraft genom att minska tiden från ide till produkt redo för lansering.

Upplägg

Cirka 45 minuter, spela in samtalet om det är ok? Samtalet kommer att analyseras i efterhand. Inspelningarna sparas om det skulle uppstå oklarheter kring vad som egentligen har sagts.

Användning av resultat och återkoppling

Sammanställas och ligga till grund för förbättringsarbete av produktutvecklingsprocessen, samt redovisas i rapport som publiceras via Chalmers.

Etik

Det är okej att avsluta när som helst. Intervjun utförs för att personen representerar en grupp i företaget och studien syftar till att undersöka kopplingar mellan olika delar.

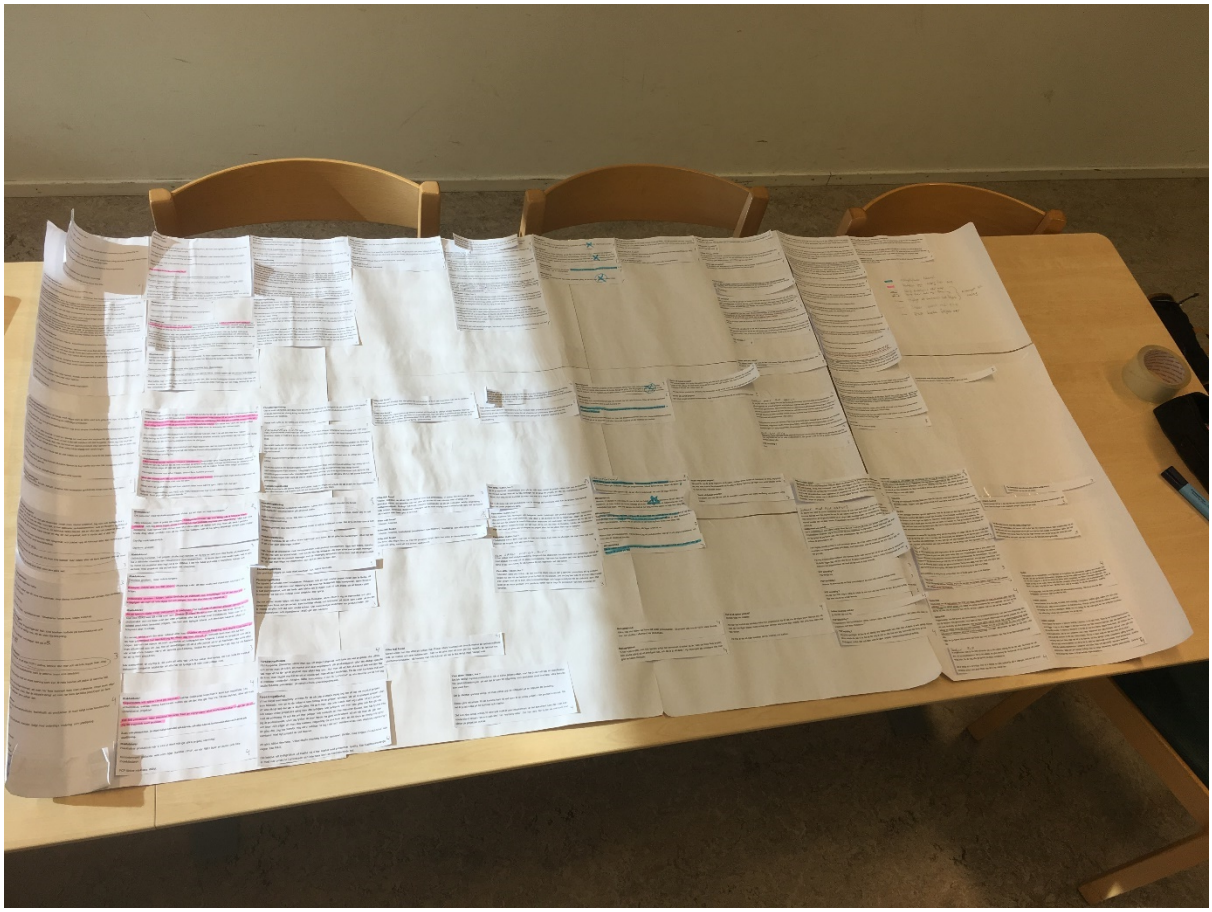
Efter intervjun

För att säkerställa kvaliteten på intervjun får du gärna läsa igenom våra anteckningar av svaren för att se så att vi inte tolkade något helt fel. Är det okej att vi skickar mail som du läser om du har tid?

