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Hybrid Development

Composing a Product Development Process for an R&D Company

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Metropolia

I would like to thank my children Saga and Leevi and my wife Sanna for support and understanding during this intensive time when both family-life, work-life and the creation of this thesis had to be simultaneously addressed. But finally - here we are.

Big thanks for our company COO Teemu Törmänen. You made this thesis possible by providing me with a quality subject and by sponsoring me throughout the journey it took me to start and finish this.

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I thank my thesis instructors Thomas Rohweder and Zinaida Grabovskaia for guiding me and for providing support throughout the course of creating this thesis. It has been almost twenty years since my previous dealings with the academic world - so indeed - guidance was needed.

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The case company is small-sized company operating in the Atomic Layer Deposition (ALD) industry. The company has been growing for some time and has also recently moved into a new market segment with semiconductor manufacturing customers. The growth and the new market have caused the product assortment to increase. This progress has created a need for a documented development process. Thus, this study was initiated to create a process for developing the existing product assortment in the case company.

This study utilizes Design research as its research approach. In Design research, the researcher is an active participant. The purpose of the approach is to not only understand a phenomenon, but also to influence it and create a change. With the objective of the thesis for creating a process, the Design Research method is viewed as a suitable approach.

The study started with creating a conceptual framework as a tool based on selected elements from relevant literature onto which the current state analysis was reflected upon. The current state analysis was performed by collecting data through interviews with targeted company stakeholders and from company quality documents. After mapping out the current state, the study set forth to co-create an initial proposal for the proposes for developing existing products through workshops with the company stakeholders. The initial proposal was validated by the company management and revised based on the management comments. The outcome was a final proposal to achieve the objective of this study.

The final proposal for developing existing products borrows its shape from two major development methods – the Stage Gate method and the Agile method. The result is a hybrid process also known as an Agile-Stage Gate method. The core element in this process is a linear stage-gate consisting of an upper-level design stage, a detail-level design stage and ending with a test stage. The stages are performed sprinting with issues collected from a Product Backlog.

The process for developing existing products created by this study was approved by the management and the study succeeded in demonstrating that the method can be used in other company development processes as well. The Product Backlog introduced by this study has already been taken into use by the company.

Keywords	Product Development, Stage-Gate, Agile, Sprint, Hybrid Development

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Acronyms

ALD	Atomic Layer Deposition
LED	Light-Emitting Diode
COO	Chief Operating Officer
CTO	Chief Technology Officer
R&D	Research and Development
OTC	Order-to-Cash

1 Introduction

As companies grow, for example, by acquiring new customers or new markets, the companies tend to grow their product assortment. Also, global competition and rapid technological advances cause a constant need for companies to develop their offerings if they are to keep or increase their market share. Part of the product development is achieved from new product innovations, and part is developed by upgrading or modernizing existing products.

Product development, according to Ulrich and Eppinger (2016), means a set of activities starting from identifying a market opportunity to delivering the product. This means that the product development process permeates most of the operations of a typical company e.g. marketing, R&D and order-to-cash (engineering, manufacturing and logistics). As a product is sold more often than once, the company will re-enter the order-to-cash process several times. Changing markets and improving technologies pressure companies to improve their existing products if they are to continue to sell them.

This study focuses on creating a process for developing existing products for the case company. The focus of this study has been set specifically on developing a process for existing products as the whole product development process, that includes innovation of new products, would be of too big a scale for one study.

1.1 Business Context

The case company is a small-sized company operating in the Atomic Layer Deposition (ALD) industry. ALD is a coating method where substrates are coated on an atomic level by chemical reactions. As the coating is a chemical reaction, it is highly uniform and ultra-thin in the nanometer scale. As today's sensitive technology is decreasing constantly in size, e.g. processors and LEDs, the requirement for coatings in the nanometer scale with high uniformity is growing ALD need exponentially. The company's business is to provide equipment for ALD coating and ALD coating recipes.

The company was founded in 1997. Currently, it employs approximately 60 people with a turnover of 20 million euros. The headquarter and factory is in Finland with subsidiaries in US, Germany, Singapore, China, Taiwan and Japan. Along the subsidiaries it has representatives in over 30 countries that offer sales and service support.

The main markets are Europe, China, Japan, and USA. The company's main offerings are sales of new equipment, spare parts, maintenance and ALD recipes.

1.2 Business Challenge, Objective and Outcome

The company has grown significantly in the recent years and its product mix has also increased proportionally, as a portion of the tools are sold as customized designs. Moreover, the company is expanding from its classic customer base of academic and R&D institutions to a more generic business sector such as the semiconductor manufacturing industry and the medical industry.

The company has from the beginning specialized in customized and unique solutions for the customer with competitive pricing and delivery times. To achieve this, the company has developed and evolved an agile product development process. But this process has not been standardized or documented, and therefore remains as an *ad hoc* way of doing things. The entry to the generic business sector has brought challenges as the new customer base demand for fast-paced development while keeping high quality. Thus, this challenge calls for the documented processes to manage the existing product mix, develop existing products, and innovate new products.

Accordingly, the objective for the thesis is *to create a process for developing the existing products.*

The outcome of the thesis is a process for developing the existing products.

1.3 Thesis Outline

The study is conducted by investigating the current state of the company`s product development process. The investigation consists of exploring the company quality documents and by conducting interviews with various stakeholders in the company. During the interviews, the future expectations of the stakeholders are also carefully gathered. A proposal for a process to develop existing products is created based on findings from literature and workshops with company stakeholders. The proposal is reviewed and validated by the case company management.

This Thesis is written in 7 sections. Section 1 provides the Introduction. Section 2 describes the research approach and how the data was collected for this study. Section 3 analyses existing knowledge and the best practice from literature and creates the Conceptual framework for the Thesis. Section 4 discusses the results of the current state analysis. Section 5 proposes an initial version of the solution for the case company. Section 6 examines the feedback from company management and validates the initial pro-

posal into the final version of the proposal. Section 7 concludes and discusses the findings and outcomes of this Thesis.

2 Method and Material

This section describes the research approach and the data collection and analysis methods used in this Thesis.

2.1 Research Approach

In organizational research, there are two basic approaches to perform research: qualitative and quantitative approaches. Qualitative approach aims to capture factors from individual cases, so that to attempt to form a theory. The purpose of the approach is to understand an observed phenomenon. In the quantitative approach, the researcher aims to understand a phenomenon by analyzing mathematical or statistical numerical data (Kananen 2017). The researcher is merely an external observant collecting data, and the numerical data will determine the result of the research.

Recently, an alternative approach was formulated to address the weaknesses of both above mentioned approaches for a smaller scale, applied research. One specific type of among various methodologies in this alternative approach is called Design research that makes a mix of both qualitative and quantitative methods (Kananen 2017).

Design research differs from two other close research approaches - Action research and Case study. The purpose of the Case study is not to create a change but to understand (Gillham 2010). In the case study approach, a phenomenon or phenomena are empirically observed so that evidence and understanding is found to support the forming of a theory. In Action research, as in Design research, the aim is to influence and change a phenomenon. In Action research, research and development is done by repeating a cyclic process consisting of planning, action taking and evaluation of action. To be classified as Action research, the research process must be iterated several times. The process is re-formed and repeated until the scope of the study has been reached. In the Action research process, the researcher is also an active participant in both research and development (Coghlan and Brannick 2010).

Based on Kananen (2017), Design research borrows the features from both approaches to create a shorter and more applicable approach for conducting research and development projects in companies.

Figure 1 below shows the summary of the three approaches summarized by Kananen (2017).

	Research families/strategies		Research approaches with multiple methods and strategies		
Type	Qualitative	Quantitative	Case study	Design research	Action research
1.Relation-ship between theory and practice	Induction (from practice to theory)	Deduction (from theory to practice)	Abduction	Abduction	Abduction
2.Purpose of research	Understan-ding	Generalization, Prediction	Understan-ding	Change	Change, Intervention
3. Researcher's role	External	External	External	External	Active, internal
4.Responses (data)	Text description (e.g. open questions, theme interviews)	Numbers (e.g. from structured responses)	Many open questions	Many open questions	Many open questions

Figure 1. Summary of research approaches (based on Kananen 2017: 29).

While the purpose of qualitative and quantitative research in their own is to understand a phenomenon, the purpose of Design research is to not only understand a phenomenon, but also to influence it and create a change. In Design research, the researcher is an active observer who also participates to some degree in the researched phenomenon.

This thesis utilizes Design research as its research approach. The Design research strategy is suitable for the study as the study needs to result in an improvement for the company.

2.2 Research Design

This study is conducted in five stages. The research diagram is shown in **Error! Reference source not found.**Figure 2 below.

As shown in Figure 2, the study starts with setting the objective. The study is conducted by first exploring best practice and literature and creating own Conceptual framework

based on the most relevant elements borrowed from available knowledge. The Conceptual framework offers a starting point for developing existing products that is subsequently used twice in the study: for investigating the case company practices and for building the proposal.

First, the Conceptual framework is used to conduct a structured analysis of the current case company practices when developing existing products. Data for the current state is gathered by conducting interviews and exploring the company quality documentation. As the company does not currently have a documented process for developing the existing products, also requirements for the process are gathered and documented from the interviews.

After identifying the strengths, weaknesses and requirements that are grounded in the current company practices, a proposal for developing existing products is made based on the findings of the current state analysis and researched best practice. The findings form the company are carefully reflected against operating models from literature, so that a preliminary proposal could be generated. The proposal is grounded in the suggestions from the relevant literature and co-created in a series of workshops with the company stakeholders.

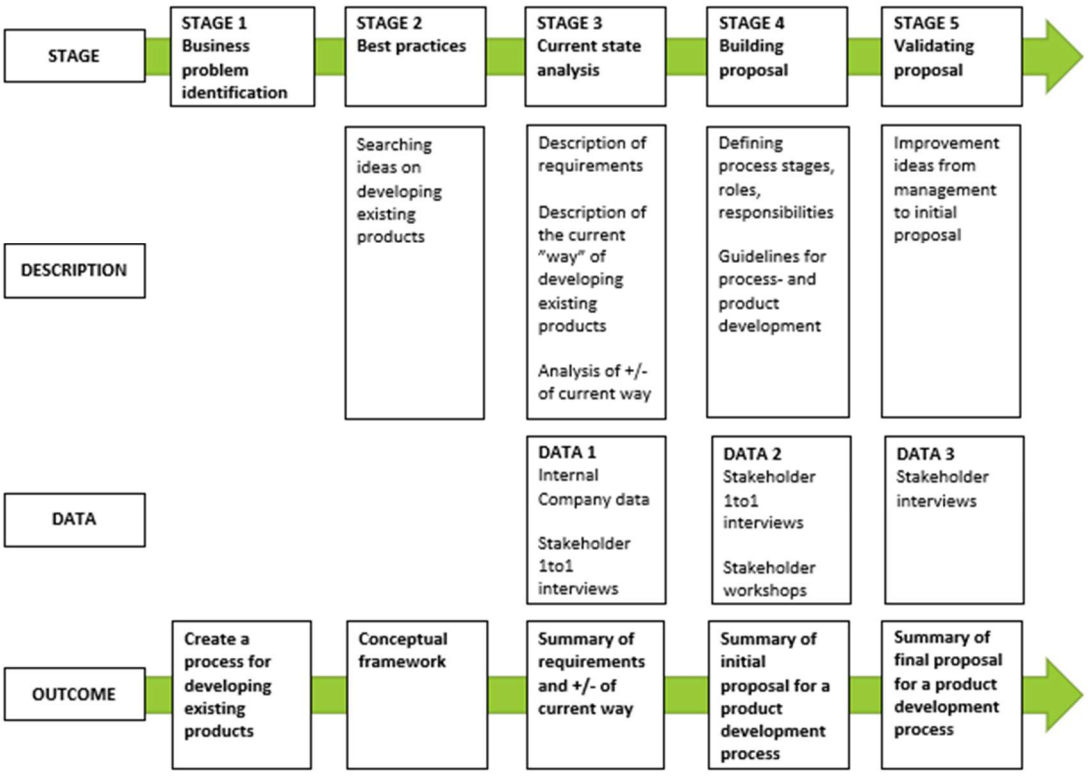

Figure 2. Research design of this study.

After building the proposal, the proposal is validated by company management and edited based on their feedback. The final proposal based on the company management feedback is created and is the outcome of this thesis.

2.3 Data Collection and Analysis

This study draws data from a number of data sources, such as the case company quality documents, interviews, group discussions and workshops. The interviews with the stakeholders were conducted in multiple rounds and held on the company premises.

First, Data 1 was collected for conducting the current state analysis. The aim for Data 1 collection was to map and understand the current way of developing existing product, while also documenting suggestions, best practice and requirements from the case company.

Figure 3 below shows the details of the interviews, discussions and workshops.

