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JAAKKO SAIRANEN
METHODS FOR NEW PRODUCT CONCEPT DEVELOPMENT
FOR EXISTING MARKETS

Master of Science Thesis

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ABSTRACT

JAAKKO SAIRANEN: Methods for new product concept development for existing markets

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Concept creation is the starting step of any new product development project. A feasible and well-designed concept gives the possibility of creating new innovative products that are competitive in the market. Not all concepts materialize into new products. Usually multiple concepts need to be created thus having an efficient process for concept creation is beneficial. Being able to create products that are cost efficient and satisfy customer needs bring competitive advantage against competitors.

This thesis is done to create a documented concept creation process for a company. The company is a globally operating mechanical machinery manufacturer. The goal was to have a process where a structured approach is used for concept creation. The process was constructed as a combination of the methods reviewed in a literature review. These methods include product development methods, facilitation methods and innovation methods. Also risk management literature and factors of competitive advantage were reviewed.

The need for the new product concept originated from the case company's needs to create a new product to replace an old one. The current product has been in the market for a long time and the company felt a new product is needed to gain more market share. As the original need for the concept was business based, the customer's needs were mapped in order to align them with the business's needs.

The new concept creation process was tested by conducting a case study where a new concept was created. The creation process included mapping customer requirements, interviewing relevant personnel in the case company to gather information, creating and refining ideas in idea sessions, evaluating the new concept and creating a risk analysis. With the new process, a new concept was created successfully though some design work was still needed for the concept to move towards to the next steps in development.

The current processes in the case company were mapped and compared to the new concept creation process. Suggestions were given to include the used methods to the current development process as the current process does not include any practical tools for designers to use in concept development.

TIIVISTELMÄ

JAAKKO SAIRANEN: Uuden tuotekonseptin kehittämismenetelmä olemassa oleville markkinoille

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Konseptin kehittäminen on jokaisen tuotekehitysprojektin alkuaskel. Toimiva ja hyvin suunniteltu konsepti mahdollistaa innovatiivisten ja kilpailukykyisten tuotteiden kehittämisen markkinoille. Kuitenkaan kaikki konseptit eivät kehity tuotteiksi asti. Lähes aina tarvitaan useita konsepteja ja siksi konseptin kehitysprosessin täytyy olla tehokas. Kustannustehokas tuotekehitysprosessi, joka vastaa asiakkaiden vaatimuksiin, mahdollistaa kilpailuedun saavuttamisen markkinoilla.

Tämän diplomityön tarkoituksena oli muodostaa dokumentoitu kehittämismenetelmä konsepteille. Kohdeyrityksenä oli globaalisti toimiva koneenrakennusyritys. Tavoitteena oli luoda järjestelmällinen prosessi konseptin kehittämistä varten. Tämä prosessi luotiin yhdistelemällä kirjallisuuskatsauksessa tarkasteltuja menetelmiä. Näiden menetelmien joukossa oli tuotekehitysmenetelmiä, fasilitointimenetelmiä ja innovointimenetelmiä. Kirjallisuuskatsauksessa tutustuttiin myös riskienhallintaan ja kilpailutekijöihin.

Tarve uudelle tuotekonseptille oli yrityslähtöinen. Vanha, pitkään markkinoilla ollut tuote haluttiin korvata uudella tuotteella, jotta markkinaosuutta pystyttäisiin kasvattamaan. Vaikka alkuperäinen tarve uudelle tuotekonseptille oli liiketoimintalähtöinen, piti myös asiakas tarpeet kartoittaa ja yhdistää liiketoiminnan tarpeisiin.

Työssä kehitettyä konseptinkehitysprosessia testattiin käytännössä case-tutkimuksessa, jossa kehitettiin uusi tuotekonsepti kohdeyritykselle. Kehittämisprosessissa määriteltiin asiakasvaatimuksia, haastateltiin henkilöstöä tarpeellisten tietojen keräämiseksi, luotiin ja kehitettiin uusia ideoita ideointipalaverissa, arvioitiin uutta konseptia ja tehtiin riskianalyysi uudelle konseptille. Kehitetyllä uudella prosessilla onnistuttiin luomaan onnistunut tuotekonsepti, vaikka tuotekonsepti vaatii vielä jatkokehitystä ennen tuotekehitysprojektin jatkamista.

Myös yrityksen nykyinen tuotekehitysprosessi kartoitettiin ja sitä vertailtiin uuteen konseptinkehitysprosessiin. Vanha prosessi ei sisältänyt kehitysmenetelmiä, joten uudessa prosessissa käytettyjen menetelmien lisäämistä vanhaan tuotekehitysprosessiin suositeltiin.

PREFACE

During the making of this thesis I have learned a lot. It has been a fascinating opportunity to study concept creation in an organization full of experienced designers and engineers. I would like to thank all members of the design team that made this thesis possible.

I would like to also thank my thesis examiner Timo Lehtonen for his constant support and interesting talks during the creation of this thesis.

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Jaakko Sairanen

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LIST OF ABBREVIATIONS

ARIZ	Algoritm resheniya izobretatelskikh zadach, Algorithm of Inventive Problem Solving
CAD	Computer-aided Design
CPM	Characteristics Properties Modeling
PDD	Property Driven Development
R&D	Research & Development
SWOT	Strengths, Weaknesses, Opportunities and Threats
TRIZ	Teoriya resheniya izobretatelskikh zadach, Theory of Inventive Problem Solving

1. INTRODUCTION

Developing new product concepts for a market that has been stable for a long time can be difficult. New product concepts are needed to keep company's offering competitive in a tight and competitive market. Not all product concepts created materialize into commercial products. Sometimes the market is not ready for a new type of product or technology is not yet mature enough to make a concept viable. To tackle these problems and to be able to produce new products to the market a large number of concepts have to be created. That is why the concept creating process has to be efficient and well documented.

1.1 Motivation

This thesis was done as a case study in a global manufacturing company which operates in the area of mechanical machinery. The field in which the case company operates has only a few competitors and relatively small number of customers. The designed product in this thesis is a modular subproduct of the final product which the customer uses. However, the subproduct conceived in the case study is very important for the customer's end process and thus oversees many customer requirements for the whole product. In this thesis, referring to the product means referring to the modular subproduct.

This thesis was done to create a process for the case company which could be used for new concept creation in stable market conditions. The current product covered in this thesis dates to 1980's and not much has changed since in the principle of the product. The company has created new platforms where the product is used and other components around the product have changed through these years. However, creating viable concepts for this product has been tried earlier with little to no success. What was common with the earlier tries was the lack of background work and preparation. The need to redevelop the product came originally from the company itself instead from direct customer request. In this thesis, related customer needs were identified. Finding out real customer needs and aligning internal needs and expectations were set as a high priority for this development process.

1.2 Thesis goals and limitations

The goal for this thesis is to create a development method for a development organization that operates in a market where the current design has been dominant for a long period of time. The main research question is:

- How to create a new product concept into a stable market?

In addition, the following complementary research questions are:

- How to determine if the new concept is better than the current product?
- What challenges are faced during the development process when the need for change is only partially market driven

The need for change originally initiated from the business's needs. Many aspects of the product were seen old. The product line, where the product is used, had been redesigned and a strong wish from the business perspective was to bring something new to the market.

Evaluating the success of the created concept development method is done by creating a concept for the case company. The concept is evaluated in terms of properties and comparison is done to the current product in the market as well as to the competitor's current product.

The case focuses only to a certain subproduct of the whole product and the development is done only in a single site of the company. This limits the results of the thesis to be used mainly at this single location opposed to being company-wide method. However, the results can be utilized in all departments operating at the location. Operations at this location are very similar and same personnel is used between departments. Having such a flexible design department makes utilizing the results easy.

1.3 Thesis breakdown

This thesis consists of eight chapters with the first one being introduction. The second chapter presents a short literature review including theory related to concept development, idea creation, competitive strategies and risk management in product development. Theory was utilized in the case study section of the thesis. The third chapter introduces research methods and strategies used in this thesis. The fourth chapter describes the current product development processes that are documented and in use in the case company. The fifth chapter presents work that had to be done prior to concept creation and the sixth chapter describes how a new concept was developed within the case company. Finally, the seventh chapter discusses the feasibility of the new development method to the company and the eight chapter summarizes the thesis with answers to the research questions.

2. THEORY

In this chapter theory related to product development is introduced. First, a couple of product development processes are introduced. Second, idea creation techniques and the role of a facilitator are reviewed. Then competitive strategies are introduced. Finally, product development risks and risk management procedure are introduced.

2.1 Product development processes

Ulrich & Eppinger (1995, p. 2–3) name five characteristics for successful product development:

- Product quality
- Product cost
- Development time
- Development cost
- Development capability

Product quality means the product's ability to satisfy customer needs. Is the product reliable? Can it function the way the customer is expecting? With good quality come a larger market share and better price for the product. Product cost is the cost of manufacturing the designed product. This also includes one-time investments to production equipment. The cost of the product affects the margins of the company together with the price the customer pays. Development time shows how quickly the company can react to changes in the market by offering new products. Faster development time makes the company stronger in the competition and returns capital invested to the development faster in terms of revenue. Development capability shows how well the company can develop new products in the future. Learning from previous development projects is essential here. The company benefits in the future when new projects are faster and cheaper to execute.

The product development process might face are many challenges. Difficult decision making happens constantly. What feels like a small decision at the time might have big consequences later when the product is in the market and the development phase is over. Trade-offs are a decision type where another property must weaken in order to make another property of the product better. Also, a multitude of decisions have to be made when defining product structure. For example, fixture methods, materials, surface finishing and other details must be defined for all parts of the product. If the product is

complex, it can have tens of thousands of parts to be defined. Also, decisions must be made in a changing environment. In most cases a product development process takes at least a year and, in some cases, up to five years. Technology that was used in the beginning of the product development process can become obsolete as new technologies emerge constantly. Time pressure is present, and some decisions must be made without complete information of all the factors involved. (Ulrich & Eppinger, 1995, p. 4–7)

2.1.1 Five-stage generic development process

Concept development is the first step in a five-stage generic development process presented by Ulrich and Eppinger (1995, p. 15–18). The development process can be seen in Figure 1. In concept development, many important definitions must be done that reflect the success of the whole development project. Different departments, including marketing, design, manufacturing, finance and legal, must participate in the concept development phase as they all have specific duties. This requires a great amount of coordination between departments which adds to the difficulty of this step of the process. Marketing is responsible of defining market segments, identifying lead users and identifying competitive products. Design department develops concepts, investigates the feasibility of these concepts, selects the best concept for further development and builds prototypes. Manufacturing studies the producibility and estimates production costs. Finance has to facilitate economic analysis and legal has to help with patent issues.

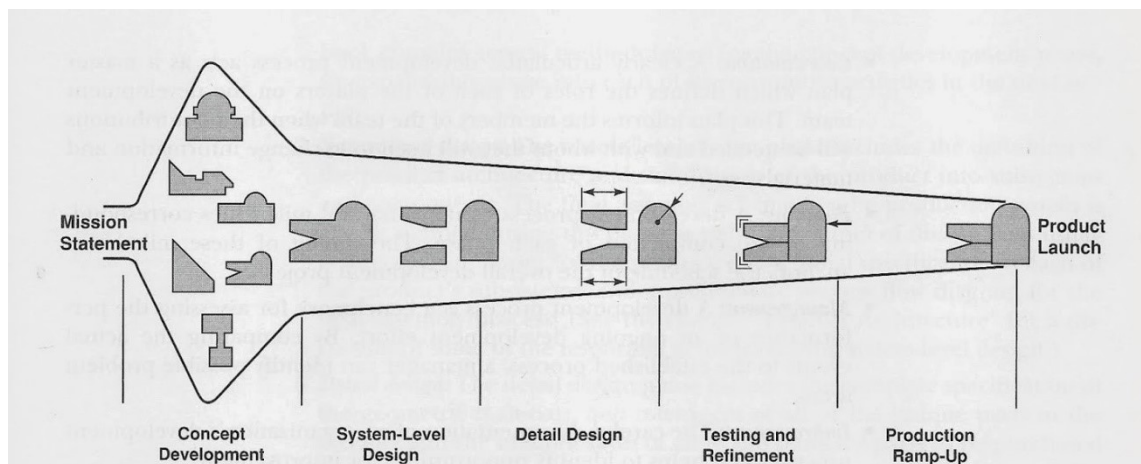


Figure 1. Five-stage generic development process (Ulrich & Eppinger, 1995, p. 15).