Appendix 2 – Intervjufrågor

Intervjukandidat:											
Arbetsposition	Hur länge har du jobbat på din nuvarande position?	Hur många projekt har du varit med i? höfta.	Har du jobbat med samma/liknande jobb förut?	Vad är dina huvuduppgifter?	Hur ser en vanlig dag ut?	Hur mycket kan du påverka ditt eget arbete?	Hur många projekt brukar vara igång samtidigt?	Vilka steg i PCP processen, är du involverad i?	Hur väl tycker du olika projekt uppnår sina mål?		
Erfarenhet					Hur många personer interagerar du med dagligen?			Vad gör ni på de olika stegen?			
Kan du berätta om ditt senaste lyckade projetkt ?			Kan du berätta om ditt senaste mindre lyckade projekt?			Hur väl fungerar öppenhet - sammarbete mellan olika parter?		Hur väl tycker du processen/modellen funger att följa?	Vad skulle hjälpa dig följa processen bättre?	Hur verifierar ni att eran framtagna produkt fungerar?	Hur behandlar ni leverabler inför Gate? Ex - Checklista eller underlag genom processen
Vad var det som gjorde att du ansåg det var ett lyckat projekt?			Vad var det som gjorde att du ansåg att detta var mindre lyckat?					Vad är det som gör att du känner så?	Är information tillgänglig	Testa mot ritning?	
Vad tror du det beror på att ni lyckades så bra´?			Vad gjorde att det blev mindre lyckat?					varför	"Best practice mallar?"	Testa mot rätt ritning?	
										Testa mot funktion?	

Appendix 3 – Intervjusvar sammanställning



Appendix 4 – Key Factors

Key factors in Theory

The key factors that was found in the literature study of scientific articles shows that many of the key factors that were found at Husqvarna are common in companies working with product development. A list of key factors found in theory:

- Defining projects
- Requirement specification
- Goals formulating
- Validation
- Productivity
- Lessons Learned
- Resources
- Launching
- Team structure/communication
- Climate and culture
- Way of working (using specific methods)
- Even workload

Appendix 5 - Instruktion Workshop Sliprobot.

Den här instruktionen används för att kunna genomföra workshop i produktutvecklingsprocessen på Husqvarna Construction Division. Det övergripande begreppet för utvecklingsprocessen är Product Creation Process (PCP). Den här workshopen fokuserar på framtagning av nya produkter New Product Development (NPD) som ingår i PCP.

Workshopen är utvecklad för att skapa en ökad förståelse för processen, genom att låta deltagarna genomföra de första tre stegen av NPD i ett utvecklingsprojekt.

I workshopen ligger fokus på de tre områden som under intervjustudien på Husqvarna Construction Division identifierades som de viktigaste faktorerna för lyckade projekt.

- Kravspecifikation
- Kundkravsvalidering
- Kommunikation med produktion/leverantör

Projektet startar med genomgång av resultat från intervjustudie på Husqvarna. Genomgången utgår från powerpoint.

Under workshopens gång fungerar instruktören som de intressenter som finns kopplade till projektet.

- Arbetsledning (ger info om lessons learned, samt nödvändiga steg att följa i mallarna)
- Slutkund (ger info till market and user requirements och bedömer sluttest)
- Tillverkare (Producerar slipskiva, batterier, samt mjukvara)
- Leverantör (Levererar Lego)
- Styrgrupp (Ansvarar för gatepassage, samt sluttest)

Deltagarna har möjlighet att när som helst under workshopens gång ställa frågor och be om synpunkter, till de olika rollerna. Rollerna måste adresseras av teamet, de måste alltså förklara att de vill prata med kunden eller arbetsledningen till exempel.