	Participants / role	**Data type**	**Topic, description**	**Date, length**	**Documented as**
	Data 1, for the Current state analysis (Section 4)				
1	Respondent 1a: Quality Manager	Face-to-face Interview	Current way of handling the development of existing products.	Feb 2019, 1h	Field notes
2	Respondent 2a: Design Manager	Face-to-face Interview	Current way of handling the development of existing products.	Feb 2019, 1h	Field notes
3	Respondent 3a: COO	Face-to-face Interview	Current way of handling the development of existing products.	Feb 2019, 1h	Field notes and recording
4	Respondent 4a: Applications Manager	Face-to-face Interview	Current way of handling the development of existing products.	Feb 2019, 1h	Field notes
5	Respondent 5a: Automation Manager	Face-to-face Interview	Current way of handling the development of existing products.	Feb 2019, 1h	Field notes
6	Respondent 6a: CTO	Face-to-face Interview	Current way of handling the development of existing products.	Feb 2019, 1h	Field notes
7	Respondent 1b: Quality Manager	Questionnaire	Identify strengths and weaknesses of current way of handling development of existing products. Requirements for future-state process.	Feb 2019	Field notes
8	Respondent 2b: Design Manager	Questionnaire	Identify strengths and weaknesses of current way of handling development of existing	Feb 2019	Field notes

			products. Requirements for future-state process.		
9	Respondent 3b: COO	Questionnaire	Identify strengths and weaknesses of current way of handling development of existing products. Requirements for future-state process.	Feb 2019	Field notes
10	Respondent 6b: CTO	Questionnaire	Identify strengths and weaknesses of current way of handling development of existing products. Requirements for future-state process.	Feb 2019	Field notes
	Data 2, for Proposal building (Section 5)				
11	Participants: Design Manager Automation Manager	Workshop	Proposal building	March 2019, 2h	Field notes
12	Participants: Systems Manager	Workshop	Proposal building	March 2019, 2h	Field notes
13	Respondent: Design Manager	Face-to-face Interview	Validation of co-built proposal	April 2019, 0.5h	Field notes and recording
14	Respondent: Systems Manager	Questionnaire	Validation of co-built proposal	April 2019	Field notes
	Data 3, from Validation (Section 6)				
15	Participants: CTO COO Product Portfolio Manager	Group interview/ Final presentation	Validation, evaluation of the Proposal	April 2019, 1.5h	Field notes and recording

Figure 3. Summary of data collected for the study.

As seen from Figure 3, data was collected in three rounds. Data 1 collection helped to understand and map the current way of developing existing products. During the first round requirements and suggestions were also gathered.

Data 1 collection relied on the analysis of the quality documents from the case company and by conducting interviews. The interviews were conducted as a two-part interview. The first part performed as an open discussion. The topics focused on how the product development is currently handled in the company and comparing them to the Conceptual framework created from best practice identified from relevant literature. The second part was conducted to ask the respondents to list the strengths and weaknesses of the current practice of developing existing products. Suggestions for improvements were also

documented during the second part interview. As part of Data 1 collection, this study also analyzed several internal documents, as shown in Figure 4 below.

	Name of the document	**Number of pages/other content**	**Description**
A	Quality manual	14 pages	Case company quality manual
B	Product Management Process	11 pages	Product Management Process description
C	Order to Cash process	12 pages	Order to cash process description
D	Sales Case Review	6 pages	Sales Case Review process description

Figure 4. Internal documents used in the current state analysis.

As seen from Figure 4, the current state analysis focused on the documents to be able to understand the business environment inside which the product development takes place. The internal documents were also utilized for allowing the comparison of documented way of operating versus actual way of operating.

Data 2 collection focused on more in-depth requirements and suggestions with the aim to create a proposal for developing existing products. Targeted key stakeholders from the company operations were involved in order to be able to create the process, as the product development process traditionally permeates several operations in companies. Data 2 was also gathered by conducting workshops. The result from the workshops was confirmed by the workshop participants before being presented to the company management.

Data 3 collection, the final data gathering round, was reserved for the company decision-maker insights in order to be able to validate the outcome and gain the company approval. The proposal, that was earlier built during Data 2 collection round, was presented to the company decision-makers and especially to the COO who was the initiator for the study. The decision-makers validated the proposal and suggested modifications and additions to the proposal. These modifications and additions were implemented to the proposal and thus the final outcome of the study was created.

All data were analyzed using Thematic/content analysis.

3 Searching Good Practice on Developing Existing Products from Relevant Literature

This section discusses different best practice to perform product development. The first and the second sub-section will discuss the two major development methods which are the Stage-gate method and the Agile method. The third sub-section will discuss a hybrid method which aims to implement the strengths of both the Stage-Gate and Agile method. The fourth sub-section will discuss how to involve and integrate the customer into the product development process. The fifth – and final – sub-section will discuss how to utilize the findings from the previous sub-sections so to be able to form a Conceptual framework for this thesis.

3.1 Stage-Gate Method for Product Development

Presently, the two major product development methods are the Stage-gate method and the Agile method.

The Stage-Gate method was first introduced by Robert G.Cooper in the 1980s and quickly became popular with several variants emerging such as the Stage-Gate method by Ulrich & Eppinger (2016). Common to them all is the method where the development proceeds through a series of stages, and each stage has a gate between them. The current stage cannot be completed – and the next stage started - before the gate requirements are met. For this, a Gate Meeting is held where the development is discussed and evaluated and the Gate Keeper – a single person – decides during this meeting whether the project is allowed to proceed or must stop (Cooper 2017).

In the Stage-Gate method, the traditional stages are concept stage, development stage, test stage and launch stage. These stages can be further divided into more detailed stages. Figure 5 illustrates the stage-gate process as described by Ulrich & Eppinger (2016: 9).

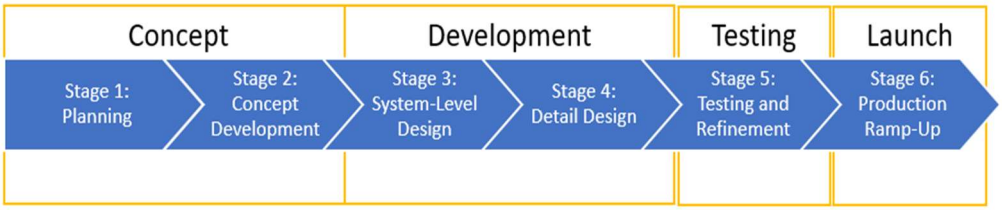

Figure 5. The Stage-Gate method according to Ulrich & Eppinger (based on Ulrich & Eppinger 2016: 9).

As seen in Figure 5, the concept part is divided into a Planning stage and a Concept Development stage. The development part consists of the System-Level Design stage and the Detail Design stage. These are followed by the Testing and Refinement stage and ending with the Production Ramp-Up stage. The content of each stage is discussed below.

3.1.1 Concept Stage

The concept part begins the stage-gate process. According to Ulrich & Eppinger (2016), the first stage in the concept part is called the Planning stage. During this planning stage the market opportunities are investigated and reflected against the company strategies and existing technologies. The output is the mission statement and business goals for the development to be performed. It is the planning stage that sets the business requirements for the technological development that will be performed in the next stages. This stage is also sometimes referred to as the Discovery stage and considered as a part of the marketing process whereas the rest of the stages are technology-driven product development activities (Cooper et al. 2002).

After the Planning stage, the Concept Development stage starts. This stage starts the actual development project that was launched in the Planning stage. During this stage, a concept or several concepts are created. Ulrich and Eppinger (2016: 118) describe the concept as "*an approximated description of the technology, working principles, and form of the product*". The identified customer needs, market specifications and company existing knowledge are brought together to create a range of product specifications on an idea level. The concept that has been identified as having the highest potential moves to the next stage which is the Development stage.

3.1.2 Development stage

During the Development part of the Stage-Gate, the concept evolves from being an idea to becoming a tangible product. The Development part starts with the System-Level Design stage. At this stage, the product is defined on a rough level that sets the framework for the detailed design to come. System-Level design outcomes are for example the modular architecture of the product, definition of standard components to be used, and preliminary detailed design of critical parts of the product (Ulrich & Eppinger 2016).

At the following Detail Design stage, the product design moves from the rough framework level to the detail level such as tolerance design and manufacturability considerations of individual components (Feng et al. 1996).

3.1.3 Test and Launch

Once the product to be developed has passed through the development stages, it enters the Testing Stage. At this stage, the designed product is manufactured as a preproduction version so to test the intended features empirically. Depending on the size of the development project, there can be several iterations of preproduction versions. Once the products perform as set by the development project requirements, a sales plan is created for the next and final stage – the production ramp-up stage (Ulrich & Eppinger 2016).

At the last stage, the product is commercialized by joint co-operation of Marketing and Operations (Cooper 2017). The commercialized version is sometimes first released to a selected number of customers whose insights are collected for a possible post-launch product review. During the post-launch review, feedback from a selected number of customers is evaluated and implemented to the product design and only after this is the product released to the whole market (Ulrich & Eppinger 2016).

The step-by-step approach described above aims to show that the Stage-Gate method is especially suitable for products whose specification requirements are well-defined from the beginning. Also, it is suitable for the products that need to maintain a rigid and strict development path in order to avoid side-stepping from the original requirements that were identified in the beginning of the development project (Eppinger & Unger 2011).

Software consultant Kent Beck interpreted the Stage-Gate approach (Beck 1999: 70) as follows; the Stage-Gate is a robust process that aims to deliver exactly what the customer has requested. But in cases where the customer does not precisely know what it needs but at the same time need it fast, the Stage-Gate method faces challenges to deliver what is required and when it is required. These cases are especially common in the software industry and to coupe with them a new way of executing development projects was introduced - the Agile method.

3.2 Agile Method for Product Development

It is a common belief that the Agile method came about in year 2001 when seventeen prominent software development specialists came together to make a proclamation for a new way of handling product development. For some time already, there was a need for a new approach as the traditional Stage-Gate methods were viewed as slow and inefficient in the fast-paced software development world (Takeuchi & Nonaka 1986). The claim made by the seventeen people became known as the Agile Manifesto. Figure 6 below shows the four corner stones of this Agile Manifesto.

Figure 6. The Agile Manifesto (Beck et al. 2001).

By now, several different Agile methods have come into existence, such as Extreme Programming, Dynamic system Development and Scrum, to mention a few. They all have in common that they share the four core values of the Agile Manifesto.

Firstly, they emphasize people and recognize that goals are achieved by talented people working in teams.

Secondly, they focus on delivering constant value to the customer throughout the development project, not just at the end of the project.

Thirdly, the development project is viewed as a co-operative process between the supplier and the customer where a relationship is formed and evolved, thus encouraging feedback and reflection from both parties during the development.

Fourthly, change is an integral and natural part of the co-operative development project. Change is viewed as progressing toward the mutual goal, not as a delaying obstacle (Abrahamsson et al. 2002)

3.2.1 The Scrum - Overview

Among a variety of the agile methods, the Scrum method seems to have become a focus of interest in the academic community (Dingsoyr et al. 2012). The Scrum method is viewed as being the strongest agile method for managing development processes (Abrahamsson et al 2003). The term Scrum is borrowed from rugby and was first introduced in 1986 by Takeuchi & Nonaka. In 1995, Schwaber & Sutherland introduced it in its current form (Sverrisdottir et al. 2014). In rugby, a scrum occurs when the opposing teams face each other in a play. The teams try to advance - sprint - down the playing field and the scrum is repeated every time a play is restarted. So too is the agile method known as Scrum played out; repeated sprints, or iterations, are carried out to be able to close in on the goal (Cohen et al. 2004). Figure 7 below illustrates the Scrum process.

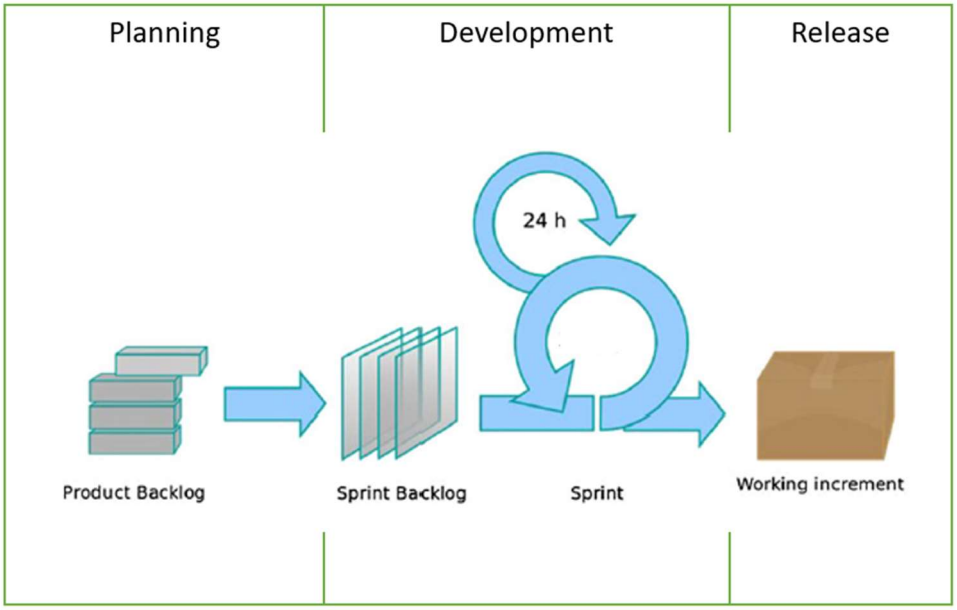

Figure 7. The Scrum process (based on Annosi et al. 2016: 518).

As seen from Figure 7, the Scrum process starts with a planning phase, continues with a development phase and ends with a release phase. During the planning phase, the objectives of the development phase are selected. Once the objectives have been selected, the development phase - or sprint – begins. The sprint has a pre-determined length after which a working solution must be presented for the release phase.