Concept development starts from identifying customer needs and providing a well-organized list of needs with their importance defined. Then these needs are formed into a list of target specification that describes what the product must do. Each specification is given a target value. Target values in the specification are not goals that must be reached but rather guidelines that are hoped to achieve. Analysis of the competitive product is required for full understanding of the current market situation. This benchmarking supports also the concept selection that happens later in the process. Now that

the required data has been gathered, the actual concept creation can happen. The aim is to create 10 to 20 different concepts which are documented in sketches and with short descriptions. The best concept is selected and a more detailed description of it is composed. The specifications related are then refined with relevant limitations and trade-offs in mind. An economic analysis is drafted. It defines the costs and profits of the product. The analysis must give positive results for the project's continuation to be feasible. If all previous steps are completed successfully, a project plan is done. It should define the strategy and necessary steps to complete the project and launch a new product. (Ulrich & Eppinger, 1995, p. 16–20)

2.1.2 CPM/PDD

Properties Driven Development (PDD) is a product development process and Characteristics-Properties Modelling (CPM) is a way of describing products. Both have been created by Christian Weber. These models have been developed to counter weaknesses found in other development processes. Weber (2010, p. 4) lists that most other approaches have deficits such as mechanical designs being emphasized in the design process, weak product model concept definition, no proper iteration loops of the process and evaluation issues excluded from the process.

CPM/PDD is a concept for modelling products and processes which integrates other existing development models and strategies into one. Characteristics in this model describe the product's structure and shape and they can be directly determined by the designer. These characteristics can be for example materials, dimensions or shapes. Properties on the other hand cannot be directly determined by the designer as they are effects of the designer's decisions. Properties of a product can be for example weight, cost, function or safety. CPM/PDD makes these characteristics and properties the focus of the product development process. (Weber, 2010, p. 4–5)

The first step in the process is to map the product according to different phases of its life-cycle. A typical life-cycle consists of manufacturing, assembly, testing, distribution, use, service and disposal of the product. Using these life-cycle steps, properties such as durability, reliability, environmental friendliness and manufacturability can be identified. These properties are then refined into more measurable criteria and they can also be sorted by their importance or sequence in the life-cycle. (Weber, 2010, p. 7)

The product structuring is done as a hierarchical part tree. All assemblies, subassemblies and parts have identification, classification, position and orientation. Parts also have parameters related to geometry, surface and material. Example of this structuring can be seen on Figure 2. (Weber, 2010, p. 6)

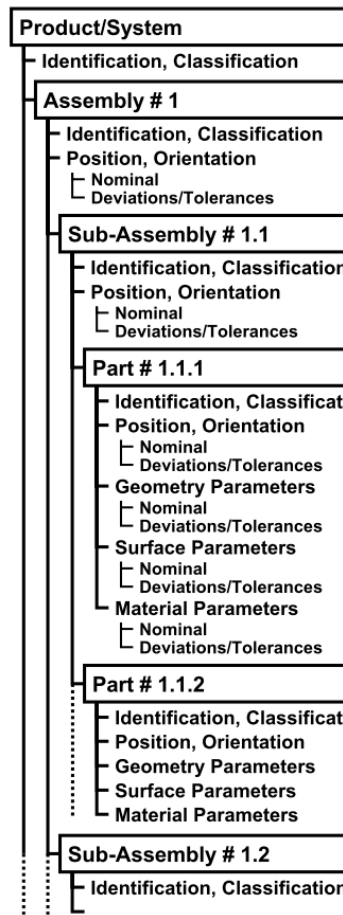


Figure 2. Initial product structure of CPM/PDD (Weber, 2010, p. 5).

The actual product development happens in cycles. A cycle consists of synthesis, analysis, individual deviations and overall evaluation. In the beginning of the development only the earlier defined requirements are known. The structure of the solution is unknown. From these requirements a preliminary structure is built. Relations between characteristics and properties and dependencies between characteristics are defined. This concludes the synthesis step which can be seen on Figure 3.

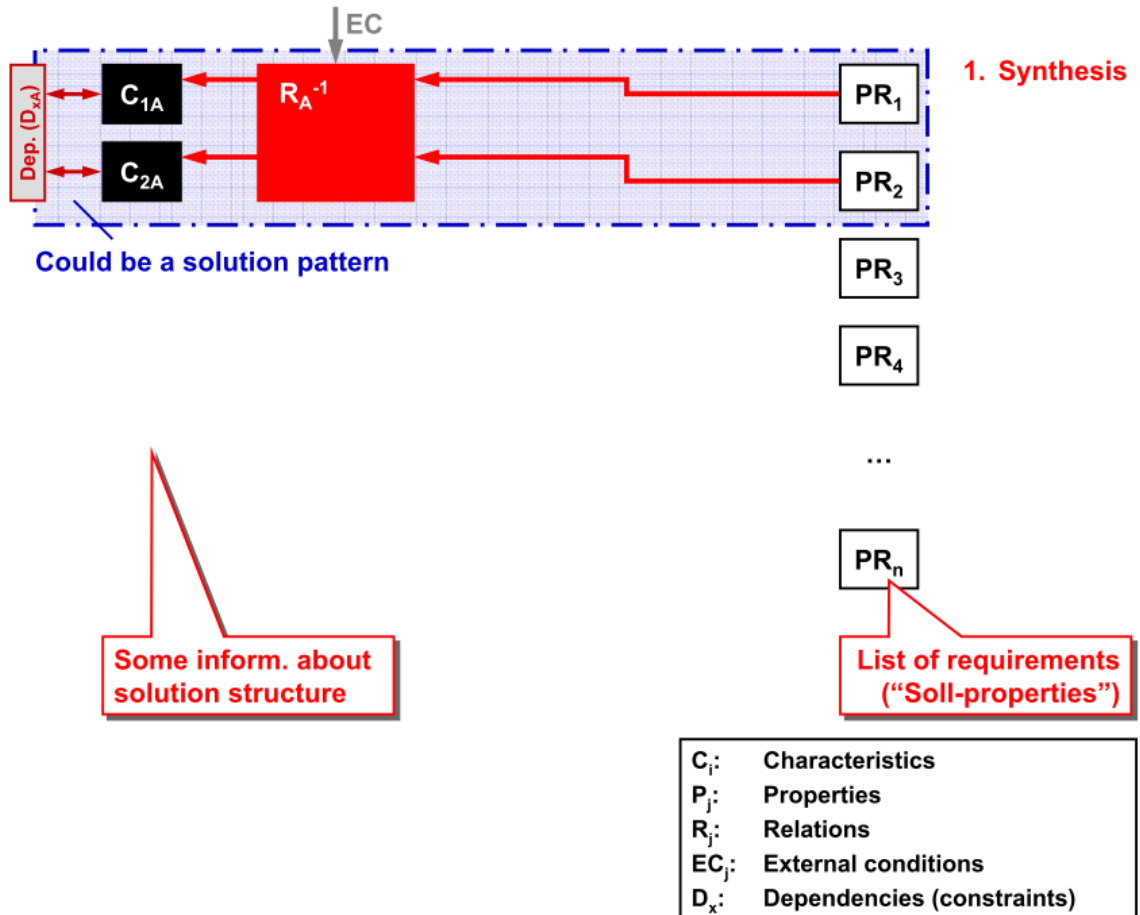


Figure 3. Synthesis phase of CPM/PDD (Weber, 2010, p. 14).

In the analysis phase the newly created solution is analyzed. In the analysis properties are created that reflect how the solution would behave. These solution properties are similar to the properties that were the initial definition of the synthesis stage. The new solution properties are compared in the individual deviations phase. With identified deviations the final evaluation is done. The result of this evaluation is the main driver for this process and the solution should be further developed based on the deviations found. The full 4 steps can be seen on Figure 4. After the first cycle has been completed a new cycle should be started, now based on the properties derived in the first cycle. By repeating the process multiple times, the differences between wanted properties and actual properties of the solution should be minimal. (Weber, 2010, p. 15–20)

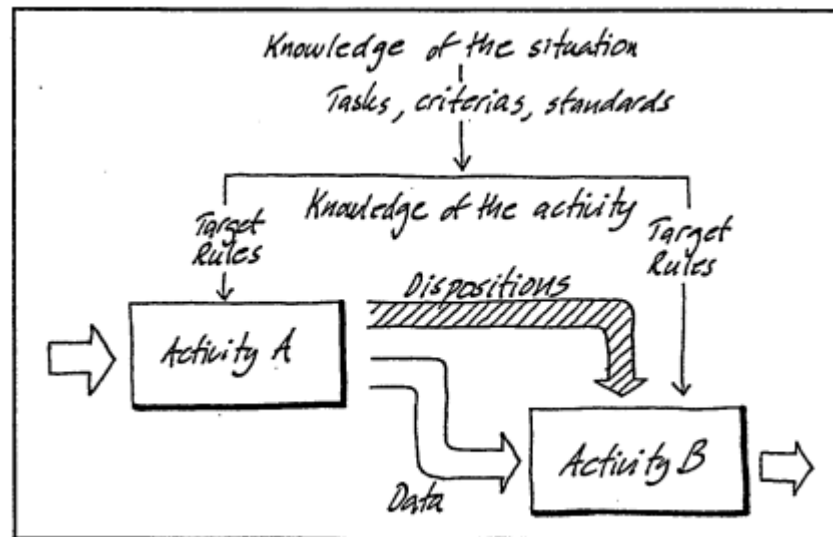


Figure 5. *Generic model of disposition (Olesen, 1992, p. 52).*

The generic model shows that dispositions always come from decisions, but the decision does not always have to be down the line in the production chain. Looking at the previous example, the disposition can be from activity B to A if the proposition to change the design has come from the assembly line to designers. The impact of dispositions does not always limit to a single activity. Changing the design of the frame can also have an impact on production planning as the assembly time is lowered. (Olesen, 1992, p. 53)

For concurrent engineering to be successful the dispositions have to be identified throughout the whole lifecycle. This can be done by applying the generic model of disposition multiple times throughout the whole activity chain of the product. Olesen (1992, pp. 57-60) presents a score model which contains all development processes for the product and all production-oriented systems. The score model can be seen in Figure 6.

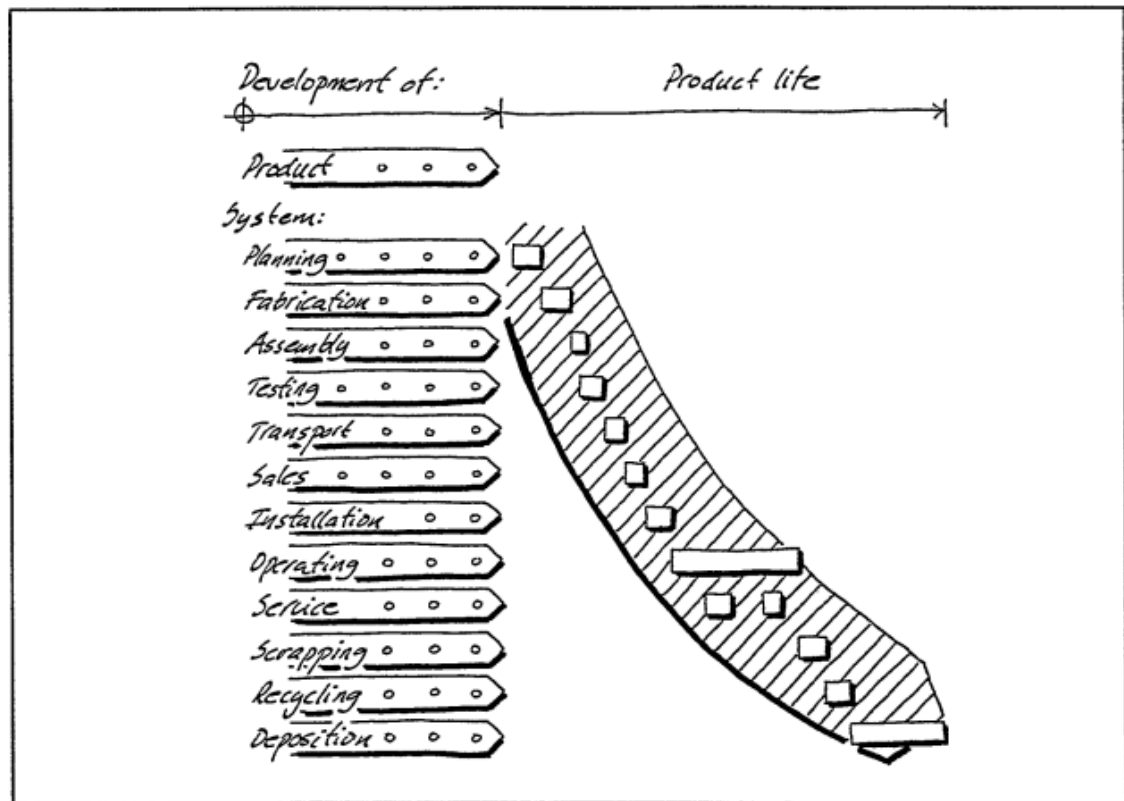


Figure 6. *The score model (Olesen, 1992, p. 58).*

The score model shows the whole product lifecycle and all systems that are impacted by product development dispositions. By examining the relationships between dispositions, it is possible to estimate the results of development decisions early in the project. To fully understand the effects of dispositions they have to be measured by parameters that characterize the design. These so-called Universal Virtues are costs, throughput time, quality, efficiency, flexibility, risk and environment (Olesen, 1992, p. 41). Olesen (1992, p. 87–91) presents a theoretical model which shows the dispositional effects of chosen design characteristics. This model is called the model of dispositional mechanism which can be seen in Figure 7. A dispositional mechanism contains:

- Two development activities from different functional areas, where either the concept, structure or details are to be determined
- Data and dispositions between the activities
- Objectives for both activities
- Rules for how the objectives can be achieved by decisions which are taken in the course of the activities
- Possible choices of design characteristics
- A calculation of the dispositional effects of particular choices of design characteristics

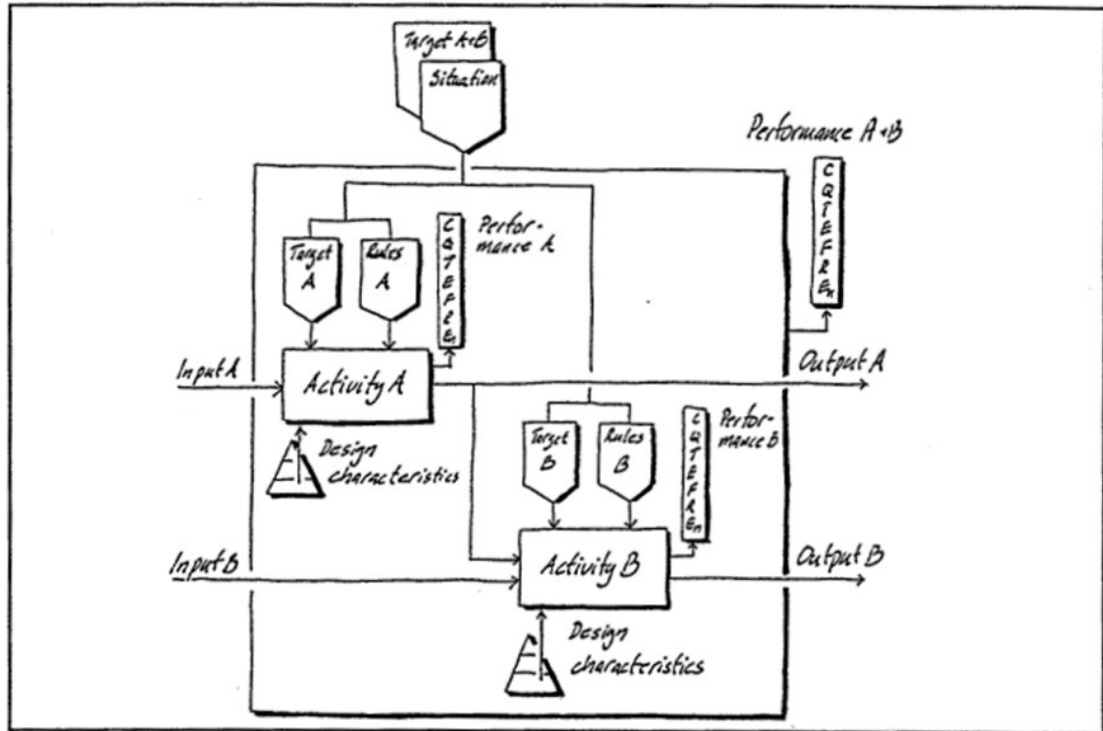


Figure 7. Model of dispositional mechanism (Olesen, 1992, p. 87).

With the model of dispositional mechanism, it is possible to develop the product and the production systems with the use of design characteristics and to map the relationships between them.

2.1.4 Stage-gate system

Stage-gate process is designed for new-product projects and it aims to show a conceptual and operational map from an idea to product launch and beyond. Stage-gate is widely used in industry and it has been developed by researching successful project teams and their actions. The process is based on five main stages with each one of them being cross-functional. Each stage contains activities, analysis of the results from the activities and deliverables which are the results from the analysis. At the end of each stage is a gate in which the current progress is evaluated and a decision for continuation of the project is made. (Cooper, 2011, p. 83) A single stage process can be seen in Figure 8.

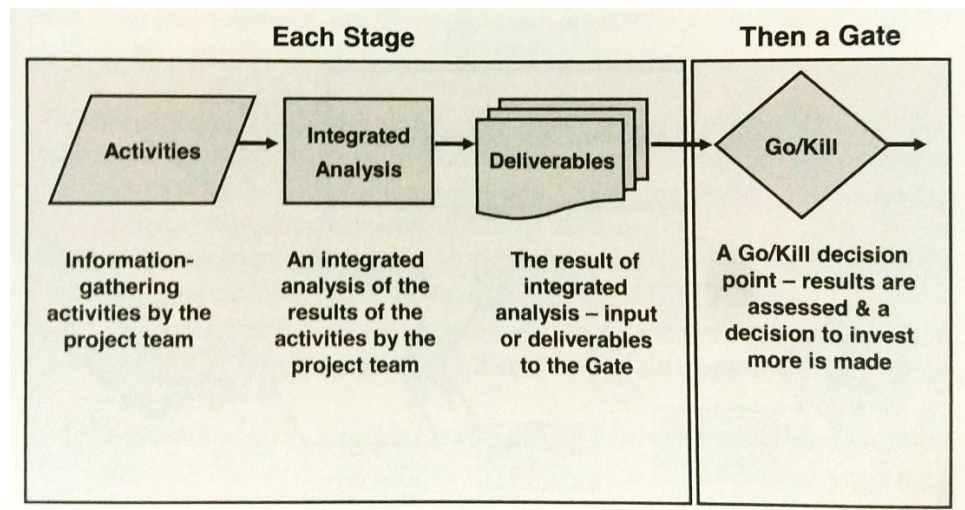


Figure 8. A single stage in the stage-gate process (Cooper, 2011, p. 100).

The full stage-gate process is shown in Figure 9. As mentioned it contains five stages with five gates. Also, an initial discovery stage is shown and in the end a product launch review gate.

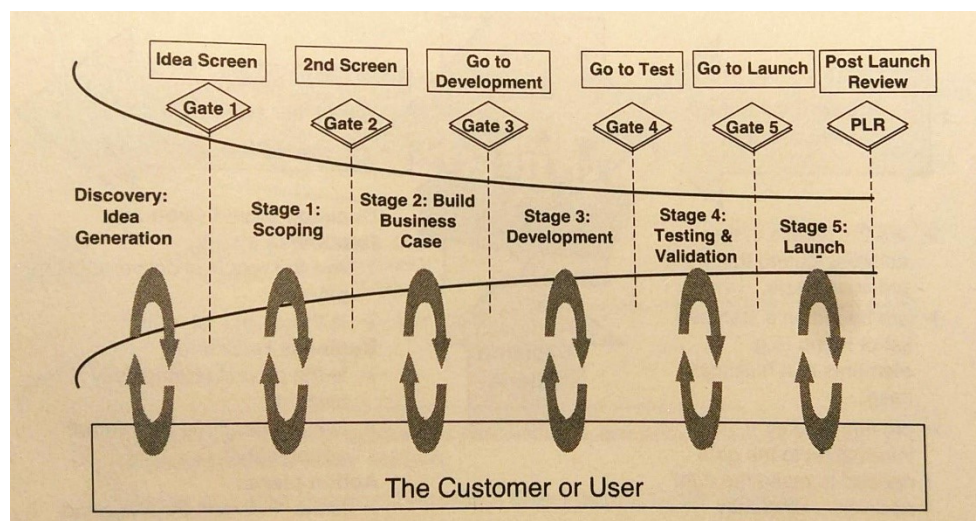


Figure 9. Stage-gate process (Cooper, 2011, p. 101).

The stage-gate process starts with a gate. In this first gate an idea created earlier is evaluated. Here, the decision is made for the resources committed to the project. The idea is evaluated for example in terms of feasibility, opportunities, market appeal and strategic alignment to the company's portfolio. Predetermined must-meet and should-meet criteria lists are used. As in any gate, the project might not pass the gate and the project can be terminated. In this first gate, failing a single must-meet criteria results in a rejection of the project. (Cooper, 2011, p. 104–105)

The first stage, scoping, is completed usually in a short time-frame, usually a month, and with a low budget. In the stage a preliminary market research is carried out. Simple tools that are easily available are used: internet, libraries, key users within the company,

potential clients and focus groups. The goal is to determine market size, market potential and market acceptance. Together with the preliminary market research a preliminary technical assessment is done. In-house personnel are asked to review the product idea with the goal of determining development and operations strategies, technical feasibility, costs, schedule and potential risks. In the first stage it is important to keep in mind the cross-functional structure of the stage-gate model. All relevant functions in the company should be involved while making these preliminary assessments. (Cooper, 2011, p. 105)

The second gate is more demanding than the first one. The must-meet and should-meet criteria is used again. Customer response and sales related issues are reviewed in more detail as more data is now available from the first stage. Financial returns are evaluated in simple detail. If the project passes the second gate. more spending can be allocated to the project in the next stage. (Cooper, 2011, p. 106)

In the second stage a business case is build. Detailed investigation is done for the definition of the target-market, product positioning strategy, product benefits and value proposition. Intensive market research is needed to have a clear understanding of the product's position in the market. Competitive analysis is also carried out in stage two as well as concept testing. Concept testing is done with potential customers to determine the customer acceptance. The product idea is transformed into a feasible product concept where some design activities can be carried out. Manufacturing viewpoint is taken into consideration with details such as supply strategy, manufacturing costs and manufacturing investments. A detailed business and financial analysis is done to justify the business case with tools such as discounted cash flow approach and sensitivity analysis are used. (Cooper, 2011, p. 107–108)

At gate three all activities from stage two are evaluated and must-meet and should-meet criteria are checked. After this gate a lot of resources are spent to the project and the development stage begins. Most of the projects that pass gate three are continued through the whole stage-gate system, so everything done in the stage two must be done precisely. At gate three a full project team is assigned to the project with designated project leader and a development plan is finalized. (Cooper, 2011, p. 109)

Stage three is where the development is done. This stage follows closely the development plan approved in the previous gate. This stage can take a long time as iteration loops and milestones are included. Deliverable at the end of the stage is a working prototype of the product. Stage three does not only focus on technical development as marketing and operations work is carried forward at the same time. Plans for product launch and testing are also prepared. (Cooper, 2011, p. 109–110)

The fourth gate reviews the development work and makes sure that the product meets the definition set in the previous gate. Financial data is also reviewed, and a testing plan is validated for the next stage. (Cooper, 2011, p. 110)

The fourth stage contains activities for testing and validating the product, production, customer acceptance and economics. The following tasks are done:

- In-house product tests
- Field-trials of the product
- Production trials
- Market testing or simulated market testing
- Revised business and financial analysis

If the fourth stage is not successful, the project can be sent back to the third stage. Full reject of the project at this stage is rare. (Cooper, 2011, p. 110)

The fifth gate is a checkpoint before launching the product to market. Tests results from stage four must be positive. The product must have a good market reception and adequate profit margins. Sometimes a product life cycle plan is approved in this gate. (Cooper, 2011, p. 110)

The last stage is the product launch where necessary production preparations are done, such as acquiring and installing needed machinery. Sales begin during this stage. A post-launch review is done, after the product has been on the market for some time. Here the project and the project team are assessed. Lessons learned are documented and best practices communicated. At the post-launch review the product responsibility is transferred from the project manager to some other party in the company. (Cooper, 2011, p. 111–112)

2.2 Idea creation

In this chapter two idea creation methods are presented. First a collaborative AIR-OPERA method and then TRIZ methodology are presented in detail. Finally, facilitator's role and responsibilities are described.