Start, deltagarna ges:

- Project proposal med ”tidigare koncept” (koncept som har använts för att lösa liknande tekniska problem tidigare).
- NPD-beskrivningen med tillhörande mallar och checklistor.
- Lego-katalog (tillgängliga delar som går att beställa av leverantör)
- Lagervaror (legobitar för sammanfogning)

Projekt Sliprobot.

Project proposal.

Trender och teknologier

För att lösa kundens krav finns det senaste Lego Mindstorms EV3 att tillgå, en lista över tillgängliga delar är bifogad. Tidigare lösningar på tekniska utmaningarna som liknar de i projektet finns i bilagan ”Existerande koncept”.

Finansiell påverkan

Tid: Tiden som finns att tillgå i projektet är totalt tre timmar, delleveranser och beräknad tidsåtgång för de olika stegen enligt nedan. Vill ett team gå till gate tidigare än planerat så går det bra.

08:30 – Introduction
09:00 – Start specification stage
09:45 – Development gate
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11:30 – Final customer validation

Projektmål

Målen för projektet delas in i tid, kostnad och kvalitet och mäts enligt följande:

- Tid: utvecklingstid från start av projekt till avklarad uppkörning.
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Intressenter

- Arbetsledning
- Kund
- Tillverkare
- Leverantör
- Styrgrupp

Marknads och kundkrav

- Kunden vill kunna polera en golvyta.
- Underlaget kräver en periferihastighet (v) på slipskivan på $5 < v < 5{,}7$ [m/s].
- Kunden vill ha en sladdlös eldriven produkt.
- Produkten ska vara av typen AGV.
- Marknaden är global, produkten ska alltså kunna säljas och användas över hela världen.

Projektinformation

Baselementen som länkar och delar för sammanfogning finns tillgängliga som lagervara och kan användas fritt utan att de påverkar kostnaden. Övriga delar måste beställas. Det finns flera olika leverantörer av batterier, slipverktyg och mjukvara. Därför behöver dessa identifieras och väljas (utifrån appendix 1). Lego är en standardvara som beställs enligt katalog (motorer, kablage, programmerbar enhet mm).

Det går att kontakta projektets intressenter med specifika frågor. Ni kommer under projektets gång gå igenom Specification stage samt Development stage 1&2, efter varje stage ska arbetet presenteras för styrgruppen för att kunna passera gaten till nästa stage. Efter design-freeze testas produkten av slutkunden.

Specification stage

När teamen genomför olika punkter kommer de behöva fråga intressenter, de olika intressenterna har då följande svar (vilka de ger i form av infoblad).

Manufacturing (TILLVERKARE):
Slipskivan. Spelledare anger att det finns tre varianter: 12, 15 och 17 [cm/diamater]. Och frågar efter ritning på infästningen. Anges inga fasta direktiv (ritning av infästning/antal pluppar) så ges skiva med 5 ploppar.

Slipskiva					
Supplier	A	B	C	D	E
(diameter [cm] och fäste)	12:5	15:5	19:5	12:6	15:6
Manufacturing cost	200	300	400	350	250
Other comments			Kompatibel med kuggstång 4499858		Kompatibel med kuggstång 4499858

Batterier: Teamet måste rikta sig till tillverkare av batterier för att ta reda på följande information, kategorierna till vänster motsvarar kategorierna i mallen/templaten för val av supplier.

Batterier				
Supplier	A	B	C	D
Other comments (Batterityp)	AAA 1.5v	AA 1.5v	AA 9v	Batteripack uppladdningsbart
Weak points	Fungerar endast med 6014051			Kräver 230 anslutning.
Material cost	20	30	40	50
Driftskostnad	30	40	10	10

Mjukvara: Teamet måste fråga tillverkare av mjukvara för att få tillgång till följande information. Uppkörningen sker sedan med vald mjukvara.