Originally, the length of the sprint was set to exactly 30 days (Schwaber 2004) but more recently the length of the sprint is acknowledged as project specific, with a length of one month or less (Schwaber & Sutherland 2017). The progress of the sprint is evaluated

daily. After the sprint is finished, the outcome is evaluated in the release phase. This process is repeated until the release-phase result reaches the final product status as has been agreed between the supplier and the customer.

To be able to better understand the Scrum method, four crucial elements need to be explained. They are the Product Backlog and the roles of the Product Owner, the Development Team and the Scrum Master, as described below.

3.2.2 The Scrum - Product Backlog

The Product Backlog lists all that is needed to achieve the final product status as it is currently know. Emphasis is put on the wording “currently known” (Abrahamsson et al. 2002). The Scrum process proceeds through several iterations with a newly developed part of the product always created in the release phase. These incremental steps toward the final product can change the Product Backlog, as the development team may discover new and better solutions that will take them towards the final product.

3.2.3 The Scrum – Roles

The Product Owner is responsible for updating and managing the Product Backlog. He or she must be a single person, not a team, and is held accountable for the success of the Scrum development project. The Product Owner will discuss with the Development Team the current Product Backlog tasks. According to Schwaber & Sutherland (2017), this is done before the Development Team makes their decision for what to select from the Product Backlog for the upcoming sprint.

As the Product Owner is responsible to managing the Product Backlog, the Development Team is responsible to resolve the Product Backlog tasks that were selected for the sprint. Even thou the Product Owner will discuss and possibly advice what Product Backlog tasks should be chosen for the upcoming sprint, it is the Development Team which ultimately decide what tasks they will choose. Once the sprint starts the Development Team takes sole responsibility to execute the sprint and deliver a solution for the release phase. During the sprint the team has, according to Scrum rules, full authority to do what it needs to fulfill the chosen tasks. Also, according to Schwaber (2004), the Scrum rules insist that the team cannot be distracted for the length of the sprint.

The fourth element – the Scrum Master – is a special role found in Scrum. The purpose of this person is to act as a kind of mixture of a consultant and a facilitator for the Scrum project. The Scrum Master will ensure that the rules of the Scrum are followed and understood by all parties. The Scrum Master acts as a mediator between the other operations of the company and the Scrum taking place, in case there seems to be interference that would possibly affect the Scrum (Abrahamsson et al. 2002). Schwaber & Sutherland comment the definition of this role as "*The Scrum Master helps those outside the Scrum Team understand which of their interactions with the Scrum Team are helpful and which aren't.*" (Schwaber & Sutherland 2017: 7).

Figure 8 depicts how the roles of the Product Owner, Development Team and the Scrum Master are involved in the Scrum process.

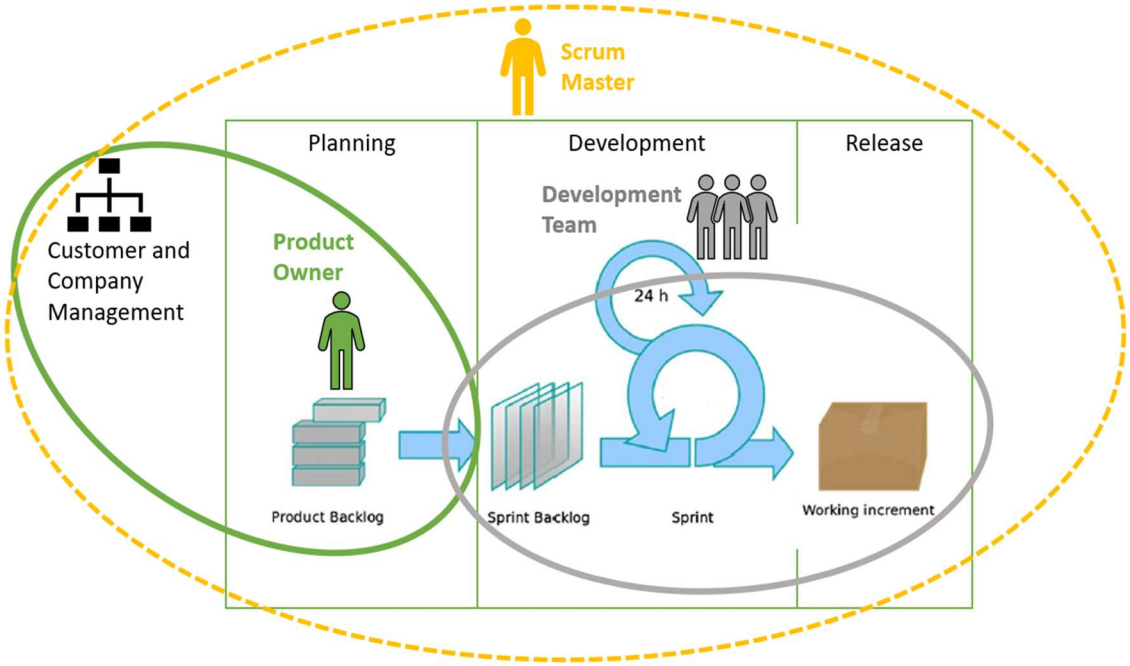

Figure 8. The Scrum roles (based on Annosi et al. 2016: 518).

As seen from Figure 8, the Scrum Master is involved in all phases of the Scrum process, and that person also interacts when needed with the company and the customer. The involvement is illustrated as a dashed circle to represent the negotiative role of the Scrum Master. The Product Owner, on the other hand, is directly responsible for the outcome to his or her superiors as well as to the customer and for the management of the Product Backlog. The Development Team is responsible for selecting tasks from the Product Backlog which to develop in the sprint. They are also responsible for executing the sprint

and for reaching an outcome that can be presented at the release phase. (Annosi et al. 2016)

3.3 Hybrid Method for Product Development

Global competition and rapidly developing technology have shortened the life cycle of products and thus created a demand for fast and efficient product development. As the customer demands are identified, new products or new versions of existing products need to be developed in a fast pace to be able to fulfill that demand before it changes or is served by the competition (Jou et al. 2010).

Identifying these needs is a core requirement for both the stage-gate method and agile methods. As described in Section 3.1, the traditional stage-gate model emphasizes the throughout mapping of the customer needs in the beginning so to be able to deliver a satisfactory solution in the agreed time frame. The agile method, as described in Section 3.2, values a dynamic mapping of customer needs. This results in small increments that aim to reach a satisfactory solution at some point in the future.

The stage-gate method has traditionally been the preferred product development method in the manufacturing business, as the cascading step-by-step flown is seen as bringing discipline into the process which translates into quality and less deviation from the defined scope (Sommer et al. 2015). As explained in Section 3.2, the software industry felt it needed a different development method as it faced a customer base with fast paced and quickly changing needs and thus the agile method was introduced. According to Cooper (2014), it would seem at first that the agile method is an improved version of the stage-gate and thus would replace the stage-gate as the product development process for the fast-paced global business. Physical products, however, are not as easily broken down into a multitude of sub-products as software code can be broken. The agile Scrum method defines that after each sprint the team must present a working product i.e. something that provides value to the customer as it is. With software this can be achieved quite well, but with physical products such as a motor the product can only appear at the end of the development project, not partly during the project.

The development of physical products (similarly to what this thesis focuses on), a method is needed that would take into account both the characteristic of this product type (challenging structure to split into sub-tasks) and the current global markets with fast paced and ever-changing development needs. For this, a third method can also be applicable - the hybrid Agile-Stage-Gate method.

The Agile-Stage-Gate aims to combine what it considers the strengths of the Stage-Gate method and the Agile method. According to Sommer et al. (2015), the hybrid Agile-Stage-Gate method borrows from the Stage-Gate the plan-driven approach with verification points. This plan-driven approach is viewed as bringing discipline to long-term development projects. From the Agile method, it borrows the fast and iterative design cycles (sprints) that give flexibility to adjust the development targets, as the customer needs change or become more precise during the development project.

Figure 9 illustrates the Agile-Stage-Gate hybrid model.

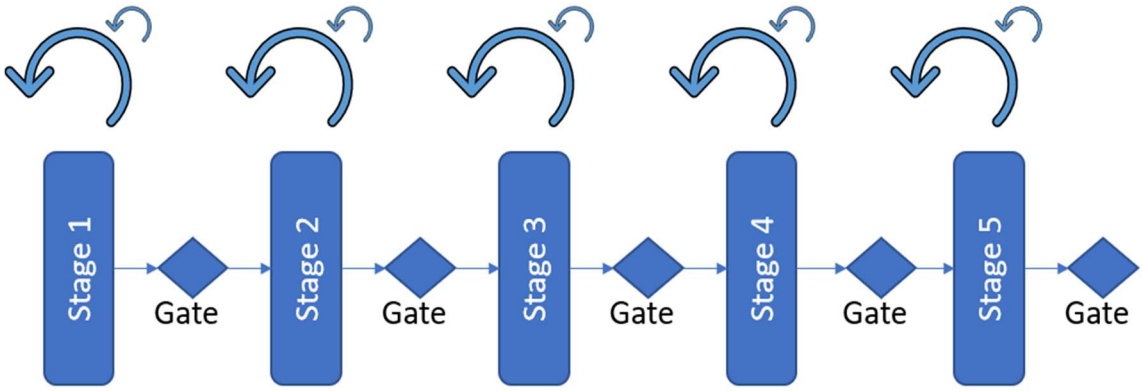

Figure 9. The Agile-Stage-Gate hybrid (based on Lehnen et al. 2016: 224).

As seen from Figure 9, the cyclic and iterative steps are added as sub-phases to the main phases of the stage-gate model. These iterative sub-phases are not the classical plan-do-check-act cycles as described by professor Deming (Moen 2009), but represent the modified versions of the Scrum process, as explained in Figure 7 and Section 3.2 of this thesis. The modification is that after the sprint the team presents “something physical” (Cooper et al. 2016: 171). With this it is meant that the team presents something that can be evaluated such as manufacturing drawings or a 3D model of an item. This differs from the Scrum method where the requirement is to provide a working product after each sprint.

However, the Agile-Stage-Gate method does not require to add modified Scrum steps to each stage. Based on Sommer et al. (2015), the number of stages that are proceeded through with a modified Scrum is specified by each company based on their needs.

3.4 Integrating Customer to Product Development

Academic research has identified three valuable aspects which to look for when selecting which customers to integrate into the development process. According to Sandmeier et al. (2010), the first aspect is the financial power of the customer. The second aspect is the level of trust between the customer and the developer company. The third aspect is the innovation characteristic of the customer - how willing the customer is to test, try and possibly fail in order to gain new technology before anyone else.

Companies with a high innovation characteristic are called Lead Users (Sandmeier et al. 2010). Financial power enables the customer to invest into the developing company as the value of the outcome is not necessarily positive. A decent level of trust between the customer and the developing company raises the tolerance of failures and setback which are likely during a development process. The third aspect, the innovative characteristic, enables both investment readiness and tolerance towards setbacks. Hence, a financially powerful innovative company (Apple Inc., as an example) seems worth gaining a trustful relationship with.

There are two generic approaches that companies introduce their products on the market: by a *market-pull* or *market-push* approach (Dowling, 2004).

In a market-pull approach, the customer needs are first identified by the company, against which products are developed. The need of the market pulls in products, to satisfy the existing needs. In the other approach, market-push, the company seeks customers for something they have developed. The products are pushed on the market to create need. Both approaches have their perils. In a market-pull the company can miss the opportunity by being late as competitors have identified the need – or pull – earlier and moved in to satisfy that need (Blank 2013).

In a market-push, the company can fail to create a need, as for example the introduced product fails to offer significant advantage against the existing market technology (Ulrich

& Eppinger 2016). To minimize the risk of a failed product launch, i.e. to better understand the customer requirements that need to be fulfilled, customers can be invited to participate in the development process. This participation, or integration, of customers to product development has been empirically proven to increase the success in launching products on the market (Callahan & Lasry 2004).

According to Blank (2013), the decision whether to go for a market-push or market-pull development approach can be viewed as a specific decision that is dependent on market, but it can also be regarded as a decision dependent on the company size. Large companies have the resources to invest in large-scale market surveys to map out customer needs with good accuracy. Large companies have also established themselves on the markets, otherwise they would not be large. Thus, they have gained a profound understanding of those markets into which develop new products (Blank 2013). This would lead to a conclusion that both market-pull and market-push are both viable options for a large sized company; size gives options to choose from.

As a result, business practitioners (Blank 2013) believe that small businesses (such as the case company in this study) are only just establishing themselves and thus may have limited understanding of the current market needs. As small-sized, they also have limited resources to perform throughout market surveys and thus gain insight into current customer needs, i.e. find out the “pull”. With limited resources, the small sized companies cannot afford too many failed product launches either. Hence, a viable strategy for small-sized companies would be the *market-push* approach where the company introduces new technology onto the market and then finds customers for it. As stated previously, the market-push has its perils where it fails to create such an impact as to create a new need. This calls for integrating the customer into the product development process in various stages of the development project to gain early insight into the needs and wishes of the market.

3.5 Conceptual framework of This Thesis

The findings from available literature and best practice on developing existing products discussed in Section 3 above were summarized and visualized in Figure 10 as the Conceptual framework for conducting this study. The explanation for each part of the Conceptual framework is given in the text below.