2.2.1 AIR-OPERA

AIR-OPERA is an innovation method developed by Finnish Innotiimi Oy. In this method groupwork is done mainly in pairs since during the methods development it was found out that creativity is highest while working in pairs. One person will facilitate the session. The facilitator can also participate in the idea creation, but his duty is also to take care of the sessions schedule. A separate secretary is not used so the facilitator is responsible for gathering all documents and ideas for the result. (Jokinen, 2001, p. 59)

The OPERA-method stands for own thought, paired suggestions, explanation, ranking and alignment (Marjatta & Powers-Erkkilä, 2003, p. 80). This 5-part process is repeated 3 times. In the first phase, it is used to create analysis of the largest problems in the topic. In the second phase it is used to create ideas for the problems selected in phase 1. In the third phase the OPERA-process is used to create solutions from the ideas. This three times consecutively repeated process can also be called AIR-OPERA (Jokinen, 2001, p. 59).

‘Own ideas’ in the process is a solo working phase that lasts usually about five minutes. During this phase participants think of their own ideas and write them down. After this, the participants are paired up and discussion about their individual ideas starts. The discussion should last 10 minutes and in the end the pairs should list their best results to a piece of paper. Ideally each group would have three to five results and each result should be written to different paper. Results from all groups are then put on a wall that is divided into columns, one column per one group. These results are presented to the group in the explanation phase. During and after these presentations no comments are allowed from other groups. Each group is given three votes that they cast to the ideas they think are the best. The votes are marked to the papers with crosses. The voting group should also provide short commentary about the ideas they vote. This ranking phase can be repeated with different symbols. The purpose of this is not to find the best idea but rather have everyone a chance to voice out their opinions. After ranking the papers are aligned so that the ones with most votes are moved to the top and the one without votes to the bottom. The worst ideas can also be removed to keep the session more focused on the better ones. (Jokinen, 2001, p. 60–62)

The AIR-OPERA process takes from 2–3 hours to complete and it suits groups from 6 to 12 persons (Jokinen, 2001, p. 59). In the end of the session, after creating solutions from ideas, a follow-up agenda and schedule is done. The agenda is done together in the group and it should have simple tasks, dates when those tasks should be done and who is responsible of the task. (Jokinen, 2001, p. 64)

2.2.2 TRIZ

TRIZ (Russian for Theory of Inventive Problem Solving) is a systematic problem-solving method developed by Genrich Altshuller. The aim of TRIZ is to solve problems and innovate new inventions through practical tools and a systematic mindset. In the heart of TRIZ is an algorithm called ARIZ (Russian for Algorithm of Inventive Problem Solving). ARIZ is a multi-step procedure which can be used to solve complicated problems with the help of predetermined questions. TRIZ also contains other tools such as the contradiction matrix and 40 inventive principles to problem solving. (Altshuller, 2007)

Altshuller (2007, p. 25–26) discusses the idea of searching concepts when an inventor is trying to move from a problem to a solution. Usually trial-and-error method is used to solve problems in product development while the results from these tries are not optimal. A large number of tries are needed for reaching a solution. Altshuller (2007, p. 26) mentions a Russian inventor B. S. Egorov who made about 300 versions of his first winding machine. None of these 300 tries were successful but time wasted was immense.

A searching concept is an initial idea used by an inventor to get to a solution. A visual representation of problem solving with trial-and-error method and searching methods is shown in Figure 10. For example, if the problem would be moving cargo from a continent to an island, an inventor could think that one should use a boat. Usually the inventor's mindset would be now locked towards this initial searching concept and other possibilities, such as airplanes or hovercrafts, would be left without interest. This tends to happen in complex problems where it takes a long time to map all possibilities within a searching concept. In the case referenced by Altshuller (2007, p. 26) Egorov was stuck to an idea of using a needle since his previous winding machine invention used a needle. This time however the scale of the machine needed to be smaller so using a needle was not possible. Still the concept of a needle was used in the beginning since it seemed like the most obvious solution.

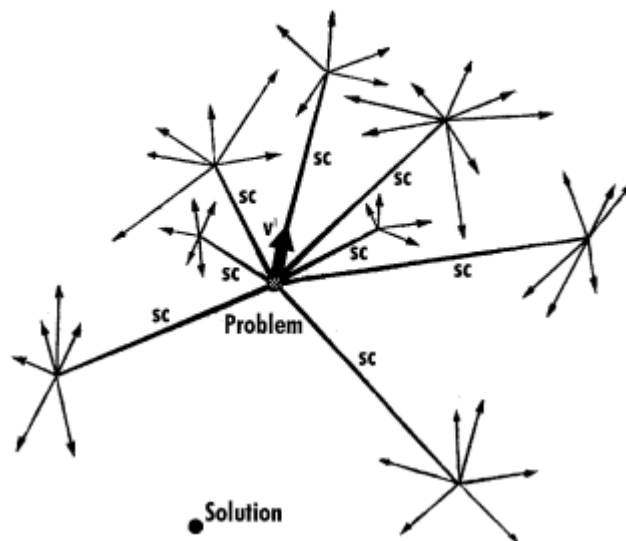


Figure 10. Trial-and-error method and searching concepts (Altshuller, 2007, p. 25).

In Figure 10 a vector v^1 can be seen. Altshuller (2007) calls this vector the inertia vector. The inertia vector points at the direction where the inventor feels the least amount of friction and that is where the inventor starts with the trial-and-error method. Egorov's inertia vector faced towards the concept of needle as it was a familiar concept for him.

Following the inertia vector happens usually subconsciously thus making the trial-and-error method less random than thought.

In TRIZ problems are sorted into five different levels depending on how challenging they are. Level one and two problems are common ones that can be solved with hundred or less trials. These problems are common enough for every engineer to be able to solve them and to create inventions. Level three problems require already up to a thousand tries and level five up to million. There can be problems that are beyond level five that require infinite amount of tries. The invention behind electro-discharge technology is given as an example of a level five problem. Solving such a problem would be too time consuming with the trial-and-error method for one inventor in his lifetime. However, such problems can be solved since work of successful inventors usually lies on top of the unsuccessful inventor's work. This way higher level problems slowly turn into lower level problems as unsuccessful tries accumulate. Based on surveys some inventors do not want to search patent information since they feel it limits their innovativeness. This is true for higher level problems since the possible existing patent that would help to solve the problem can be in a totally different domain of science or technology. (Altshuller, 2007, p. 44–50)

The ARIZ algorithm was developed to make the process described in the previous paragraph faster. Turning a higher-level problem into a lower-level problem is required to solve it (Altshuller, 2007, p. 66). Different versions of the algorithm have been developed throughout the years. They differ slightly from each other and new versions of ARIZ are constantly being developed.

2.2.3 Facilitator's role

The responsibility of the facilitator defined by Wilkinson (2012, p. 7) is to be a motivator, guide, questioner, bridge builder, clairvoyant, peacemaker, taskmaster and praiser. To be able to master all these roles the facilitator must be very experienced person about different facilitation techniques. Facilitation is also about the personal traits of the facilitator. Wilkinson (2012, p. 7–8) talks about the soul of the facilitator. The facilitator must care about people and value their views and input. The facilitator must also be willing to help all participants so that the meetings feel easy to be and lastly the facilitator must put his ego aside, so they can serve the group as well as possible.

The role of the facilitator, however, can change depending on the needs of the session. A facilitator can work as a meeting adviser who helps the meeting leader to plan the session. During the meeting the facilitator is rarely involved and will step in only if assistance is needed by the participants. Working as a meeting manager is a more involving role where the facilitator sets the agenda and rules, starts the discussion and keeps the session flowing, but does not intervene much to the content of the session. As a meeting leader the facilitator does the same as in the meeting manager role, but in addi-

tion the role is more about participating in the session. The aim is to lead the session and keep it focused by asking challenging questions and making sure that all participants are heard and engaged in the session. Motivating and giving insight about the importance of the session is also needed. The last role that Wilkinson (2012, p. 6) mentions is participating facilitator. In this role the facilitator works as a meeting leader, but also takes actively part in the discussion as a participating member of the group. (Wilkinson, 2012, p. 6)

To fulfil these roles in a best way possible a facilitator need skills for presentations and training group members in addition to the facilitation skills. It is important to be able to mix these skills seamlessly and at the same time be active listener in the group. This way the facilitator can encourage the participants to keep talking and to summarize ideas together. Making the group interact helps achieving the goal. (Kopra, 2012, p. 106–107)

A facilitator can come to a session from within the organization as an internal facilitator or outside of the organization as an external facilitator. There are different benefits and disadvantages that associate with both roles. As an external facilitator working can be less biased, it is easier to stay outside of the content and easier to concentrate to the process. Also, not being in the same organization as other members of the group helps the facilitator to avoid any political structures thus making working more free and open minded in the group. The downside of using an external facilitator is the need to have a more thorough briefing about the subjects in hand. Some members of the group may also resent an outsider. Using an internal facilitator makes the groupwork faster as the facilitator is familiar with the topics and history of the task in hand. It is much harder for the internal facilitator to stay objective since he might have own opinions beforehand. Sometimes the internal facilitator can be biased towards some individuals and their ideas and may risk the process by not giving equal attention to all participants. (Hogan, 2002, p. 54)

2.3 Porter's generic strategies

Porter (2008, p. 34–40) states that a company has three different ways of competing on a market: acquiring cost leadership, differentiation from other competitors or focusing the operations to serve a certain field better.

Overall cost leadership is a strategy that requires cost efficiency throughout the whole organization for the company to make above-average returns. A company that has a cost leadership has usually high market share and other competitive advantages such as good availability of raw materials. To be successful in the cost leadership position, a company should design their products to be easily manufacturable and to be able to have multiple customer segments for the same product. (Porter, 2008, p. 34–35)

Differentiation requires the company to product something that is considered unique industrywide. The ways to acquire competitive advantage through differentiation are many. Design, brand image, technology, features, customer service or dealer network are possible ways to differentiate from competitors. Differentiation helps the company to have a share of the market which is hard for the competitors to take over. It also helps on pricing since customer loyalty should be higher thus making customers less price sensitive. (Porter, 2008, p. 37–38)

Focusing as a strategy can be mixed with the previous strategies. A company can focus, for example, on a certain market segment or a certain price segment. What makes focusing different from differentiation is that a focused strategy never tries to serve customers industrywide. A company using focus as their strategy can also achieve a low-cost position on the market. (Porter, 2008, p. 38–40) Having a low-cost position in the market is often hard to achieve without focusing on the most profitable segments. Porter (2008, p. 41–42) emphasizes that it is necessary for a company to choose one of these strategies to keep competitive in the market. A company that is not following these strategies is on a path for low profitability as it will lose customers that look for lower prices, differentiated products or differentiated service since other companies are more focused to serve their needs better.

2.4 Risk management in product development

Risk is always a part of product development. All decisions made in a development project contain some amount of risk. In product development innovation is an important part of the outcome. Innovation brings additional risk that is not always present in normal projects. In innovation decisions must be done based on incomplete knowledge that reveals itself later in the project. This forces the development project to create iteration cycles so that assumptions made in the start can be verified. Risks can never be completely removed as uncertainty is always present. Thus, risk management is needed. (Smith & Merrit, 2002, p. 3–6)

Risk management aims to increase the likelihood and impact of positive events and decrease the likelihood and impact of negative events. A risk always has a cause and an impact, which can be positive or negative. Risks can be sorted into known risks and unknown risks. Known risks are identified and analyzed and if risk management is done properly, a plan to response to these risks is done. Unknown risks are not identified so they cannot be managed beforehand. Reservations can be made for unknown risks. For example, extra time can be added to a projects schedule to negate the effects of possible unknown risks that may occur during the project. (Project Management Institute, 2013, p. 309–311).

Knowing the organization and its take on perceiving the risk of a product development process is mandatory. An organization whose risk appetite is low tolerates only small

amounts of uncertainty in a project. Risk tolerance determines how much risk an organization is willing to take. To set the limits for a project a risk threshold must be set. When a preset risk threshold is crossed the organization will select a predetermined response for the risk. (Project Management Institute, 2013, p. 310–311)

In product development projects technical development is only a small part of the whole project. Cooper (2011) claims, that out of the nine most important functions for a product to be successful in market, only one is completely a R&D function. This shows well that project risks should not be only dealt in the development team. It must be remembered that project risks are a much wider concept than product risks. Engineers tend to think about the risks of the product, such as safety hazards or reliability issues, and not to think about other risks that can negate the market appeal of the product.

A risk management process in a project contains the following steps:

- Planning risk management
- Identifying risks
- Performing qualitative and/or quantitative risk analysis
- Planning risk responses
- Controlling risks (Project Management Institute, 2013, p. 309)

Planning risk management can be done with analytical techniques, expert judgement or meetings. The goal is to create a risk management plan which defines roles and responsibilities, budgeting, scheduling of risk management activities and tools used for risk management. Also risk categories are set and impact scales are set. Table 1 shows an example of impact scale defining where risk types are also set on the left side of the table. (Project Management Institute, 2013, p. 313–318)

Table 1. Impact scale definition (Project Management Institute, 2013, p. 318).