Supplier	A	B	C	D	E
Steering options	Ljussensor som följer linje	Ljussensor som följer linje	Styrning med app	Styrning med app	Styrning med fjärrkontroll
Manufacturing cost	100	50	75	80	50
Other costs (driftskostnad, påverkar kunden)	0	0	50	50	50
Weak point		saknar start av slipmotor	Saknar start av slipmotor		Saknar start av slipmotor
Other comments	Anpassad för bakhjulsdrivet fordon med sensor fram	Anpassad för bakhjulsdrivet fordon med sensor fram			

Supplier: (Leverantör)

- Lego
- Motorer (Om tillfrågad anges 240 rpm som varvtal på liten motor. I normalfall används portarna B och C till stora drivande motorer samt A till liten motor)
- Kablage
- Sensorer (ljussensor, port 3)
- Däck, Band.
- Kuggar, stor svart 36, liten svart 12, stor gul 20, liten gul 12

Market and user Requirements TEMPLATE:
Om spelaren frågar (ARBETSLEDNING) så är punkterna: 2.3, 7.1, 7.2, 7.3 samt 9.1 och 9.4 viktiga.

2.3 Lessons learned
Om teamet frågar: Vilka lessons learned togs upp I “Project kick off”?

För att beräkna utväxling använd formel:
I=utväxling I=n1/n2 n1=hastighet på drivande axel n2=hastighet driven axel. I=z2/z1 z1=antal kuggar på drivande axel, z2=antal kuggar på driven axel.

I tidigare projekt har legobit 4494222 använts som anslutning för roterande verktyg och sitter fast ansluten mot slipskiva.

7. Consumer insights
Om teamet frågar (KUNDEN):
7.1 End-user needs and problems

- Vill kunna polera vägar i sorteringslager
- Produkten används i byggfasen så det saknas väggar, produkten behöver alltså inte kunna slipa hela den egna brädden.
- Ska kunna polera minst 12 cm i diameter

7.2 Intended solutions

- Det finns en markerad slinga som går att följa med färgsensor

7.3 Research conducted

- Global produkt, 230 anslutning kommer inte fungera i USA.

9. Overall system description.
Om teamet frågar (KUNDEN):

9.1 End-user description
Ritning av lagerlokal

9.4 Functional requirements
Teamet bör sätta ihop krav från leverantörer, tillverkare, kunder, marknad, project proposal.

Development gate

Stämma av arbetet på alla stage objectives och samla in bom-lista för att kunna leverera delar i phase 1.

Development stage phase 1

Teamet får beställda Lego-delar från leverantör, antal leveranser kommer då räknas.

Teamen går även igenom design verification mallen och bestämmer hur de ska validera att de lyckas uppfylla alla requirements. Samt D-fmea för att säkerställa att designen fungerar vid sluttest och att onödiga risker är eliminerade.

Investment gate

Stämma av arbetet på alla stage objectives, lägg extra fokus på D-FMEA

Development stage phase 2

Efter final supplier selection levereras batterier, mjukvara och slipskiva

Industrialization gate

Stämma av arbetet på alla stage objectives

Uppkörning

Bedömning av kvalitet av slutkund

Appendix 6 - Projekt Sliprobot.

Project proposal.