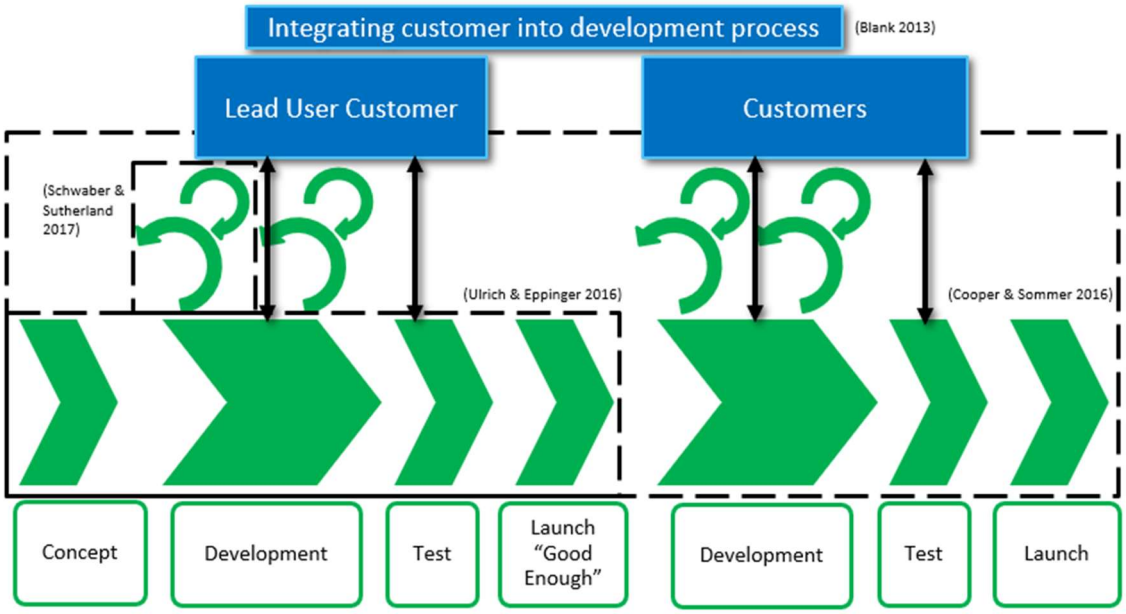

Figure 10. Conceptual framework for a process for developing existing products.

As illustrated in Figure 10, the development process consists of three key elements. The first element is *the core process* of the framework which is the stage-Gate process (Ulrich & Eppinger 2016), as described in Section 3.1 of this study.

The second element is the modified Scrums which is added to various Stage-Gate phases of this process. The result of a Stage-Gate method with added modified Scrums is called *a Hybrid-Stage-Gate method* (Cooper & Sommer 2016), as described in Section 3.3 of this study. The Scrum itself as a method (Schwaber & Sutherland 2017) is described in Section 3.2 of this study.

The third element is *the integration of the customer* to the development process at various phases (Sandmeier et al. 2010, Blank 2013).

The first element, the Stage-Gate method, is described in its core features and makes the foundation for this Conceptual framework. The number of phases can be considered scalable according to the size of the development project as a Scalable-Stage-Gate (Cooper 2014). Scalable means that the number of phases varies from the total maximum, as shown in Figure 5 of Section 3.1 of this study. The number can be scaled as necessary for the development project at hand.

The second element, the modified Scrum, is added to the Development Phase where the third element, the Customer Integration, also takes place. The intention here is to collect a Product Backlog (described in Section 3.2.2) which to execute sprints from. The sprint result – which is a modified Scrum result i.e. “something physical” which to evaluate - is evaluated together with the customer and reflected to the existing Product Backlog. During the development phase, several sprints are iterated until the result is deemed as meeting the customer requirements. After this, the process advances to the Test Phase.

The Conceptual framework also includes and specifies the Test Phase as a phase where the customer is integrated. The product from the Development Phase is tested together with the customer until the result is deemed as meeting the customer requirements. The study considers it an important detail that the customer is already involved from the Development Phase into the Test Phase. By involving the customer already at development, the customer is likely to not test “a product”, but “their own product”. This is likely to increase the customer tolerance toward delays and setbacks (Sandmeier et al. 2010).

Thus, according to this Conceptual framework, the total product development process can be divided into two major sub-processes. The first major sub-process is the first Concept-to-Launch where the customer to be integrated is a Lead User. A Lead User is a customer whose characteristic is to get involved in new technologies to be able to remain a forerunner on the market (Sandmeier et al. 2010). Together with this customer, the product is developed into a product that fulfills the minimum level of requirements to be able to pass the requirements of the Lead User customer. Here, emphasis is put into wording *“minimum level”* or *“good enough”,* as the aim for the developing company is to create a product with which to proceed to the second major sub-process of the developing process. Hence, the product is not considered to be a final version, but still a version in development.

The second major sub-process is basically the same as the first part with the following exceptions. First, the customer to be integrated is expanded to include several customers which are not necessary characterized as Lead Users. The process continues from the previous step, the “good enough” launch into a new Development Phase where a new customer, or set of customers, is included in the sprints as in the previous Development Phase and Test Phase. This time the aim is to develop a product that can be launched to a whole market.

In the next sections, the study continues to applying the Conceptual framework to data gathered from the current state analysis in Section 4 and then using the Conceptual framework as guidance for proposal building in Section 5.

4 Analysis of the Current Product Development Practices in the Case Company

This section discusses how the current state analysis of existing product development practices was conducted in the case company and what the findings where. The section begins with an overview of the stages in the current state analysis. It continues with analysis of the findings and finally tells how the study proceeds to creating a proposal in Section 5.

4.1 Overview of the Current State Analysis Stage

As mentioned earlier in Section 1.2, the current way of developing products is not documented and exists only as an *ad hoc* way of doing things in the case company. Due to this, the study started by searching literature and best practice for suggestions on developing existing products. From the key elements of these suggestions, the Conceptual framework was synthesized for applying it for the current state analysis of existing product development practices in the case company.

The current state analysis was conducted in three steps.

The first step relied on six targeted interviews which were performed in order to collect data and analyze the current way of doing product development. The interviewees were asked to reflect in their opinion the current way against the process modelled in the study Conceptual framework. The topics discussed included: (a) how the company currently handles the major stages of the Stage-Gate method - which are the Concept & Idea stage, Development stage, Test stage and Release stage. The interviewees were also asked (b) to identify any other stages that the company might have which they felt was not covered by the four major Stage-Gate stages. In the last question, the interviewees were requested (c) to describe how the company's current way of developing products is connected to the customer.

The second step, performed separately after the first step, was to ask the same interviewees to identify the strengths and weaknesses of the current way of doing product development. The questionnaire was themed according to the same major Stage-Gate stages as during the first step. They were also requested to list improvements and requests for a future-state process.

During the third step the findings from the interviewees were summarized and analyzed.

4.2 Detailed Description of the Current ”Way” of Developing Existing Products

As the current way to develop existing products is an ad hoc way of doing things, the study set forth to first check the current company practices against the best practice synthesized into the Conceptual framework. It was used as a tool onto which the interviewees could reflect the current product development process.

Figure 11 below summarizes the findings from interviews during the current state analysis. These findings will be examined and discussed in the following sub-sections.

	Key focus area from the Conceptual framework	*Stakeholder description of focus area*	*Stakeholder requirements regarding future state*
1	Concept Stage	*Initialized by customer*, described by 6/6 interviewees.	*Fluent handovers between stages.* *Unambiguous roles and responsibilities.* *“Definition of Done” clearly specified at the beginning of a project.* *Resource needs mapped beforehand.* *Properly defined inputs and outputs through the whole process.* *Understand the overall view, not only details.*
2	Development Stage	*Development focuses on details,* described by 4/6 interviewees. *No time for iterations as development is part of a project delivery schedule* , described by 5/6 interviewees.	
3	Test Stage	*Lacking “Definition of done”,* described by 4/6 interviewees. *Done just before shipment*, described by 3/6 interviewees.	
4	Launch Stage	*Does not yet exists,* described by 6/6 interviewees.	

Figure 11. Summary of data gathered from interviews during current state analysis.

The results of this analysis showed that the interviewees were able to recognize three out of the four main stages present in the Conceptual framework. Figure 12 below illustrates the four main stages of the Conceptual framework - the Concept stage, the Development stage, the Test stage and the Release (or Launch) stage - which were checked in the current state analysis.

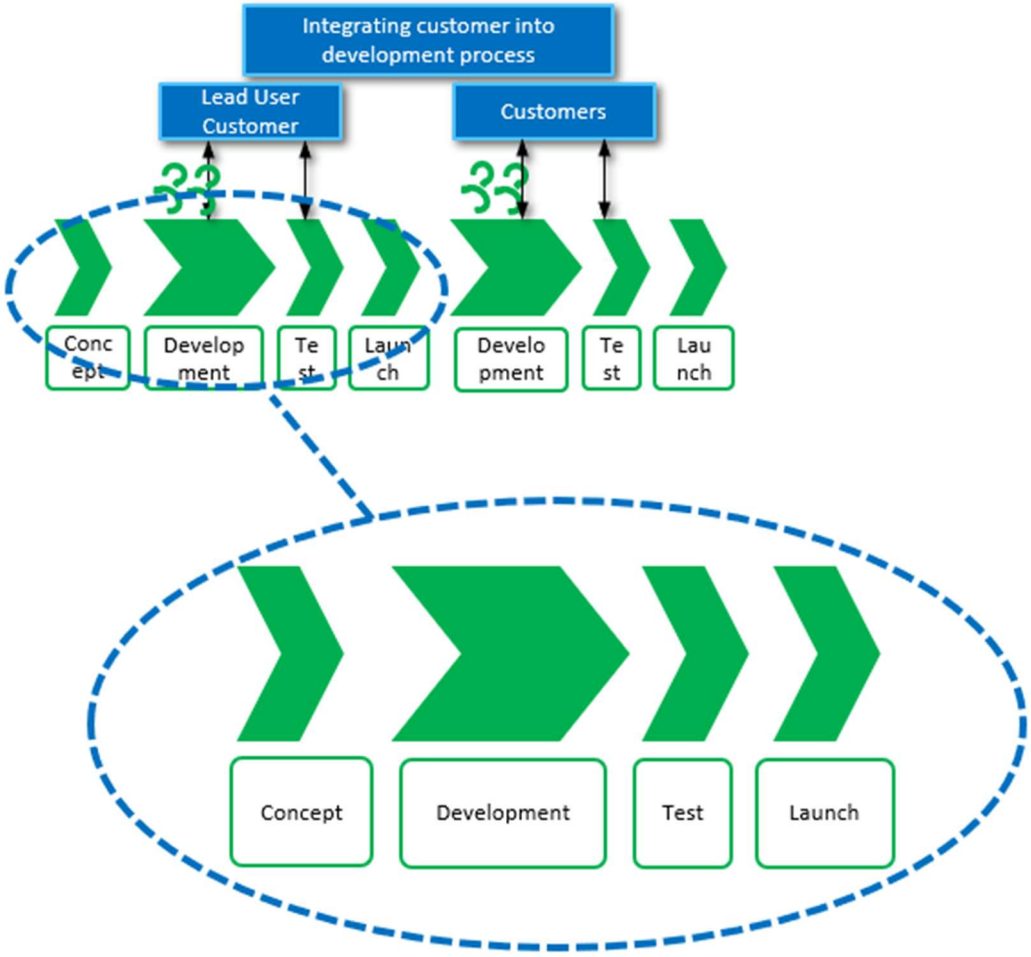

Figure 12. Four main stages of the Main Conceptual framework for a process for developing existing products.

4.2.1 Concept Stage

> "*We do not actually have this stage, as concept-requirements come from customers…Customer has sold us an idea and we start developing that idea" – Design Manager*

The data from interviews and company quality documents indicate that the Concept phase is currently initiated by the customer as a "market-pull" i.e. market demands are initiating the start of the development process.

There are a few cases where the company has started this stage, but in majority of cases it is governed by customer initiatives. The customer has an idea or problem that they bring to the case company`s attention and this need starts the stage. According to the case company quality documents, the concept stage resides within the R&D organization and its purpose is to find evidence to support the validation or invalidation for concepts that have been selected for productization. Referring to Section 1.1 (Business Context) of this study, the concept can either be equipment or recipes.

The recipe concept is validated or invalidated by studying relevant academic literature and previous archived case results. Based on these findings the concept is either discarded (customer request is denied) or it continues to the recipe development stage.

The equipment concept is validated or invalidated through an internal company process called a Sales Case Review, where key stakeholders evaluate and discuss the customer requirement. Based on the evaluation of the stakeholders the customer requirement is either approved for quotation or rejected. If the request is approved the concept does not enter the development stage, but instead enters the Sales process where it eventually can turn into a sold customer project.

4.2.2 Development Stage

As identified from current state interviews, the total development process is typically initiated by the customer and hence the development stage focuses on solving particular problems. As one interviewee summarized it: "*Development is performed according to customer expectations, not company interests or strategy*".

In the company current practices, the two concept cases, the equipment development and the recipe development, continue from the concept stage in differing directions. The recipe development moves forward within the same R&D operations where it was initiated. During the development stage the recipe concept, that is validated though literature findings, is now empirically produced in small quantities using case company equipment.

The validated equipment concept, however, is transferred from R&D to the Order-to-Cash process as a Design Development Project within the customer delivery project. The development stage is initiated once the customer delivery project has been approved and started. During the Development stage, the previously validated concept –

that led to the Design Development Project - is again investigated and developed into a product or part of a product.