Defined Conditions for Impact Scales of a Risk on Major Project Objectives (Examples are shown for negative impacts only)					
Project Objective	Relative or numerical scales are shown				
	Very low /0.05	Low /0.10	Moderate /0.20	High /0.40	Very high /0.80
Cost	Insignificant cost increase	< 10% cost increase	10 – 20% cost increase	20 – 40% cost increase	> 40% cost increase
Time	Insignificant time increase	< 5% time increase	5 – 10% time increase	10 – 20% time increase	> 20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

This table presents examples of risk impact definitions for four different project objectives. They should be tailored in the Risk Management Planning process to the individual project and to the organization's risk thresholds. Impact definitions can be developed for opportunities in a similar way.

Identifying risks can be done with various techniques. Expert knowledge, SWOT analysis, brainstorming and root cause analysis are few to mention. The main output of this step is to provide a list of identified risks. Also, root causes of those risks could be usable in next steps and sometimes potential responses to the listed risks rise during the identifying step. (Project Management Institute, 2013, p. 319–327)

Qualitative risk analysis is analyzing risks by the probability of occurrence. This combined with the impact of the risk helps to assess which risks are dealt with first. The strength of this method is that it is not solely based on measurable numbers so risks concerning abstract things, such as quality, can be valued also. Qualitative risk analysis combines the work of the two previous steps and uses the probability and impact matrix. An example can be seen in Figure 11. The probability and impact matrix is a tool used to prioritize risks with numerical values based on the probability of the risk as well as the possible impact of the risk. Expert judgement and multiple sources of information are needed when the matrix is used. (Project Management Institute, 2013, p. 328–333)

Probability and Impact Matrix										
Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)

Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Figure 11. Probability and impact matrix (Project Management Institute, 2013, p. 331).

Quantitative risk analysis is used to determine the effects of the most potential risks identified in qualitative risk analysis. A numerical value for a risk, usually a cost value, is determined. Many different tools are available for this analysis: sensitivity analysis, expected monetary value analysis and Monte Carlo simulations to mention few. An example of cost risk simulation results can be seen on Figure 12. It is not always possible to perform the quantitative risk analysis as data required might be missing for the creation of these models. (Project Management Institute, 2013, p. 333–340)

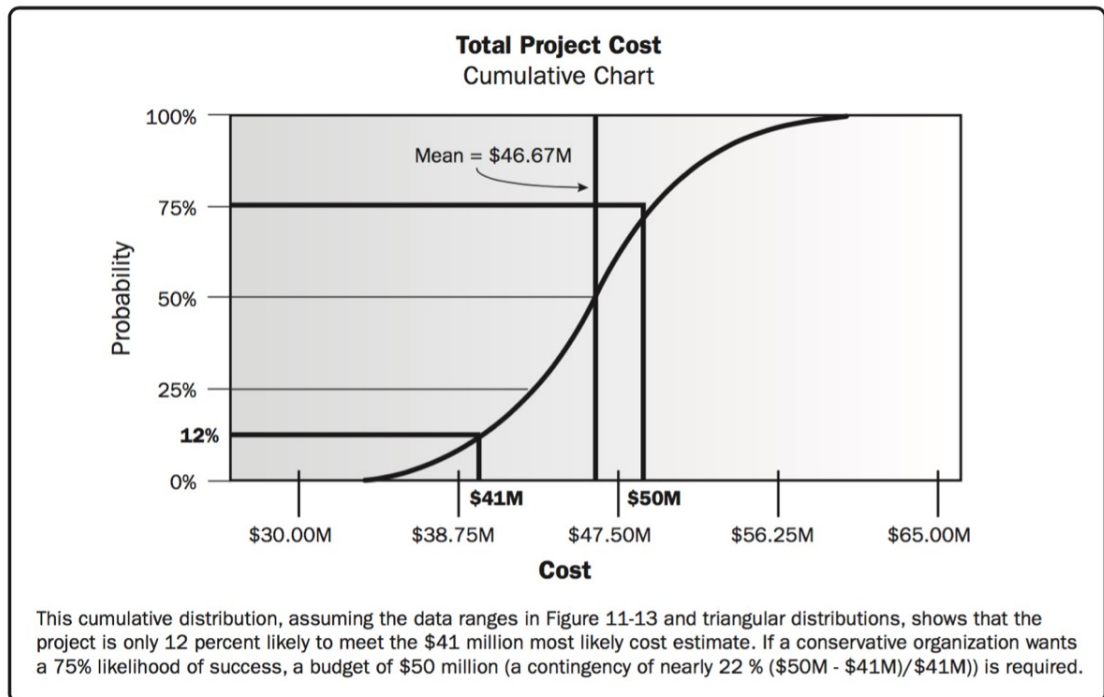


Figure 12. Cost risk simulation results (Project Management Institute, 2013, p. 340).

There are few different tactics for responding to identified risks. Most efficient strategies include usage of multiple techniques. For negative risks, three common strategies are: avoid, transfer and mitigate. For positive risks, there are four common strategies: exploit, enhance, share and accept. Accept can be also used for negative risks. (Project Management Institute, 2013, p. 342–346)

Avoiding a risk means typically eliminating the threat or negating the impact of the threat. There are various ways of doing this and it always depends on the situation. The most drastic way of negating a threat is to end the project. Transferring the risk does not make it go away – the impact of the risk is only transferred to a third party. This can be done via agreements that specifically set another party liable for a certain risk. This kind of risk transfer usually makes the project more expensive since a risk premium is paid to the third party. Mitigating a risk is to reduce the probability or impact of the threat. Mitigating requires early actions to avoid costly damages of an occurred risk. Sometimes it is best to accept the risk and do nothing about it. This approach must be used only with proper consideration and contingency reserves can be used as a preparation for the risk. (Project Management Institute, 2013, p. 344–345)

Exploiting a positive risk is to remove any uncertainties and to make sure that the positive risk realizes. This can be done in various ways, for example, resource allocation. Enhancing is the opposite to mitigating a risk. The probability and impact of the positive risk are enhanced so that the risk has as big as possible positive impact to the project. Sharing a risk is to allocate the risk to a third party that is more capable of realizing the risk. Joint ventures are an example of sharing a positive risk. Accepting can be done

when no actions are needed to pursuit the opportunity. (Project Management Institute, 2013, p. 345–346)

The last step is controlling risks. This is the process where all the previous steps are taken into use. Identified risks are tracked, new risks are identified and the whole risk process is evaluated. Techniques such as variance and trend analysis are used. The risk management should be also a regular topic on checkup meetings of the project. (Project Management Institute, 2013, p. 349–354)

3. THE RESEARCH PROCESS

The nature of this study is qualitative. A qualitative study describes real life and it assumes that it is diverse. Events in real life have effects on each other and qualitative research aims to take all of this in consideration. The aim is to be as comprehensive as possible. A qualitative research is rarely formed from a single research method. (Hirsjärvi, et al., 2007, p. 157–159) In this research multiple research methods are used. In addition to case study, participate observation is used in the idea creation sessions. A small literature review is also included.

This thesis contains a small literature review of few selected theories. A literature review aims to show how research has been done previously and how the current research links to existing research. This way the reader can check the original writings and asses how the researcher has used these in the study. (Hirsjärvi, et al., 2007, p. 117) In this thesis, the literature review concentrates on selected product development processes, idea creation processes and risk management. Reviewing these helps to understand the case study presented in this thesis.

The majority of research in this thesis is conducted as a case study. Case study is a research form where information from a single case or a small set of cases is studied intensively and in small detail. Typically, a case study targets a single person, group or community and the point of interest is processes. Data is gathered by multiple ways which include observing, conducting interviews and researching documents. In most cases the aim of the case study is to describe how something happens. (Hirsjärvi, et al., 2007, p. 130–131). When the case in a case study is of a secondary interest and the main goal is to facilitate the understanding of something else it is called an instrumental case study. When the researcher is interested in a particular case the study is called intrinsic case study. A collective case study is performed when multiple cases are reviewed to find similarities between phenomenon. (Denzin & Lincoln, 1994, p. 236–237) “How” and “why” questions are the most common ones in a case study (Yin, 2003, p. 5). In a case study these questions are asked when dealing with a contemporary set of events and when the researcher can only have little to none impact over the events (Yin, 2003, p. 9). In this research two out of three research questions are “how” questions. However, the researcher has possibilities to influence in the case. For example, the researcher did most of the preliminary work and participated in the idea sessions.

Participate observation is a type of social research where the researcher plays an active role in the studied scene. Participant observation is more of a humanistic research method compared to other more scientific method as human interaction in a group is hard to

measure in traditional ways. The role of the researcher can define a lot in the research. Activities the researcher does while in interaction with the subjects causes variation in the study as well as the role of the researcher as an insider or as an outsider. (Denzin & Lincoln, 1994, p. 248–249) In the idea creation sessions both viewpoints are used as the facilitation was done first in the role of an external facilitator and later in the role of an internal facilitator. Also, the idea sessions were observed and documented.

The meaning of this research is to be normative. A general normative research produces a theory of practice. The theory of practice describes a professional activity, such as product designing. When a general normative research is taken into real life it is a normative case study. In addition to the general normative research, a normative case study aims to improve something physical that currently exists. This existing present state can be used as in evaluation of the research results. The evaluation must be done from someone's point of view and it is important to define whose point of view is used. (Routio, 2007) In this thesis, the current physical existing state is the current product and the improvement is the new concept. The viewpoint used when evaluating the products is the customer's viewpoint. Also, production, maintenance and design views have been taken into consideration. The customer's viewpoint can be biased towards some certain customer's. The information is gathered from personnel inside the case company. Certain personnel deal with certain customer's and thus some customers are not represented at all.

4. CURRENT PRODUCT DEVELOPMENT PROCESSES

The case company has only one innovation development process documented and in use. The current process is based on the stage-gate model by Cooper (2011). Stage-gate model being more focused to the full project scale, the focus in here is more on the process that is used in the early phases of the projects where ideas and concepts are created. The case company has documented a work model for product development and it is used together with the main development process. It must be noted that not all projects in the case company follow this process. Small scale projects are not required to have active project control and there is no documented way of working with these smaller projects.

4.1 Project model

The case company's main development process is divided into three phases that all contain three steps each. The process can be seen in Figure 13. On a development timeline the first stage, Business Justification, is in the same region as this thesis work. Thus, only the first stage and the three steps in it are described in detail.



Figure 13. Development process of the case company.

The first phase, Business Justification, is triggered by a need, a problem, an opportunity or an idea for an improvement. Here, drafting of the possible solutions is made and discussed. Needs for improving the solution are also evaluated and a business case is built. Risk assessment is started, and legal needs are mapped. The first gate is set to the end of the conceptual step. This gate is similar to the gate 1 in the stage-gate process which can be seen in Figure 9. A checklist is used for the evaluation at gate 1. The idea must be in line with strategic and financial objectives to pass the gate. It also has to have benefits that justify the development commitment and the risks connected to the realization of

the idea must be tolerable. If everything is clear in gate 1 the project may continue to the next step in the first phase.

The second step in the first stage is the feasibility study. Here some resources are used to create a more detailed solution and more calculations of the benefits and costs required to realize the idea. This step follows closely Cooper's (2011) stage-gate model's scoping stage. Deliverables from the first gate are made more detailed and accurate. Requirements for bringing the product to market are listed in a high level and resources, monetary and personnel wise, are estimated. A feasibility report is drafted, and the preliminary business case is updated. A pre-study charter is also prepared which is used in the third step. The second gate comes directly after the feasibility study. In addition to viewing the results from the feasibility study checks are made according a checklist. Things such as top-level management involvement, need for a steering group and project manager appointment are checked at the second gate. If the project is approved in the second gate it will move to the last step of the first stage, pre-study.

In the third step a project charter is built where project objectives and scope are set. The business case is also finalized with proper financial calculations and risk analysis. Key subcontractor bids are obtained in the pre-study stage and the strategy for the production implementation is drafted. In the third gate the business case, project charter and the pre-study report are approved. Once again need for top-level management and steering group is evaluated. When the third gate is passed the project moves into the development phase where large investments are done. Like stated in the stage-gate model (Cooper, 2011), only few projects are killed after passing the third gate.

4.2 Work model for product development

The work model for product development is a subprocess used to describe the technical work processes and the way of working for different areas of design. Systems engineering standard ISO/IEC 15288 has been used to structure the technical processes in this model. The work model for product development can be seen in Figure 14.