Trender och teknologier

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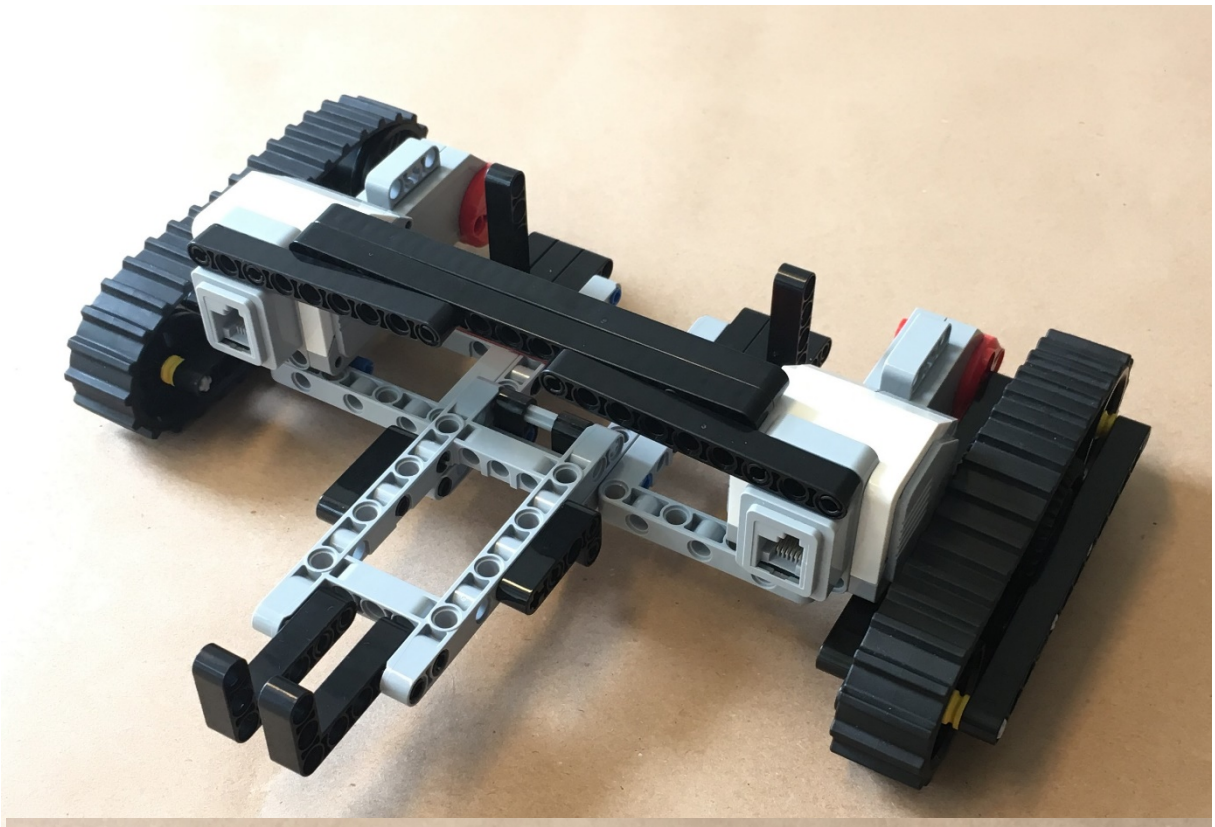
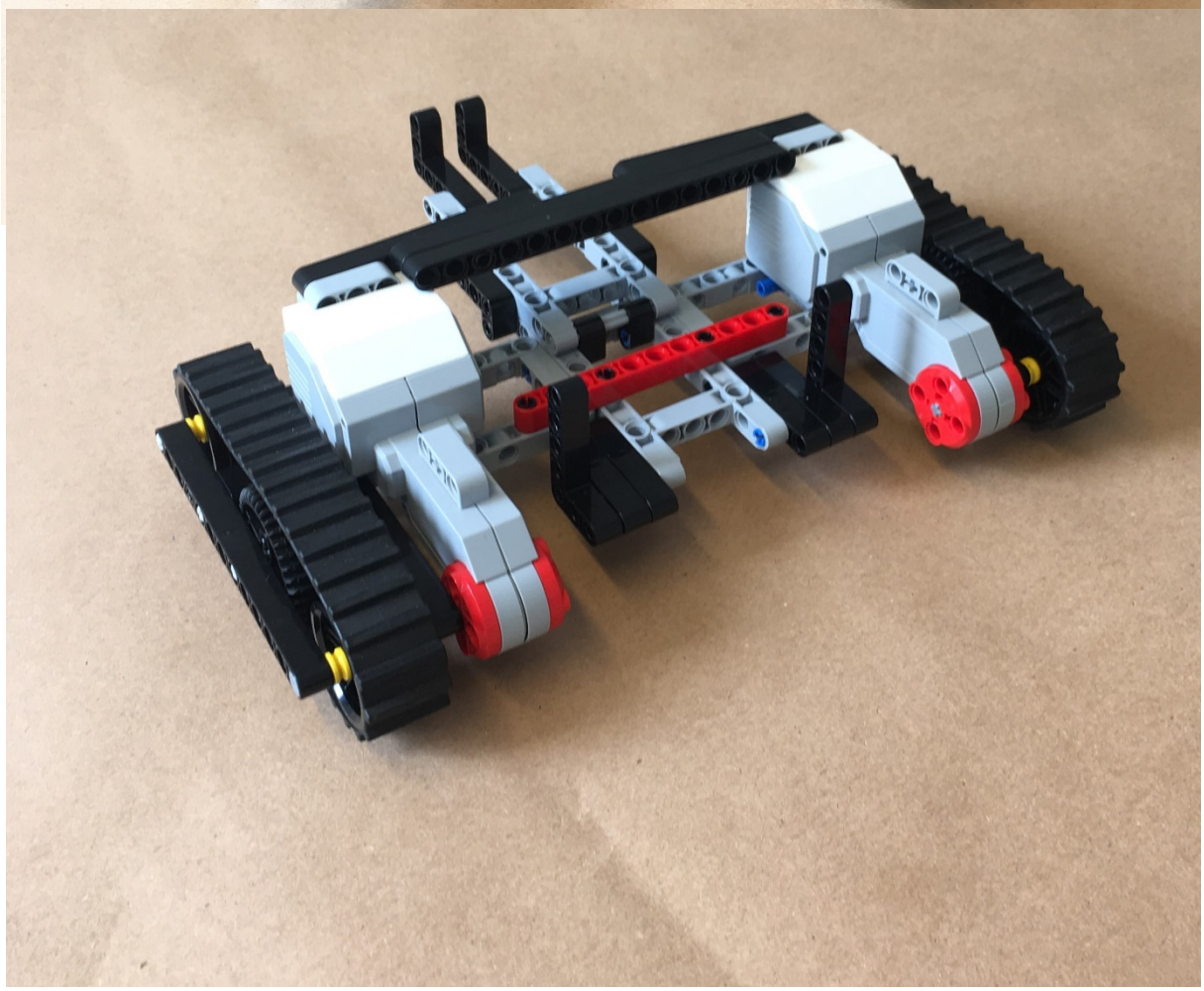
Appendix 7 - Existerande koncept