4.2.3 Test and Launch

For recipes, the produced small quantities are tested and verified against development requirements. If the results do not support the customer requirements, the development process is canceled, and Sales department is informed. If the results support the requirements, then the recipe is launched to case company Sales for further negotiations with the customer.

Presently, in the case company practices, the equipment development test stage resides within the customer delivery order and takes place close to customer order delivery date. The Launch stage is not a separate stage as the delivery of the customer order signals the end of the development process, as identified by Automation Manager comment:

> "*We execute projects and not product launches. Project item becomes a product without any kind of process or systematic decision". – Automation Manager*

Therefore, the interviewees were able to recognize only three out of the four main stages of the development process.

4.3 Analysis of the Current "Way" of Developing Existing Products

Based on the initial interviews and discussions, the study moved further to analyzing the current "way" of developing existing products by reflecting the data gathered from interviews and the case company quality documents against the Conceptual framework. For this end, the current development process was mapped using the same elements that the Conceptual framework is built of. Each stage is analyzed and discusses in the following sub-paragraphs.

Figure 13 below illustrates the "way" of developing existing products in the case company as data from interviews and company quality documents picture it.

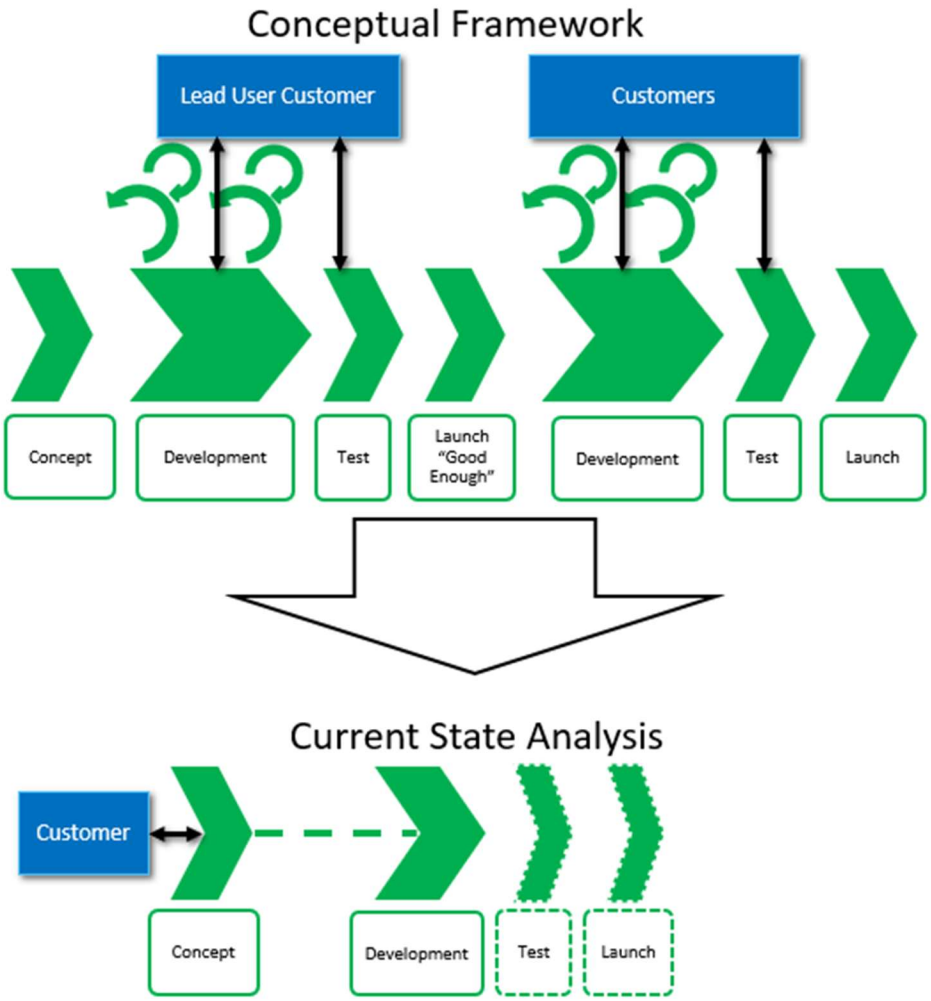

Figure 13. Reflecting findings from the current state analysis against the Conceptual framework.

As seen from Figure 13, the current "way" of developing existing products was "mapped" by using the same elements as the Conceptual framework has. It was discovered that there exists an integration with the customer in the beginning of the process. The main stages of a Stage-Gate method – Concept, Development, Test and Launch stages – are also identifiable. A notable element in the current state process "map" is the long and dotted line between the Concept stage and the first Development stage. This dotted line represents the extensive time between when these two stages are active.

4.3.1 Concept Stage Analysis

From a customer integration perspective, this stage is heavily influenced from the customer side. As data indicated in Section 4.2.1, the customer is initiating this phase and thus the customer is initiating the total product development process for existing products.

As discussed in Section 4.2.1, there are two separate concept stages; one for equipment concepts and one for recipe concepts. The recipe concept development is initiated to support the validation or invalidation of the equipment concept. Figure 14 below illustrated the two separate concept stages and their connection to each other.

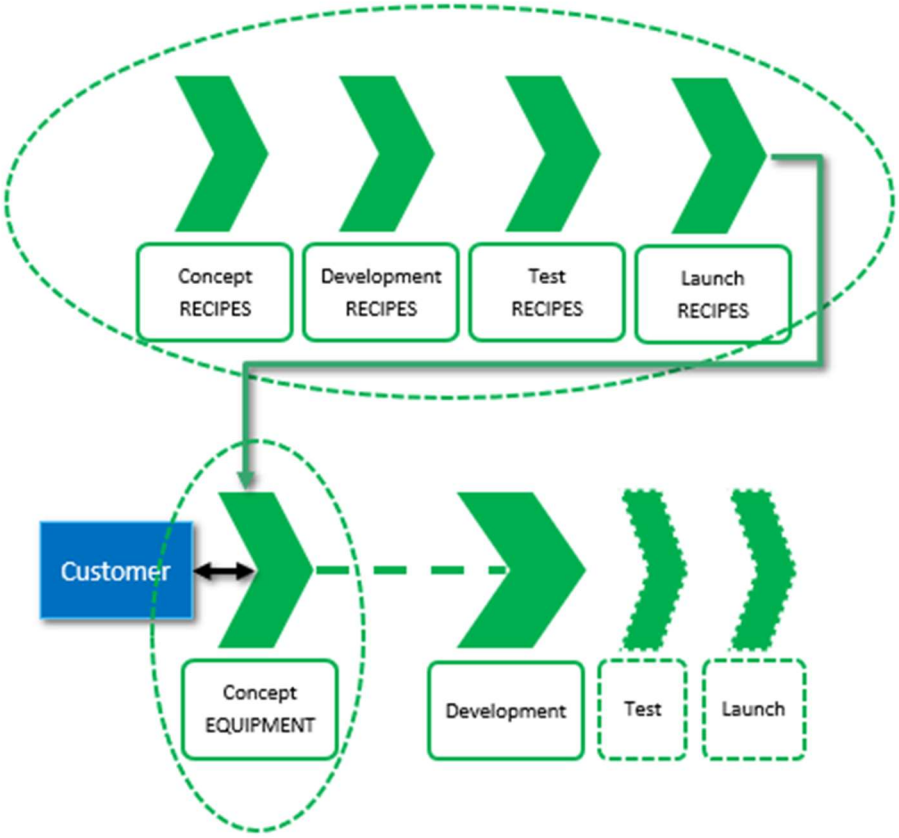

Figure 14. Connection between recipe development and equipment development.

As seen from Figure 14, the total recipe development process (concept, development, test and launch) resides within the concept stage of the development process for existing products. This leads to the conclusion that the process for developing existing products can be discussed as one total process instead two separate processes. Data indicates that challenges during this stage are related to the key company stakeholders reviewing the equipment concept validation at this stage, as explained in Section 4.2.1.

In those cases when the stakeholders need to review the concept offered by the customer with incomplete information and a tight schedule, the customer need can be misunderstood. As the decision to validate the concept leads to the Sales process, not the Development stage, the validation decision may be based on proceeding the process

without a clear definition of what has been validated for development, the “definition of done” may hence be occasionally lacking or vague.

> *“Customer approaches with a problem that we start to solve. Sales give also input into this stage. We start rarely from a technical point of view.” -CTO*

Reflecting the current process to the Stage-Gate method as described in Section 3.1, the concept stage includes only the Planning stage and excludes the Concept Development stage as explained in Section 3.1.1.

4.3.2 Development Stage Analysis

Analysis of current company practices indicates that the Development stage is orientated towards solving the specific requirements initiated by the customer, and that an upper-level framework development is missing which would tie the development “to the bigger picture”.

Reflecting to the Stage-Gate method from Section 3.1, the current development stage seems to skip the System-Level design stage and moves directly to the Detail Design stage as described in Section 3.2.1 of this study. Figure 15 below illustrates the case company Concept stage and Development Stage compared to the Stage-Gate method (according to Ulrich & Eppinger 2016).

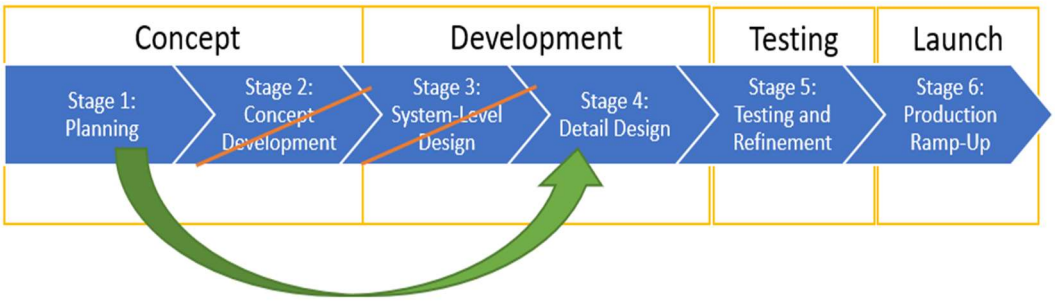

Figure 15. Case company Concept stage and Development stage reflected upon the Stage-Gate method (the Stage-Gate method is based on Ulrich & Eppinger 2016: 9).

As seen from Figure 15, the Concept stage consist only of the Planning stage and the Development stage consist only of the Detail Design stage. The (Concept) Planning stage focuses on the “big picture” whereas the Detail Design in the Development stage focuses on the particulars of a case. Combining these two stages in one jump may create

challenges for the development of existing products, as utilizing the Stage-Gate approach fully would require more steps; from “big picture” step-by-step to the details and not in one big step.

> *“The development is part of the order-to-cash process…Developed during a project delivery schedule… Fast fixes are often needed as the schedule cannot take delays that much” – Quality Manager*

Another feature identified from the analysis is that the development process is executed within the Order-to-Cash. This means that this stage is tied to a customer delivery project. Customer delivery projects have mostly tight deadlines because of competing offers during sales phase. Hence the development may face challenges if there are needs for iterative development stages caused by unreached requirements. The Gate Keeper and Gate Meeting features, as described in 3.1 of this study, are also challenging to implement as the development takes place within the customer delivery order. Canceling the project with a no-go decision from the Gate Meeting would be a huge decision to be made at this point.

4.3.3 Test and Launch Analysis

Analysis of current company practices indicates that as the development process has moved into the customer delivery project, the test stage has a limited time window to be processed. As discussed in Section 4.3.1, the “definition of done” has been lacking from the concept stage and hence the test stage faces difficulties to evaluate, if a test is validated or invalidated by the test results. Combining the limited time window and incomplete definitions of requirements cause this stage to become ineffective and merely a phase in the delivery project, not a stage in a development process.

Thus, the Launch stage, as a stage in a development process as discussed in Section 3.1.3, can be viewed as missing. The Launch stage in the current development process has more the nature of a customer project delivery point.

4.4 Summary of Findings

The findings from the data collected and analyzed from the interviews and company quality documents point to the three major findings.

Firstly, analysis of the interviews and company quality documents indicate that a Stage-Gate model exists, even though it is partly undocumented and performed at some stages in an *ad hoc* way. This Stage-Gate is, however, executed mainly within the Order-to-Cash process that will result in tight schedules due to the customer order that needs fulfillment firsthand. Thus, possibilities to make development iterations and verify the current development outcome with the customer are limited in order to perform on a good development level.

Secondly, the Stage-Gate approach is lacking steps, i.e. a Concept Development stage and System-Level Design stage, and this could be a probable cause for part of the challenges that the company is facing during its current product development practices.

Thirdly, analysis of the interviews indicates the need for clearly defined roles and responsibilities within the product development process. Also, there is a clear need for the "definition of done", as visible from interview comments:

> *"Tester doesn`t have a "definition of done" nor specifications so the tester has to improvise and decide when the test passes." – Quality Manager*

> *"Traditionally we do not have clear go/no-go indicators…Definition of done is missing in most cases" – Design Manager*

Figure 16 illustrates the three major findings identified that are explained above in detail.

Figure 16. Three major findings from the current state analysis.

These three major findings, as illustrated in Figure 16, are identified based on the reflection against the Conceptual framework in this study. Next, Section 5 of this study tackles these three major findings in the proposal for the process for developing existing products.

5 Co-Creating a Proposal for Developing Existing Products for the Case Company

This section merges the results of the current state analysis and the conceptual framework towards the building of the proposal.