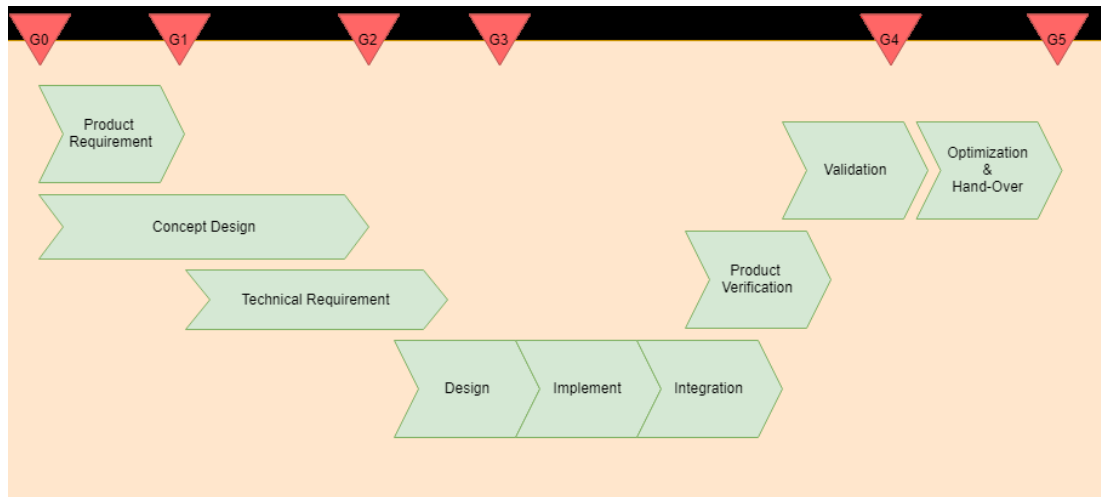


Figure 14. Work model for product development.

The work model starts with product requirement where requirements from internal and external stakeholders are listed. Main functions, key features and general performance of the product are defined, and risks involved identified.

Concept design in the work model is creating a conceptual design and architecture of systems and subsystems in the product. A product breakdown structure is drafted to identify interfaces in the product. Specifications are developed for the systems and long lead time parts are identified. Also, new areas of competence regarding new technologies and possible needs of customer training should be identified.

Technical requirement defines parameters for systems and subsystems designed in the concept design phase. The requirements should be also quantified for measuring and assessing the technical performance of the product.

Design, implement and integration is where the product materializes through detailed design work, making or buying the wanted subsystems and components and assembling the system. Prototype building is used, if possible, to define the build and assembly strategy. Parts and components are ordered for ramp-up of the product.

Product verification is confirmation that the technical requirements for the product are fulfilled. This can be done through reviews, tests, calculations or simulations. Results are documented, and necessary corrective action is taken. This step confirms that the product was designed and built right.

Validation is product verification done in the specified use environment in intended use. This step confirms that the right product was built for the customer.

In optimization and hand-over phase fine tuning according to feedback is done. This feedback can come from the ramp-up of the product or from field testing with external

customers. After this the product is handed-over from the project to the organization that will take responsibility of the product through its life cycle until the end of its life.

4.3 Usage in case company

The two processes presented are not actively used in concept creation phase of projects. An individual department for project management manages these processes. They are mostly used in larger scale projects. Managing the projects usually starts when a proper business case and concept already exists. Idea creation is not done systematically, and concept generation has proven to be unsuccessful earlier. The processes are also very general and do not offer specific instructions for concept development. In addition, regular designers are not well aware of these processes or how to utilize them. The concept creation method presented in the next two chapters aims to improve this situation by giving a concrete example of how to create and evaluate a product concept.

5. PREREQUISITES FOR PRODUCT CONCEPT DEVELOPMENT

This chapter describes the gathering of information needed for the new concept development. The prerequisite information was gathered before the actual creation of the concept. This phase was more demanding than thought in the beginning of the project and it required a lot of work which caused small delays to the original schedule. However, the important knowledge of accurate demands of the customers, business targets of the company and current state of competitors was crucial information that was worthwhile to acquire. For the new concept development process, a group of designers was formed. These designers had good knowledge of concept development and the current product.

5.1 Market situation

The current state of market of the case company is very stable. The market has been dominated by two companies – case company being the other one – for a long time and the solutions they offer are based on old and reliable technology. New innovations are rare, and the customer process has been similar for over 25 years. This situation in the market makes new product development intriguing as new innovations could provide major competitive advantage over the competitors.

The current focus of the case company in terms of Porter's competitive strategies is a mixture of focus and differentiation. The company provides highly technical solutions that require minimum amount of workforce from the customer making the product more expensive than other competitor's products. Also, the case company focuses on the core machinery needed for the customer's production rather than providing everything needed in the process. It is clear that the customer is willing to pay for the reliability of the product thus price of the new product is not a big concern during the development process. The current state analysis of the products is concluded by interviews inside the case company, using material gathered from competitors and browsing different public data such as product catalogues and promotional videos.

5.1.1 Own products

Knowledge of the current products is easily available. Product data information from a PLM system is used mainly in the development process. Factory visits are also made so that the current product is seen in real life and in different build phases. Discussions are

held with the factory workers about the manufacturability of the current product. The only information related to the product that is not available is first hand user experiences. The case company's customers operate mainly abroad so a meeting with a customer is not a possibility. The lack of customer input could be also noted later in the process. All the designers do not have the same level of knowledge of the current product and extensive research is done from the customer point of view to lay a foundation of relevant knowledge. The customer view is taken into consideration through the sales organization that provided information from their discussions with the customers. This information is documented in interviews held at the company's premises.

Through acquisitions and mergers, the company manufactures similar product also in few locations abroad. The products share the same principle of operation, but some details are different. Getting product data information from abroad is challenging. A 3d-model, videos and pictures are provided that are used for evaluation of the similar products. Some interesting details are found from the material and direct influence is taken from the other products.

Concurrently with the development of the new concept, other development projects are running forward. These projects are benchmarked, and key findings are taken into consideration. Some designers are able to give valuable information after working on these projects as well as in this new concept development project.

5.1.2 Competitors

Previous research has been conducted in the company about the main competitors and their offering. The total number of competitors identified is 13, but out of those only one is recognized to produce competitive offering for the targeted market segment. As only one main competitor is recognized, much of the focus is put into the technology of that competitor.

The main competitor's product information is very difficult to acquire. Basic specification sheets are available online that provide main dimensions and main properties. Making in-depth analysis is challenging since no user information is available. Also, videos or photos of the products are hard to acquire. However, some pictures and videos are found, and the basic functionality of the competitor's product is identified. Some personnel inside the company have seen the product in use so they are able to give important information about the functionality and properties.

5.1.3 Patents

A patent study is conducted in the pre-development phase of the project. The study is done with related search phrases from online patent databases such as Espacenet, Derwent Innovations Index and Google Patents. Searching focuses primarily to patents filed

by competitors and sorting is done also by release date. Generally, patents that are older than 20 years have expired (Knight, 2001, pp. 16-19) and thus are discarded in the search. Some relevant expired patents older than 20 years are discovered, but no recent patents that are still valid are found.

Overall the patent study did not bring any useful information for the concept creation process. Still, leaving patent study out when creating new products is not advisable as patent conflicts can render a new product useless.

5.2 Customer needs

Customer needs are a big influencer on design choices made in the development. As mentioned earlier, first hand customer input is not available.

The customer process tells how the customer uses the product to create value for himself. Since the customer is not near to the development team it is necessary to map the customer processes. This helps all parties involved to have a common basic knowledge of the product and the customer demands related to it. The customer process is mapped using the Gripen method introduced by Pakkanen (2015, p. 195). In this method the process is mapped by using pre-determined questions. The aim of this process is to clarify the use cases of the product and to analyze variability needs of the product. The Gripen approach consists of the following questions:

- What kind of processes can be recognized in which the customers use the company's products?
- What kind of generic process steps and segmentation can be identified from the way in which customers use products?
- What kind of alternative parameters or options, that have an effect on the definition of the product, are related in each process step?
- Are there any other issues or preferred ways of working that cause the need for different products or product options? (Pakkanen, 2015, p. 195)

The mapping is done in two sessions with senior developers, design manager and product line manager. The result is a visual slideshow presentation which showed the basic actions of the product from the user's point of view. The results from the Gripen process are also used in the definition of product properties in Chapter 6.1.

5.3 Business targets/needs

Need for a new product comes also from the business needs. A new product platform is being developed and a strong wish inside the company, especially product line and sales, is for all new modules to be used in this product platform. Competitor's advantages in certain technical aspects are also a driver for the development. In the view-

point of sales staff, more appealing features are required. However, overall productivity must at least stay in the same level as it is in the current product

Different departments of the company have different requirements that need to be aligned to create a satisfactory end-result. To ensure this, the goals and requirements of the product development project are presented to all parties involved. Collaboration is necessary to ensure that the project would have a forward momentum going beyond the concept development phase. As Cooper (2011) stated, only one of out of nine functions in creating a successful product is completely R&D based.

Other ongoing and future projects has to be taken into consideration to make sure that the new product fits into the offering of the company. For example, one upcoming project gives input to the maximum weight requirement of the new product. The new product should weigh less than the current product to gain overall competitive advantage. This is not a must have requirement, but if fulfilled, the other project will be easier to execute successfully.

6. CONCEPT DEVELOPMENT

In this thesis a new concept was developed with the help of CPM/PDD process. First, product properties are defined. With the help of these properties the current product and one competitor product are evaluated. Then a concept is created in idea sessions with the help of AIR-OPERA method. The challenges faced in the process are described and the concept is evaluated with the CPM/PDD process. Finally, a risk evaluation is done.

6.1 Defining product properties with CPM/PDD process

The first step of the CPM/PDD process, the definition of product properties, can begin, after successful definition of customer needs and different customer processes. Doing the first step properly is vital to the end results of concept creation. In addition to providing a helpful tool in the process of creating the concept, the product properties are used to evaluate different concepts and the current products on the market.

The definition of the wanted product properties bases strongly on the definition of the customer process and customer needs. Productivity is kept as the focus point during the development process. In addition to productivity, also other properties are identified. They are mainly related to the physical size of the product but also to manufacturability and reliability. In total, 15 properties are identified, and they can be seen in Table 2 in a general form. A column for weight of each property is also included. These weights are defined together with the design team and product line management. Some of these weights could be also defined by the customer but most likely some customers would have very different views on the importance of certain features than some other customers. That is why the concentrated knowledge inside the company is seen as the best input for weighting these properties.

Table 2. Defined properties for CPM/PDD.

Properties	Grade	Weight	Weighted grade
Productivity	0	10 %	0
Speed	0	10 %	0
Weight	0	15 %	0
Lenght	0	13 %	0
Safety	0	5 %	0
Capacity	0	7 %	0
Variability	0	5 %	0
Versatility	0	5 %	0
Reach of the device	0	3 %	0
Usability	0	7 %	0
Level of automation	0	5 %	0
Production friendliness	0	2 %	0
Reliability	0	5 %	0
Serviceability	0	5 %	0
Cost	0	3 %	0

The weight of the product is the most important property in the evaluation table with a 15 % weighting. Length, productivity and speed are also noted important. These all are related to the usage of the product. The least important properties are production friendliness, cost and reach of the device. Production friendliness and cost are not important because of the nature of the product. Like earlier stated, the cost of the product is not usually a big factor to the customers since they want to have an efficient and reliable product. Since the production volumes are also low, production friendliness is of a low importance.

Using the properties defined for the new product, the old product and the main competitor's product are also evaluated. The goal for this initial evaluation is to point a direction for the development. The complexity of the product requires narrowing down the areas of development. The evaluation of the current product and the competitor's product can be seen respectively in Table 3 and Table 4. The grading scale is numerical with four being the lowest score and 10 being the highest score.

The current product is given a score of 6.63. The best rated property is speed while six other properties are rated just one number below this. The most important property, weight, is given a score of four. Other properties that are given the lowest score are capacity and level of automation. Weight and capacity are identified as the biggest areas

that need development. Also, in many interviews these two properties are also identified as the weak points of the product.

Table 3. Evaluation of the current product.

Properties	Grade	Weight	Weighted grade
Productivity	8	10 %	0,8
Speed	9	10 %	0,9
Weight	4	15 %	0,6
Lenght	8	13 %	1,04
Safety	8	5 %	0,4
Capacity	4	7 %	0,28
Variability	8	5 %	0,4
Versatility	7	5 %	0,35
Reach of the device	8	3 %	0,24
Usability	6	7 %	0,42
Level of automation	4	5 %	0,2
Production friendliness	6	2 %	0,12
Reliability	8	5 %	0,4
Serviceability	6	5 %	0,3
Cost	6	3 %	0,18
SUM	100	100 %	6,63

The main competitor's product is given a score of 6.41. The best rated properties are usability and productivity. The largest differences compared to the case company's own current product are reliability, usability, variability and weight. Usability and weight are currently better in the competitor's product. Overall, the products are very close to each other. This reflects the current market situation as well. The market is basically divided by two companies and depending on the customer profile, certain customers prefer the case company's products, and some prefer the competitor's product. Also, customer loyalty is strong in the market since changing the product leads into additional costs as training is needed and productivity can go down for the ramp up period.