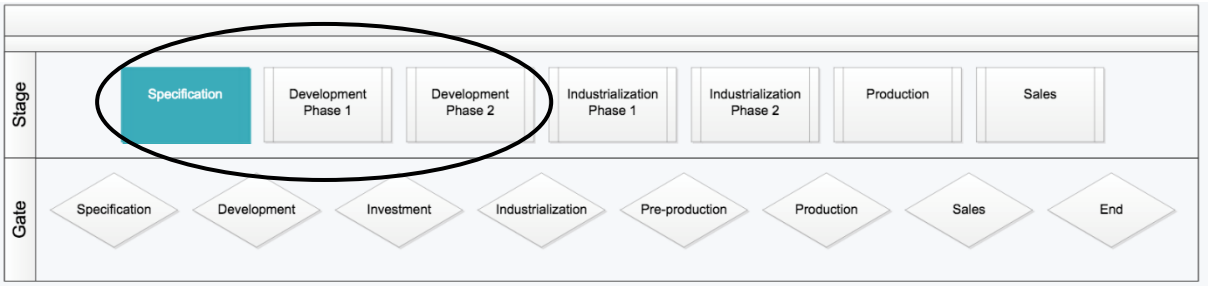
18cm mellan larver





Appendix 8 – PCP short

Specification stage



Purpose

Generating a product specification and developing product concepts that meet the set market- and user-demands from the project proposal.

Description

Project proposal is analyzed and important demands are compiled, evaluated and specified in a product specification.

A structured development method will be used, for example set-based concurrent-engineering. Sketches of prototypes can be used to validate that the concept meets the demands. Potential suppliers and manufacturers are identified and evaluated based on if they meet set demands on quality etc.

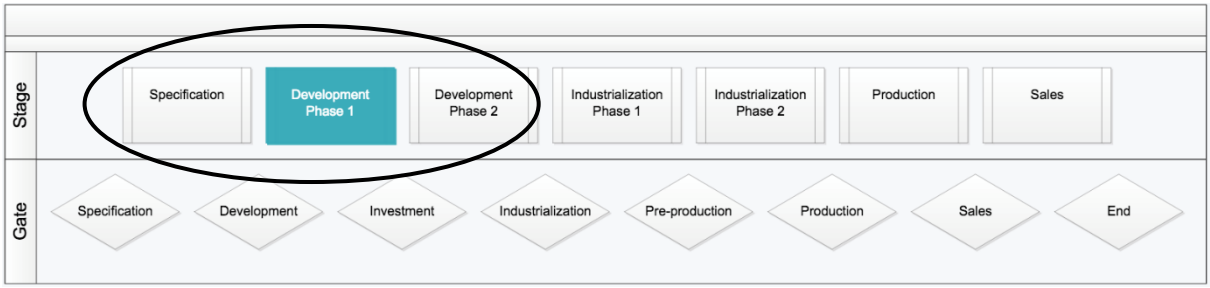
Input

Project proposal with initial Market and User requirements.