5.1 Overview of the Proposal Building Stage

In this section the study aims to build a proposal for developing existing products by combining the major findings from the current state analysis with the suggestions from relevant literature merged into the conceptual framework.

The conceptual framework was constructed in Section 3 from studying best practice found in relevant literature. In Section 4 of this study, the current state analysis was conducted by interviewing the key company stakeholders and by utilizing the company quality documents. The current state analysis was reflected upon the conceptual framework to be able to explore the current *ad-hoc* process of developing existing products. After identifying the current "way" of doing, three major findings were identified.

Figure 17 below illustrates the conceptual framework and the three major findings from the current state analysis.

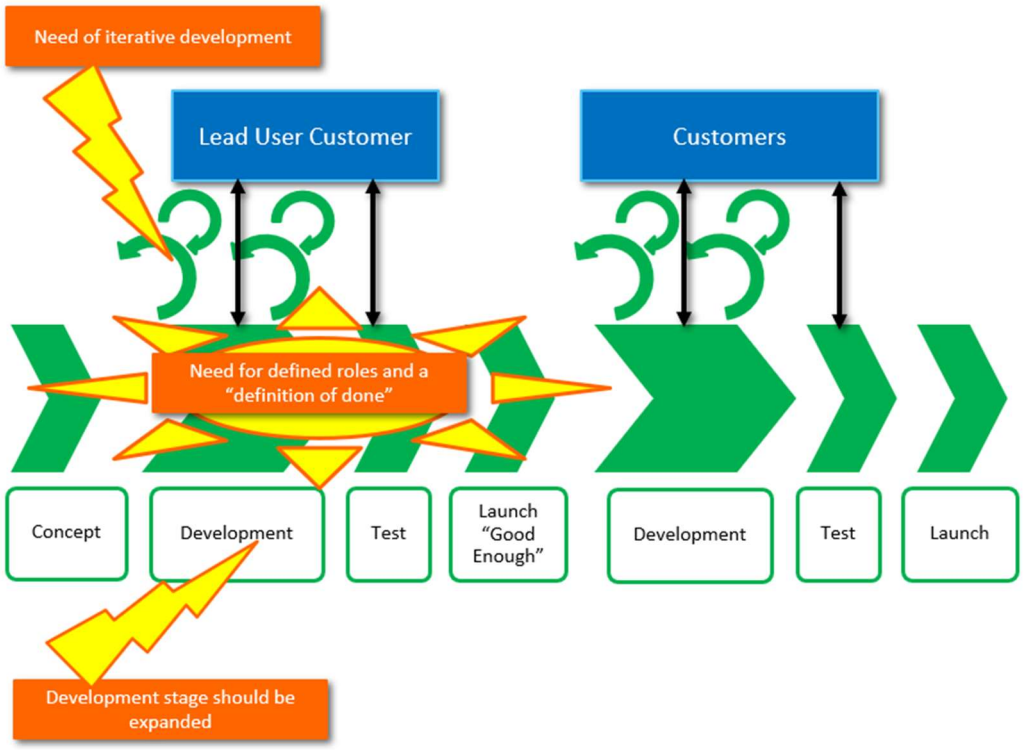

Figure 17. The conceptual framework merged with the three major findings from the current state analysis.

Figure 17 merges the three current state analysis findings together with the conceptual framework. Together they create a skeleton upon which the key stakeholders were asked to join into creating an initial proposal for developing existing products for the case company.

The proposal building was performed in three steps. First, key stakeholders were identified with which to co-create a proposal for developing existing products. The persons identified to become involved were the Design Manager, Automation Manager and Systems Manager.

Secondly, the two first stakeholders, the Design Manager and Automation Manager, were asked to join a workgroup with the target outcome to build the structure of the process. The reason for selecting these two stakeholders is that they both are in a position that will be most impacted by the result of this study – a process for developing existing products.

Thirdly, the Systems Manager was invited to a separate 1to1 workshop with the focus to expand and investigate the details of the process from the previous workshop done by the Design Manager and Automation Manager. The reason for selecting the Systems Manager is this person's vast experience in complex system-level design planning.

All stakeholders were involved in the proposal building. A summary of their suggestions for the proposal are provided in Figure 18 below.

	The three major findings from the current state analysis	*Suggestions from stakeholders*
1	Development stage should be expanded	Development needs to be separated from the Order-to-Cash. System-level Design should be performed by a Team and that Team could come up with several concepts which to introduce at the Gate. Second step (Detail-level design) can be executed by individuals as deemed necessary.
2	Need of iterative development	Sprints with pre-determined time are needed to help the Team Managers manage their resources. Always validate what you are doing, either by simulation, prototyping or testing.

3	Need for defined roles and a “definition of done”	“Definition of Done” needs to be short and simple. The “Definition of Done” can be refined during the development stages. Product Manager would be the Gate Keeper between phases. The actual requirement must always be visible to the developers.

Figure 18. Summary of Stakeholder suggestions for building the proposal.

The stakeholder suggestions, as evidenced in Figure 18, are further discussed in detail in the following sections.

5.2 First Element of Proposal: Expanded Development Stage

> *”First step (System-level design) is always executed by a team” - Design Manager*

> *”(It is) Important to understand on what level you are operating - you need to understand the relations between what you are developing now and what upper-level systems it will affect” – Systems Manager*

As the participant of the second Workshop reminded, “*80% of the products costs are created during the beginning of the development process*”, so is the first element of the proposal the expansion of the development stage. Currently, the development stage - as identified from the current state in Section 4.3.2 - is a one stage process step with focus on details. As seen from Figure 19 below, the proposal should expand the current state development stage to include a higher-level development step before diving into the details of the design. This expansion is called System-Level design.

The next step after System-level design is the Detail-level design. During this stage the elements for creating the product are finalized. These are, for example, manufacturing drawings, material selections, defining of tolerances and surface treatments.

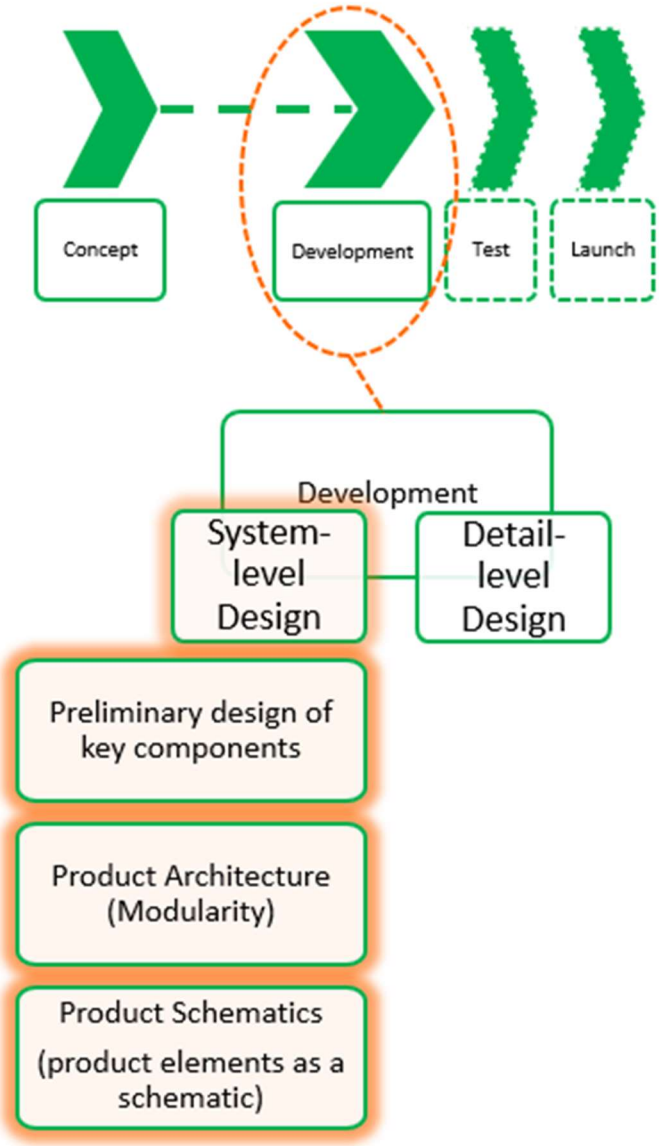

Figure 19. The expanded Development Stage.

As shown in Figure 19, the current Development stage was split into two stages: the System-Level stage and the Detail-Level Stage. Workshop number two especially focused on introducing the System-Level design stage. During the System-level design, the key components are identified and preliminary designed. Design of the key components is not only about designing something new, it is also about identifying and understanding the relations between what is currently being developed and what the upper-level systems it will affect. During the System-level design, one should also investigate the requirements for being able to modularize the developed product once it enters the

Detail Design stage. In other words, the Product Architecture for the product to be developed is charted.

By this it is meant that the interactions between various parts of the product are investigated and decided upon. The functional needs (e.g. make a flipping movement) are assigned to physical elements (e.g. motors, shafts and actuators) which create ”building blocks” for the product. The functional needs combined with physical elements often require additional control elements (e.g. software), and this can make the charting of the Product Architecture challenging.

To aid charting the Product Architecture, the proposal includes a method known as Product Schematics. In this method, the product is pictured as a block diagram as shown in Figure 20.

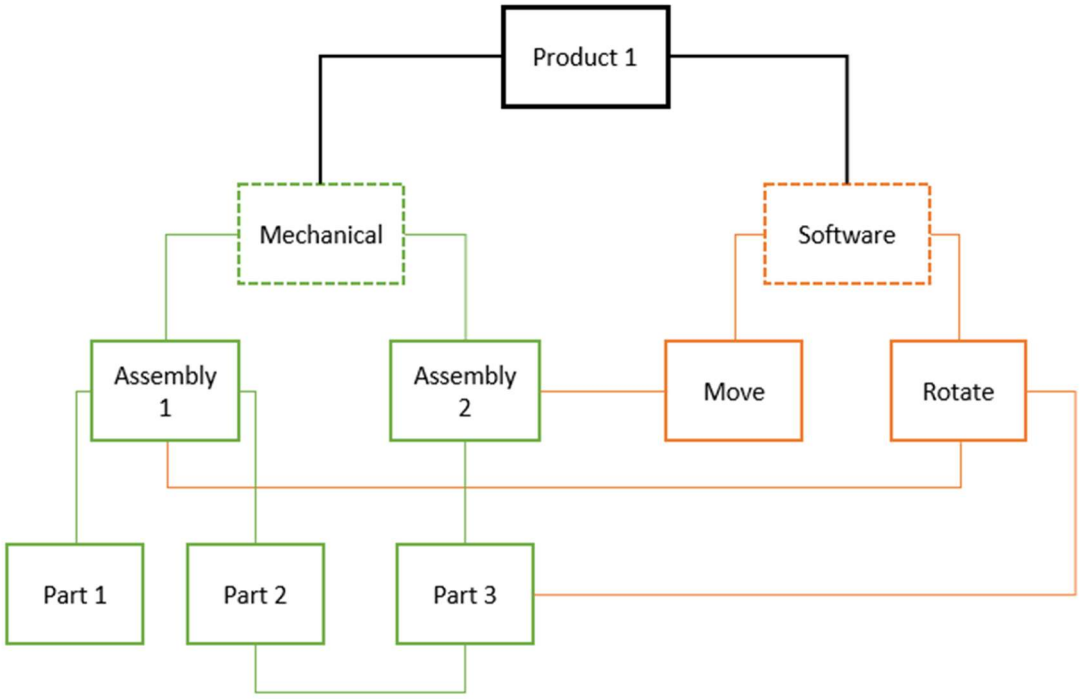

Figure 20. An example of the Product Architecture method where the product is pictured as a block diagram.

The example in Figure 20 shows the dependencies of various functional and physical elements of a product. By identifying these dependencies, the developers can then aim

to create a layout where the connections between the various elements are such that the architecture needs for the product to be developed are met.

During Workshop number two, it was identified that this stage would incorporate the concept development together with a higher-level design of the product to be developed. The reason for the decision to meld the concept development together with the system-level design is the introduction of the Product Backlog and the sprints in the various development stages. The Product Backlog and the sprints are discussed in the next sections of this study.

5.3 Second Element of Proposal: Iterative Development

> *”Sprints with pre-determined time are needed to help the Team Managers manage their resources...It is much easier to promise a resource for a project when the time that the resource is reserved is known beforehand” - Automation Manager*

The second element of the proposal is the need of iterative development in the development process. The conceptual framework has presented an Agile-Stage-Gate method where sprints are introduced at various stages of the process. Both the first workshop and the second workshop found the idea of performing development in sprints as an idea worth applying. There was discussion during the workshops about the length of the sprints and it was decided that the proposal would include a process that is scaled according to the size of the development project. Hence, the length of the sprint will be proposed as two weeks per stage in larger projects, a total of two weeks for all sprints together in medium-scale projects. For small-scaled development projects, the stages will be reduced to two, and the total time for the whole development project would be from a few days to maximum one week.

As discussed in Section 3.3 of this study, the sprints in the development process proposal are modified sprints. After the sprint starts, the development team must not be instructed by stakeholders other than team members of the same sprint. This means that the team has independence and authority to make their own decisions as long as the sprint is active. The sprint will remain active only for a pre-determined amount of time as discussed in this section. Once the sprint is finished, it will enter the next stage through

a gate. At the gate, the sprint result will be evaluated against the “Definition of Done” inherited from the Product Backlog.