Table 4. Evaluation of the main competitor's product.

Properties	Grade	Weight	Weighted grade
Productivity	9	10 %	0,9
Speed	6	10 %	0,6
Weight	7	15 %	1,05
Lenght	6	13 %	0,78
Safety	8	5 %	0,4
Capacity	6	7 %	0,42
Variability	4	5 %	0,2
Versatility	5	5 %	0,25
Reach of the device	8	3 %	0,24
Usability	9	7 %	0,63
Level of automation	6	5 %	0,3
Production friendliness	6	2 %	0,12
Reliability	4	5 %	0,2
Serviceability	4	5 %	0,2
Cost	4	3 %	0,12
SUM	92	100 %	6,41

Using the CPM/PDD process for the evaluation of the current product's in the market made it easy to continue with the concept creation. The comparison shows that the products are close to each other in performance though they beat each other in some areas.

6.2 Idea sessions

Concept creation is mainly done in workshops that are held in the premises of the case company. Workshop participants are a set of selected engineers that have experience with the current product and the market. The structure of the workshops is predefined, and a facilitator is selected for both sessions. The goal is to create a pool of ideas from which smaller team of designers can create a feasible concept.

An important part of the concept creation workshop sessions is the definition of the problem. Altshuller (2007, p. 82–83) tells about a design competition and its problem setting. The problem was cargo handling and the way the problem was stated gave the assumption that certain piece of machinery had to be used in the process. This narrowed down the possible solutions to the problem and it was not possible to achieve good results. The problem setting is very open in the first session and it is narrowed down to-

ward the second session. This is done to have room for fresh and crazy ideas in the beginning. As more preparation work is done, targets and limitations of the development process are better known. This leads to certain boundaries that are inserted into the problem phrasing. However, room for being innovative and creative is always ensured and ideas outside the given problem setting are taken into consideration.

6.2.1 First idea session

First idea session is held with a very open problem setting. The initial target is to get the group introduced to the project and to test the usage of the concept creation tools. The session is held at a quiet meeting room at the company's facilities. The session lasts five hours.

At first background information of the project is introduced as all participants are not familiar with the project and its scope. Then the defined properties are introduced with commentary from the authors of the property listing. The AIR-OPERA method and the CPM/PDD process are presented as tools for this project. Some participants have used the AIR-OPERA method previously. CPM/PDD is completely new and some criticism is given to the method. A discussion is held about the chosen methods and some resistance is detected.

Previous product development projects concerning the product being developed had not been successful and it created a challenging atmosphere. Now that driver of the process are the properties defined in Chapter 6.1, concerns emerged that the customer process is forgotten. The customer process is discussed briefly and conducting a pareto analysis of the customer process is suggested. After addressing the concerns of the group, the AIR-OPERA method is commenced as described in Chapter 2.2.1. Problems faced in the idea creation are described in Chapter 6.2.3.

No actual results emerged from the first idea session. Since the problem setting is loose and the original goal is to use the session as an introductory meeting, no results were expected. The five-hour timeframe is enough to do the introduction to the project and run a full cycle of AIR-OPERA. In future sessions this time is shortened as all participants are familiar with the techniques and the content of the project.

The first session showed that the problem setting has to be narrowed down to gain better results. An external facilitator is used in the first session which proved to be somewhat demanding. The facilitator also lacks knowledge of the product that is being developed. Time has to be spent to create a common ground of understanding between the participants and the facilitator. In addition, only few participants are able to understand how the product functions as a unit, despite having the best expertise available in the idea session. This might be due to the complexity of the product. Many designers work on specified parts of the product and their expertise lays within smaller regions.

Some participants did not have enough understanding of the different customer processes. As a solution for this problem the customer process is mapped in better detail and visual aids, such as videos and pictures of the product in use, are brought up for the future sessions. The duration of the customer process is also researched as making the customer process faster is seen as a possible source of improvement. Old material from the company's research projects are gathered and this is combined with the customer process mapping that is done with the Gripen method in 5.2.

6.2.2 Second idea session

For the next idea session two problems are generated as a predetermined problem setting and more preliminary work is done. This allows time savings in the second session and a more guided session where focus is held on the important topics. Few ideas are generated between the sessions within unofficial talks amongst colleagues. A week before the next session a memo is posted to attendees of the idea session. This is made for the participants to revisit the goals and scope of the project. Another important goal of this memo is to plant an idea seed for everyone participating. Having some ideas created before the meeting is ideal so the meeting itself can be used to refine those initial ideas as well as to create new ideas.

The second idea session is shorter, approximately three hours, with a more solution focused mindset. A narrower problem setting is introduced together with the visual presentation of the customer process. The problem setting clearly defines the boundaries for the idea creation session. Certain aspects of the process are left out on purpose and participants are allowed to forget some real-life boundaries that could otherwise distract the creativeness of the session.

The results from the customer process mapping and durations of the customer process are eye-opening. It is discovered that the current product itself is good and that customer satisfaction is in a good level. Other processes linked closely to the product are the largest limiting factor for overall increase in productivity. From the whole customer process, the product being developed influences only one sixth of the whole process time. Thus, time savings created by the new product will not be a first priority in the development from this point on. Making the product lighter is determined as a priority. Also, savings in production costs will be another way for competitive advantage. However, when process time is measured, the new concept should not be worse than the current product.

Similarly, to the first session, a facilitator is used in the second session also. This time the facilitator is changed to an internal facilitator which makes the session flow better. As the participants are now familiar with the goals and methods used, the work on the actual problem can start immediately. The participants are divided into three groups, 3–4 participants in each group. As per the AIR-OPERA process, first individual ideas are

created and then teamwork is utilized. The difference to the first idea session is that the AIR-OPERA process is modified. As the problem setting is now done before the idea meeting, the analysis phase from the process is left out. Also, the ranking and alignment steps are combined to create additional time savings. In the first session, the ranking phase with multiple voting cycles took too long and the participants did not feel it necessary. The rankings did not change much although many cycles were used in the first session.

Results from the second idea session are good. Enough ideas are created to form a new concept that can be evaluated with the CPM/PDD process. More idea sessions are to be held later. In these sessions the focus is on the processes near the product where more time savings could be achieved. This is out of the scope of this thesis and thus it is not documented here.

The new concept is drafted based on the ideas from the second idea session. A CAD model is created, using mainly existing components from existing products. During the creation of the model iteration already happens. Not all versions of the product are documented in detail as multiple changes can occur in a matter of hours. The CAD model is done during a few weeks' time and only few designers participate in the creation of the model.

6.2.3 Challenges using selected tools

Some difficulties occur during the product development process that are not considered in the beginning of the process. Most of them are related to the idea sessions and they are corrected for the next sessions. Using techniques as described in literature is not always the most fitting way to get the best results and, in future, concept creation project's development time can be cut down with better preparation.

The AIR-OPERA method described in Chapter 2.2.1 is found to be too long if executed as instructed by Jokinen (2001). The analysis phase's results in the first session are too general and they result in a problem that covers nearly the whole product. The problem setting of a complex product is hard to make in a large group. Condensing the problem and sharing it to smaller pieces beforehand makes the idea sessions more effective and faster to execute as the analysis phase can be left out. For managers in charge of the development the analysis phase can be useful as all participants get to voice their opinions about the problems with the current product. However, this should be done before the idea session through personal interviews or by a written questionnaire to save the workshop for more productive work.

The CPM/PDD method described in Chapter 2.1.2 proved to be hard in the property selection phase. Some of the properties have conflicts between each other. For example, productivity as a property is troublesome. Almost all other properties contribute to

productivity and essentially it is a sum of the other properties. That is why leaving out productivity from the properties would make sense. On the other hand, productivity is one of the most important properties the product has. In this case it is decided that productivity should stay in the selected properties as it is important to the customers. Also, as a sales argument, productivity is essential. So, it is not wanted for the development teams focus to steer away from productivity. For example, the reach of the device is heavily dependent on the weight of the device. However, improving the weight property does not mean that the reach of the device gets better. This just gives opportunities for future development projects to optimize the reach of the device. Other aspects also contribute to the reach of the device such as dimensions and product layout. In addition, problems occur with the communication of the properties to the designer group. The selection methods of the properties have to be explained well to get the group working properly.

6.3 Concept evaluation

The evaluation of the created concept is done with the help of the CPM/PDD process. The comparison is done to the current product and the competitor's product which are evaluated in Chapter 6.1. The evaluation is done by the product line management and the designers involved in the process.

The concept evaluation can be seen in Table 5. The new concept is given a score of 8,16. This is 1,53 points better than the current product and 1,75 points better than the competitor's product. Comparing to the current product, 11 properties have increased and four have stayed the same. Two properties have changed more than one point from the comparison of the current product: weight and capacity. These two properties were identified as the main areas of development earlier in Chapter 6.1. The weight property has now a score of nine and the capacity property has a score of eight. Productivity property has stayed the same as in the current product, which was set as a goal when defining the goals of the development project. In the new concept, level of automation is the lowest ranking property. This has increased slightly from the current product, but clearly requires further development.

Overall the new concept gained positive feedback. The simplicity of the new design is praised as the new mechanism developed requires less moving parts compared to the current mechanism. The improvement in the weight, as well as general dimensions, is said to be good. Also, the new capacity is said to be sufficient. The general perception is that after some more development is done in the concept phase, a proper design phase could be started.

Table 5. Evaluation of the new concept.

Properties	Grade	Weight	Weighted grade
Productivity	8	10 %	0,8
Speed	9	10 %	0,9
Weight	9	15 %	1,35
Lenght	9	13 %	1,17
Safety	9	5 %	0,45
Capacity	8	7 %	0,56
Variability	8	5 %	0,4
Versatility	8	5 %	0,4
Reach of the device	8	3 %	0,24
Usability	7	7 %	0,49
Level of automation	5	5 %	0,25
Production friendliness	7	2 %	0,14
Reliability	9	5 %	0,45
Serviceability	7	5 %	0,35
Cost	7	3 %	0,21
SUM	118	100 %	8,16

As the concept is still in a very premature phase and not all technical solutions are certain to work, the validity of the concept evaluation becomes a question. However, the evaluation still is useful as the results give a good base for discussion. The uncertainties must be processed in a risk evaluation to make the evaluation process more accurate. With the combined knowledge from both, concept evaluation and risk evaluation, the decision making is easier.

6.4 Risk evaluation

Creating a new concept always includes risk. To identify the most important risks that come with the new concept, a risk evaluation is performed. This evaluation is used to determine the desirability of starting a full-scale product development project based on the created concept. The accuracy and reliability of the concept evaluation is heavily dependent on the risks and the probability of their realization.

As the scope of this concept development project is smaller than a full-scale development project, only some of the steps introduced in Chapter 2.4 are used. These steps are risk identification and risk analysis. Risk management planning, risk response planning

and risk controlling are left out for a possible future large-scale development project. The goal in this project is only to help the evaluation of the concept by showing potential threats and opportunities.

6.4.1 Risk identification

The risks identified from the concept can be seen in Table 6. In total 10 risks are identified in the process. Some of these risks are related to the product itself, some to market and customers and some to the company and its operations.

Table 6. Identified risks.

Risks
Redesign of the main component in the product
Customer approval
Customer training for new process
Own production capability
Timing to market
Performance: Concept vs. Prototype
In-house sales approval
Cost overruns
Threat to brand image

To have the new concept work as wanted, a partial redesign of a main component is needed. This component is used in multiple products and thus redesigning it will be a demanding task. Making changes to these kind of core components of the company is not seen wise. A new project and approval from top management would be needed for it.

Customer approval and need for customer training is needed in the new concept. The customer process changes with the new product making it more complex than before. The customer base is used to the old process, so a new product with a new process can cause resistance.

Bringing in a new product to production involves always a risk. Getting experience is required to have a well working production process that can deliver products on time with high quality. As some parts of the new product would be contracted, finding suitable contractors can be a challenge as well.

When launching a product to market, timing is everything. The market in which the company works is highly sensitive to business cycles and launching a new product in a downcycle can be disastrous. Since the product is manufactured to order, the effects are not as high as with products that are made to stock.