Stage objectives

- **Product Specification.** From Requirements defined for the project from stakeholders like manufacturing & suppliers (appendix 1), market & users (appendix 2), in addition to product compliance requirements.
- **Product Concept.** Including Bill of Material and Design direction with the possibility to fulfill the Product Specification and the agreed parts of Requirements.
- **Preliminary Design Verification and Validation plans.** Covering each of the development steps (appendix 3).
- **Identified approved potential suppliers.** And their possibility to fulfil requirements (appendix 2).
- **Go to Development Gate**
- A **recommendation** if and how the project shall proceed.

Development stage - Phase 1



Purpose

Improving the product development project to a level that makes a stable assumption about the business proposal for investment request.

Description

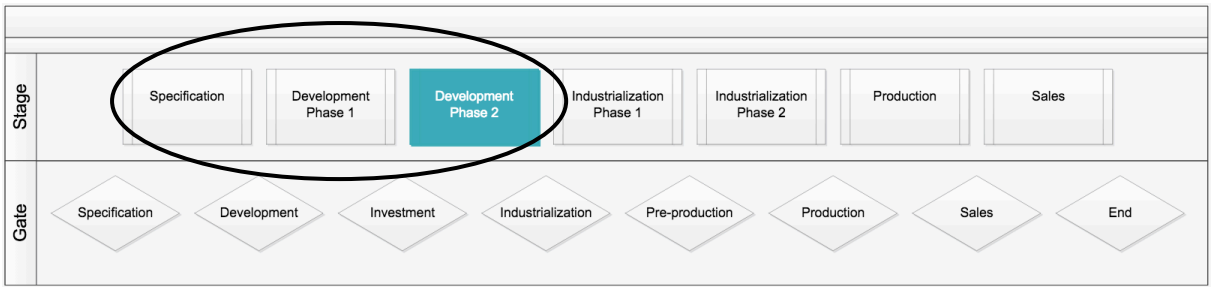
An industrial and technical design for the chosen concept is developed. With start on a system level, decomposed into part-systems and component level. This means development and affirming of an industrial design model and preliminary blueprints of critical elements.

A stable software architecture is developed. Viability must be secured by concurrent product- and process construction as well as contribution by stakeholders, (suppliers, production and customers.) FMEA, risk assessment.

Stage objectives:

- **A matured Product and Brand Design meeting all requirements agreed. Includes the whole scope of the product and product software.**
- **Design risk analysis, D-FMEA** (Appendix 4)**.**
- **Design Verification plan is set for all development stages, from Prototype to Manufacturing Pilot status.**
- **Stage report and recommendations how to continue project.**

Development stage - Phase 2



Purpose: Verification and validation of design. Make sure that the product design, functions and production concept meet set demands.

Description: 3D and 2D blueprints as well as specification are finalized, and released for ordering of design verification-prototypes. The prototypes are manufactured and measured according to the specifications. Design verification testing and customer demands validating is performed to ensure fulfilling of product specifications as well as user and market requirements. Software is also tested to ensure it meets the demands. In the end of development phase two the software should be 100% constructed, implemented and tested.

Stage objectives:

- **Engineering design is verified to Product Specification and other agreed requirements through prototyping, completed D-FMEA and simulations.**
- **Engineering design freeze.**
- **Manufacturing process and equipment designs are frozen.**
- **Final supplier selection is completed based on fulfillment of requirements.**
- **Stage report and recommendations how to continue project**

Final test

- **Test run the mission.**
    - **Evaluate the result of the project**
    - **Discuss what was good and bad with the project.**