Figure 21 below illustrates the proposal with the three different sized development projects. From top to bottom, it shows the large-scale development project with customer involvement, the medium-sized project, and finally the small-sized development project with reduced number of stages.

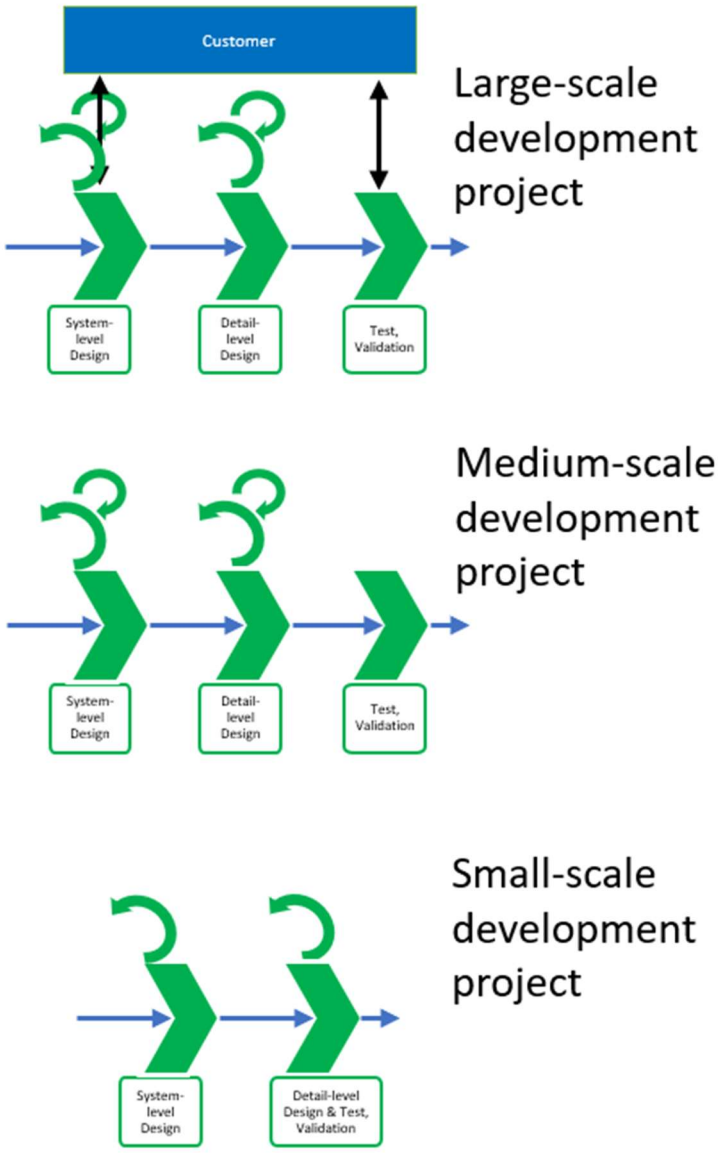

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Figure 21. The proposal with three different Agile-Stage-Gate processes depending on the scale of the development project.

The development process shown in Figure 21 consist of three development stages: the System-level Design stage, the Detail-level Design stage, and the Test & Validation stage. Both System-level and Detail-level design stages are performed sprinting, as described in this section, with daily sprint meetings held where the current situation is evaluated and decisions for that day's tasks are assigned to the sprint team members. The third process shown at bottom of Figure 21 is the shortest version of the development process where the stages have been reduced so to include two stages: The System-level design followed by a compact stage including both Detail-level design and Test & Validation. The total length of this process is in days not weeks, hence, the daily sprint meetings have been removed.

As the sprinting with daily sprint meetings can be seen as iterative – reflecting the current situation with the target every day and changing course as needed – so, too, is the second feature introduced in the proposal. The sprint with daily sprint meetings is the first iterative feature and the second iterative feature is the Backlog, both the Launch Backlog and the Product Backlog. Figure 22 below illustrates the development process with the Product Backlog and the Launch Backlog.

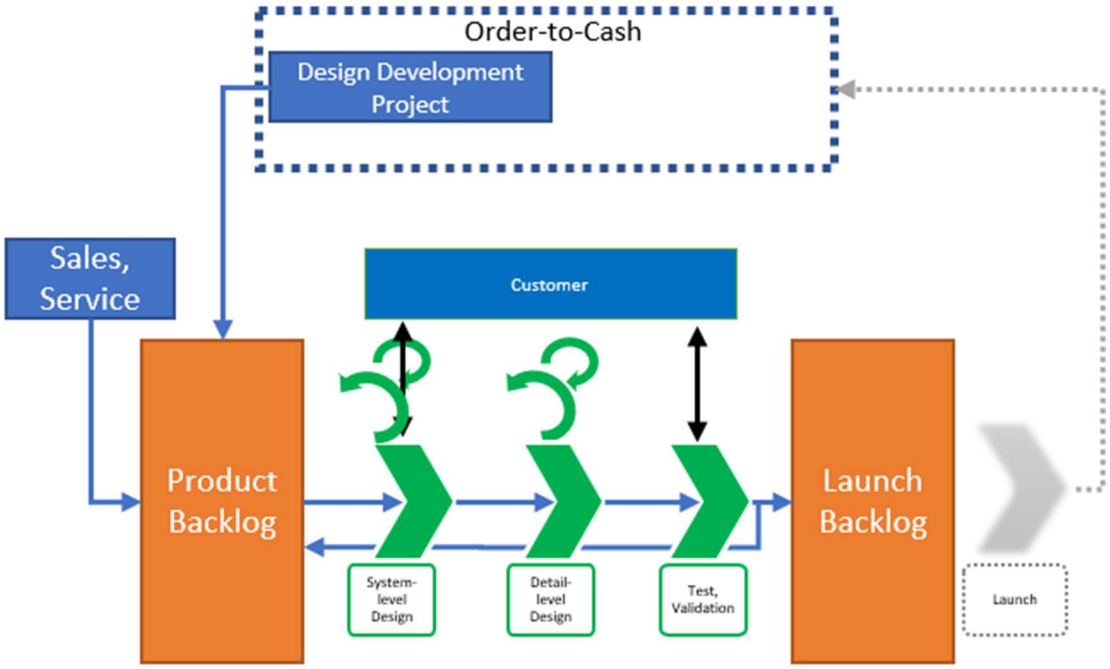

Figure 22. The Product Backlog and the Launch Backlog

During the first Workshop, it was decided that the actual Launch stage would be removed from the proposal as it was viewed to be "owned" by the Marketing with the development

process being a supportive process delivering results for the Marketing and the market launch. As seen from Figure 22, the Agile-Stage-Gate product development process begins with the Product Backlog and ends with the Launch Backlog. The Product Backlog, as discussed in Section 3.2.2 of this study, is the "database" of all identified needs, wants and requirements collected from various operations and stakeholders.

Figure 22 above lists the main channels for these operations and stakeholders. These are the Sales (needs from the market), the Service (needs from the users) and customer needs identified during the execution of a sales case; a Design Development Project as discussed in Section 4.2.2 of this study. All are collected into the Product Backlog for further analysis and decisions.

Once a decision has been made to develop certain issues from the Product Backlog, they move through the development process from System-level design, through Detail-Level design and end with the Test Stage. After the Test Stage, a decision is made whether to move the developed issues back to the Product Backlog for another iterative development cycle or move them, or part of them, to the Launch Backlog. The Launch Backlog collects all issues that are developed and deemed important enough to be included in the product.

The next section will discuss the Product Backlog more in detail. It will also discuss who makes the decisions during the process and what guides those decisions.

5.4 Third Element of Proposal: Roles and the "Definition of Done"

> "*Instead of blaming the poor designer, the blame should be on the poor decisions*" - *Systems Manager*

> "*Definition of Done needs to be short and simple, preferably one or two sentences as maximum*" - *Automation Manager*

This section will discuss the third element of the proposal which is the need for defined roles and a "definition of done". The "definition of done" identifies what exactly is required in order to be able to finish the task at hand. Both Workshops and the current state analysis data stressed the importance of a clear definition of the goal.

During Workshop number two, the importance to document requirements was discussed. This was seen especially important when selecting what issues were going to be pursued for a product development project. The better the requirement is discussed and documented, the easier it is to map out the ”Definition of Done”. For example, when comparing a requirement ”product must be cheaper” with ”product pedestal should be 20% cheaper than the previous xyz-type pedestal”, the latter requirement has a clear ”Definition of Done” compared to the first one. The first statement is, by all means, also achievable but needs evaluation at the end of the development project, and thus, the development team cannot be sure if they are closing in on the target during the sprints. The latter has a clear goal, and even if that goal is not reached, the evaluator can measure he achievement against the original goal.

> *”The actual requirement must always be visible to the developers so the activities can be constantly reflected towards it in order to not go in the wrong direction” – Systems Manager*

Figure 23 below depicts the development process of the proposal as it moves from the Product Backlog towards the Launch Backlog.

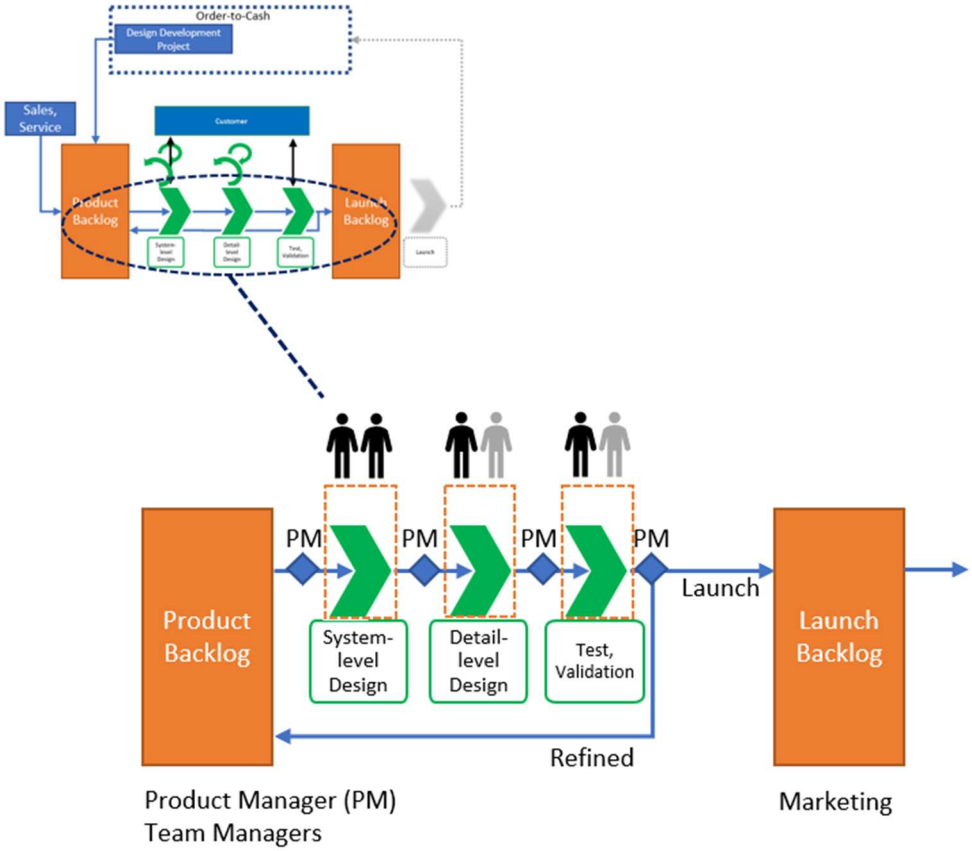

Figure 23. Roles and steps of the development process

As seen from Figure 23, the development process starts from the Product Backlog. The Product Backlog is a database where all identified requirements for the product to be developed are collected for further processing. Once a requirement enters the Product Backlog, it is evaluated by a committee consisting of Team Managers (mainly Design Manager and Automation Manager) and is chaired by the Product Manager who is also responsible for the decisions that are made. The evaluation focuses on mapping out four key elements as a minimum. The first element is the resource need i.e. what engineering departments are involved. The second element is the estimated sprint time. The third element is a “Definition of Done” and fourth element is the strength of the validation.

The first element, which is the resource need, is the estimation of what company departments and/or subcontractor resources are needed to fulfil the requirement. This is important to evaluate in order for the Team Managers to be able to allocate resources when the requirement becomes active. Especially important is the evaluation of subcontractor resource needs such as 3rd party inspectors. The availability of such services should be reserved well before the development project is initiated to be able to perform the development in the allocated time.

The second element is the evaluation of the length of the development project. This element together with the first element – the resource need – will enable the Team Managers to more effectively manage their department resources. As the quantity of resources needed is known, together with the length when those resources will be unavailable for other tasks, the Managers can more easily predict the upcoming workload and can also evaluate when to commit resources. It is more comfortable to promise resources for various stakeholders when the time of commitment is known beforehand (sprints have a pre-set length).

The third element, “Definition of Done”, was identified as one of the most important elements during both workshops and is explained in the beginning of this Section (5.4)

The fourth element, strength of the validation, is an element that was brought up during Workshop number two. The strength of the validation signifies the source from which the requirement originates.