With a concept the determined performance targets are always evaluated without knowledge of the actual real-life performance. Actual performance levels can be seen later. In some cases, the prototype phase gives accurate information about the performance of the product, sometimes a real customer environment is needed. A lot of effort can be put into a product development for a product that does not work as it is intended in the concept stage.

When a new product is introduced, the old product lives alongside the new for some time as not all customers want the new product immediately. This creates a challenge for the company's sales department. In many cases the sales staff get compensated, at least partially, based on the sales they make. When a new product is brought to the market, it can be tempting for the sales staff to keep offering the old and proven product to the customers. Encouragement is needed to support the sales efforts and to gain market traction for the new product.

Cost management is important to avoid cost overruns. In a development project, design costs are one of the main sources of cost overruns. These costs are related to the time that the design phase takes and how many man-hours are used. The scope of the process and the nature of the design changes done determine a large amount of the costs in the design phase.

With a new product going to the market reputation is always at stake. Bringing incomplete products to market can harm the image of the company seriously and impact future sales significantly. With a well working and production improving product, the brand image can also grow which will help future business as customer satisfaction rises.

6.4.2 Risk analysis

Qualitative risk analysis is used to evaluate the concept's risks. It is selected because very little numerical information is available at this state of the concept development process making quantitative risk analysis hard to execute. A probability and impact matrix is used for the risk analysis. First the risk probabilities are evaluated, and their impact is determined. Through these two evaluations a risk class is set for each risk identified in Chapter 6.4.1. Finally, some ideas are presented to lower these risks and their impact.

The probability and impact matrix used for the risk evaluation is seen in Figure 15. Both probability and impact have five levels. The probability can range from rare to almost

certain and the impact is from insignificant to severe. With the combination on these, four risk classes are determined: low risk, moderate risk, high risk and extreme risk. A low risk is something that is tolerable without special actions. A moderate risk requires attention and some plans should be made to reduce the impact or probability of the risk. A high risk must be dealt with immediately as it threatens the success of the whole project. An extreme risk is a showstopper. Before the project can continue further and more resources are used for the project, an extreme risk must be negated.

		Impact				
		Insignificant	Minor	Moderate	Major	Severe
Probability	Almost certain	M	H	H	E	E
	Likely	M	M	H	E	E
	Possible	L	M	M	H	E
	Unlikely	L	M	M	H	H
	Rare	L	L	M	M	H

L = Low risk M = Moderate risk
H = High risk E = Extreme risk

Figure 15. Probability and impact matrix for risk evaluation.

The identified risks are evaluated and placed in to the four risks classes. These are presented in Table 7. One risk is determined as an extreme risk, one as a high risk, four as moderate risk and three as low risk. This shows the uncertainty of the concept. The technical solutions selected for the concept are not ready and having one extreme risk requires changes to the concept.

Table 7. Risks with determined risk classes.

Risks	Risk class
Redesign of the main component in the product	E
Customer approval	M
Customer training for new process	L
Own production capability	L
Timing to market	M
Performance: Concept vs. Prototype	H
In-house sales approval	M
Cost overruns	M
Threat to brand image	L

Redesign of the main component in the product is determined as an extreme risk. The probability of it happening is likely and the impact is major. A large amount of redesigning is needed and doing this to a critical component to the company is not viable. The benefits from this are not enough to justify such a large investment to development. For the concept to be ready to development phase, the extreme risk must be lowered or gotten rid of. This requires a redesign of the main component in the product.

Customer approval is rated as a moderate risk. The impact of it is moderate and the probability of it is possible. The customer base is very resistant to changes as reliability is a major factor for them. Bringing a new piece of equipment to a worksite for the customers includes always a risk. The company's good reputation and close relationships to customers helps to alleviate the risk.

Need for customer training is considered a low risk. The impact of it is seen minor and the probability is unlikely. The changes to the customer process are small and the concept is designed to automate the user interface to single button usage. Thus, in most cases, the customer does not need to know how the process works to use the product.

Own production capability is evaluated as a low risk. The new concept contains mainly components that are in use in other products that the company manufactures. The in-house assembly work does not contain large risks and low production volumes in the beginning give a chance to have lessons learned before larger volume production starts.

Market timing for a new product launch is considered as a moderate risk. The impact of a miss-timing is minor, and the probability is likely. The market situation is currently good, but the past has shown that it can change rapidly. Customers' investments are based on macroeconomics and the business is highly volatile by nature. It is likely that the market situation will change before the new product is in market and getting orders for the product can be harder. However, the company is aware of the nature of the market and hasty decisions regarding products are not done based on macro economical situations.

The actual performance of the product compared to the thought performance of the concept is a high risk. This can be only properly tested with a prototype which requires a lot of design work. Possible changes to the product are harder and much more expensive to implement after the detailed design phase.

In-house sales approval is considered as a moderate risk. If this unlikely event should happen, the impact of it would be only minor. Having the sales staff part of the product development process and keeping customer demands at the center of the development should make the product wanted also in-house. Pricing of the product must be similar to the current product or cheaper.

Cost overruns are possible, and the risk involved is evaluated as moderate. Design phase of a completely new type of product with unknown technical solutions can take longer than expected. If multiple prototypes need to be built, the cost impact can be moderate.

Brand image of the company can be harmed if an unfinished product is launched to the market. This poses only a low risk as the product is not in a hurry to reach the market. A perfectly working solution is already in the market and customer satisfaction is good. This can change if a competitor launched an innovation to the market, which takes starts to take the market share rapidly. It must be made sure that only well working product with finished details is launched.

7. DISCUSSION

In this chapter, the methods used in the case study are compared to the current product development process which is presented in Chapter 4. Then the feasibility of the used methods is evaluated. Also, recommendations are given for the case company for further improvements to the concept creation process.

7.1 Comparison to the existing processes

This thesis proposes a combination of existing methods as a concept development process for the case company. The current process the company is using is more focused on project management and it is not described in good detail. In the company's existing process, no concrete methods are introduced. The process introduced in this thesis is concrete, easy to implement and proven to be efficient.

The proposed process consists of the same basic elements as the company's work model for product development introduced in Chapter 4.2. The first step is to identify the requirements for the product. In the proposed process this is done with interviews and by the usage of the Gripen method. In the work model for product development main functions, key features and general performance are defined. The same characteristics are defined in the proposed process as well. In addition, in the existing model, risk identifying is done. This differs from the proposed process. Risk identification and analysis is done after the first round of concept creation. In the development model used by the case company, risk assessment starts before the first gate. The proposed process uses the CPM/PDD as a tool to define and weight the main properties. With this a simple structure is created for the process. This creates easy to understand metrics for the project group to follow as new concepts can be easily evaluated and compared to current products. Gate review system is used in the current process. While it is systematical and a proven method, it does not help on the comparison. A project gate can be passed as long as set requirements are fulfilled. In a case where several concepts are created, many of them could pass a gate without knowing which one of them is the best.

The concept design in the work model for product development is described as creating a conceptual design and architecture of systems and subsystems in the product. Also, a product breakdown structure is drafted with identified interfaces. In addition, specifications for needed parts are created. The concept design phase in the proposed process focuses more on the idea creation which is missing from the work model. To build a concept, ideas are needed, and to create them efficiently, a process for idea creation is

needed. Idea creation in this thesis is based on group work. Using the AIR-OPERA method is a quick and efficient way of working in idea meetings. The case company is lacking a system to create ideas and to document them. Having one person as a facilitator that also processes the created ideas from the meeting is important. If no documentation is done, the same ideas will start to circle, and progress slows down. It is important to be efficient in idea creation as Altshuller (2007) suggests. Idea generation should be an ongoing process that is separated from the design processes. Thus, both processes, the current and the proposed, should not need to create new ideas, only make existing ideas better. Now idea creation has to be done in the idea workshops in addition to improving existing ideas.

7.2 Feasibility of the methods used

The methods used were tested in a case study where a new concept was created. These methods suited concept generation well and the results were positive.

The CPM/PDD method proved to be efficient in evaluation of the products. Listing all product properties in one chart was a convenient way to compare different products. Creating a unified view of the main properties that need development was important. This helped the whole team to keep focus in the important areas of development. This can be seen in the evaluation results, where the main focus areas, weight and capacity, have increased the most. The CPM/PDD process also gave a base for discussion for the members in the development team which helped communications. Overall the method proved to be successful and easy to use. It is recommended to use this method in the future concept development projects.

The AIR-OPERA method was used in the idea creation sessions as a facilitation tool. It was important to have a structured approach to the idea sessions to keep them flowing and to keep the focus in the predetermined problem. Using the AIR-OPERA slightly modified, like in the second idea session, proved to be more suitable for the case project. The original version was too lengthy which influenced the late stages of the process negatively. The multi-stage voting system did not provide added value compared to a more simplified voting and ranking done in the second idea session. However, this is dependent on the composition of the group. Having the multi-stage ranking of ideas makes the idea session more acceptable to everyone's ideas and does not rule out members that are not visible in the group. Also, it is the facilitator's task to make sure everyone's ideas are taken into consideration.

The risk management methods used in this thesis proved to be good. The risk analysis pinpointed an important risk that should be solved before moving forward in the development process. The results lead into concrete actions. An additional idea session will be held to solve the problems that were identified in the risk analysis. Having the risk

analysis done in an early stage of the concept development project makes it easier to continue using the risk management tools when the project moves forward.

The methods used are general and proven functional in use also in the literature. Thus, they can be used in various concept creation projects regardless of the product and industry. Due to the nature of the methods, the results in this thesis can be and should be applied to other departments in the case company. The methods are also usable in other companies. Product development is a widely researched field in which a multitude of different methods are available. Also, other methods can be used in addition or instead of the methods used in this thesis.

7.3 Future improvements

This concept creation study shows that some changes should be done to have an efficient product development process for new product concepts. Suggestions here are based on the observations made during the concept creation process.

The documented product development process should include practical tools to use in the process. As the current process only tells what should be done, but not how, a toolbox of development methods is required. The toolbox should include similar methods that are used in this thesis. This helps the concept development to be more organized and better documented. However, these methods provide only guidelines to development. Engineering expertise is needed also to create good concepts.

The improved product development process should be trained and marketed to the personnel. Each designer should know the standard procedures for product development. The current situation where only the project management office is in charge of processes is not sustainable. Facilitating idea sessions should be trained to have efficient sessions in future projects.

For the concept creation to be successful in the future, ideas are needed in large amounts. Idea generation needs to be more organized and personnel should be encouraged to create and submit ideas more frequently. An idea database should be established where ideas can be submitted. All old ideas are seen in the database and new ideas are evaluated by peer-review. Best ideas should be rewarded periodically. Through ideas coming from the database, better quality concept development work can be carried out. This would also release more resources into development of existing ideas in the idea sessions instead of generating new ideas, which is time consuming.

8. CONCLUSIONS

The objective of this thesis was to create a method for concept development. This was done by combining methods discovered in a literature review and validating the usage of these methods by conducting a case study where a new product concept was developed.

The methods presented in this thesis form a working process for concept creation. This approach gives tools for the development team to list out relevant customer requirements, evaluate weaknesses and strengths of current products, generate concepts through idea sessions and to evaluate new concepts and risks that come with new concepts. Using these methods, a case study was done where a new concept was created successfully.

The main research question was “How to create a new product concept into a stable market?”. The process created in this thesis answers this question. The CPM/PDD process gives a solid foundation as it helps to keep the development’s focus in key areas of the product. The AIR-OPERA method gives tools for teamwork where initial ideas are created and refined into concepts. Risk management tools give more depth to the feasibility analysis of the concept. It must be noted that there can be other ways of utilizing these methods to form a concept creation process and some other tools that are not presented in this thesis can be used too.

The first complementary research question was “How to determine if the new concept is better than the current product?”. This is answered with a combination of evaluating the properties of the concept by the CPM/PDD process and evaluating the risks of the new concept with risk management tools. It is found out that the new concept is better but needs more development for its risks to be in an acceptable level.

The second complementary research question was “What challenges are faced during the development process when the need for change is only partially market driven?”. Finding out the customer requirements was challenging when only second-hand information was available. Gathering and processing this information was time consuming as multiple interviews had to be conducted to get a proper understanding of the needs. Having a direct contact with the customer would have made the development faster. The internal needs of the company were not known in accurate detail. Future projects determine some of the needs in the development. Since those projects are not yet fully planned, best guesses had to be used.

The concept creation process presented in this thesis is a good addition to the existing product development processes used in the case company. As this process provides concrete tools to improve ideas and to gather necessary information for concept creation, it provides clear benefits to all design departments in the case company. Further improvements are also suggested to make idea creation and idea processing more central part of the organization's processes.

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