> *”It is especially important to document, with traceability, the requirements that are driving the development. This way you can always ground your decisions and choices afterwards when questioned.” – Systems Manager*

Strong validations, for example, relate to the requirements originating from the standards that dictate a certain industry such as the Machine Directive or the semiconductor industry standard SEMI. These should be categorized as “must have”. Validations originating from the company decision-makers or customers can be categorized as “must have” or “could have”. Requirements from the company internal interest groups such as marketing could be categorized as “could have” or “nice to have”. Once the requirement is evaluated, it is stored in the Product Backlog and remains there until chosen for a product development project.

Once the company decision-makers deem development should take place, a product development project begins. The Product Manager chooses one or several requirements – by consulting Team Managers - from the Product Backlog and assigns an engineering team to start the development project. The engineering team evaluates the task(s) and execute the first stage of the process which is the System-Level design. During this stage, the team sprints through the stage and presents one or several solutions at the gate. The Product Manager decides which solution to pursue as the process proceeds to the Detail-Level design stage.

At the gate between the System-Level design and the Detail-Level design, a decision is made whether to continue the development process in a team, as individuals, or as a work for one individual only. This decision is based on the solution(s) provided at the end of the System-Level design. One should note that the System-Level design is always started as a team no matter the development task at hand. The decision to always start as a team was made during Workshop number one as it was noted that the evaluated requirements are – as the name implies – based on evaluations. Thus, the resources needed should be validated during the first sprint of the development process which is the System-Level design stage.

After the Detail-Level design stage, the process continues to the Test and Validation stage with the Product Manager acting as the gatekeeper who decides whether to allow the result to proceed as it is.

The Test and Validation stage ends with a gate where the result(s) of the development project is evaluated against the “Definition of Done”. Based on this evaluation, the result is either transferred to the Launch Backlog or it is deemed as completed but not eligible to pass on to the Launch Stage and is, therefore, moved back to the Product Backlog as a refined requirement.

Requirements transferred to the Launch Backlog await the decision from marketing as to when become part of a product launch.

5.5 Proposal Summary

The initial proposal is built using the proposal draft as the basis. The proposal draft was created using the conceptual framework after reflecting it against the findings from the current state analysis. This way a pre-made “skeleton” could be used in both workshops which would steer the discussions and solutions toward a proposal that this study aims to solve – a product development process for existing products.

Figure 24 shows the draft version – or “skeleton” – which function was to focus and guide the workshop towards an initial proposal for a process to develop existing products.

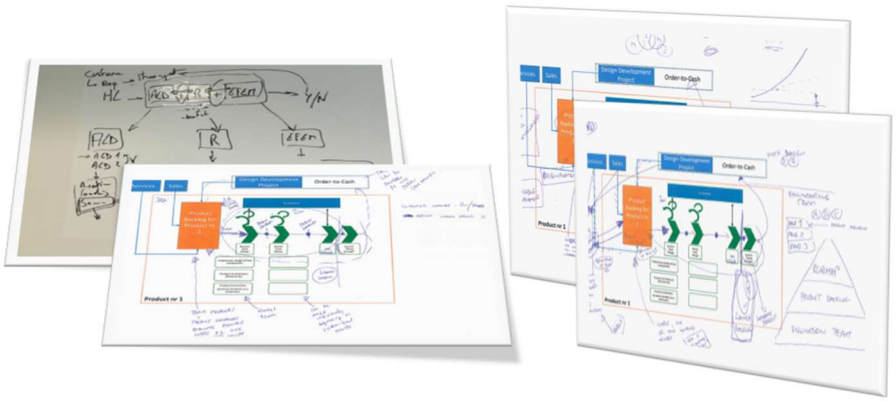

Figure 24. Proposal being created during the workshops.

The initial proposal was created in co-operation with workshop participant and is illustrated in Figure 25.

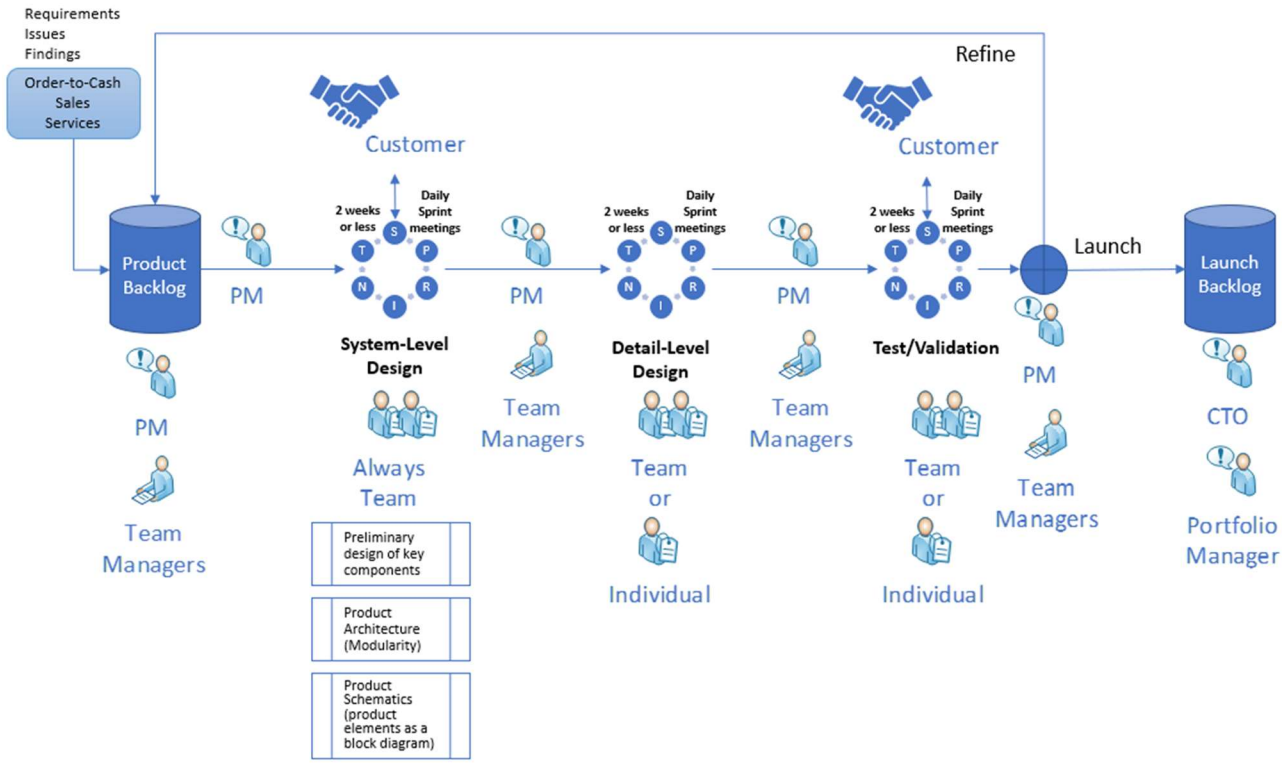

Figure 25. Initial proposal with roles and steps of the development process

As Figure 25 shows, the process starts with the Product Backlog and end with the Launch Backlog. The Product Backlog consist of identified requirements for the product. These requirements arrive from various sources such as Sales, Services, or customer-specific projects. These requirements are evaluated by the Product Manager and the company Team Managers, mainly from Design and Automation. As minimum, all requirements are issued an evaluated resource need, development time, strength of validation (importance) and a “Definition of Done”.

All requirements stay in the Product Backlog until such time that it is decided to initiate a development project for the existing product. Taking from here, the Product Manager selects one or several development requirements from the Product Backlog and issues them to a development team. The team perform the first sprint at the System-Level design stage and at each stage that follows, which are the Detail-Level stage and the Test Stage.

Once the development project has completed the Test Stage, it enters the final gate where the solution is either transferred to the Launch Backlog for further processing by other parties or it re-enters the Product Backlog as a new – refined – requirement.

The following three figures illustrate the three major findings from the current state analysis as embodied in the initial proposal.

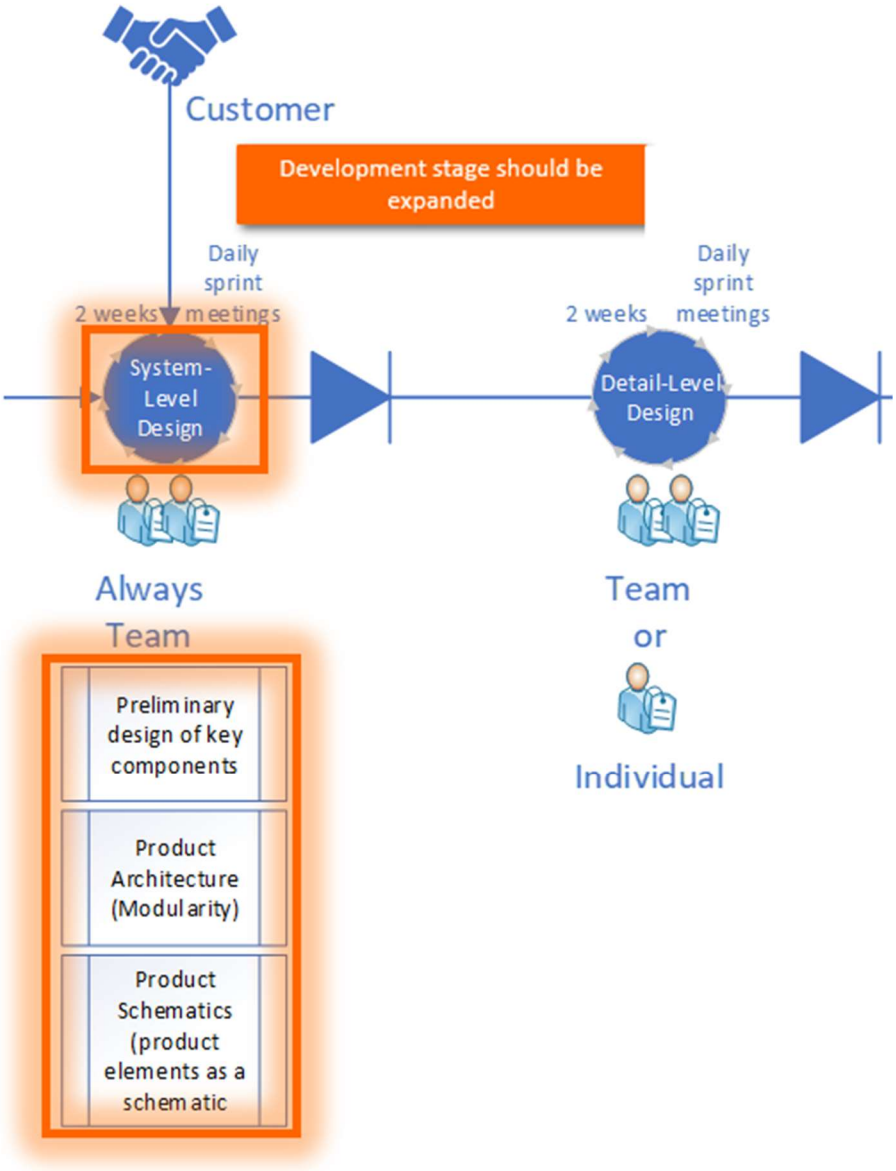

Figure 26. “Development stage should be expanded”- finding implemented into initial proposal

Figure 26 show the first element identified from the current state analysis, which is the need for an expanded development stage. The current development stage, which is

identified as focusing on Detail-Level design, was expanded to include a system-Level design stage.

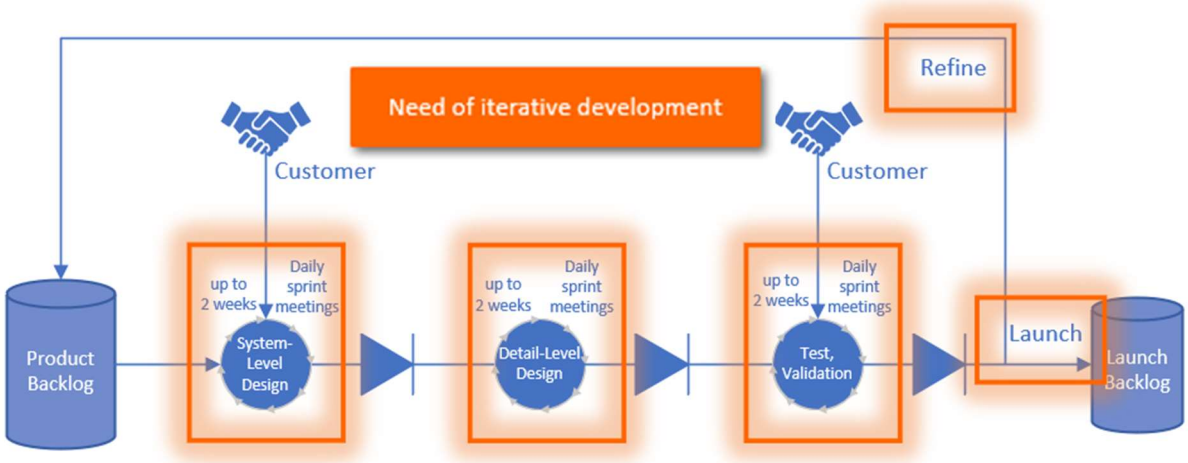

Figure 27. “Need of iterative development” – finding implemented into initial proposal.

Figure 27 shows how the proposed development process aims to handle the need for iterative development. This need was identified as the second major element from the current stage analysis. Each stage is performed sprinting with daily sprint meetings to adjust the focus of the development. At the end of the process, the solution is evaluated and returned to the Product Backlog for further development in case the solution is not deemed as viable for the launch stage.

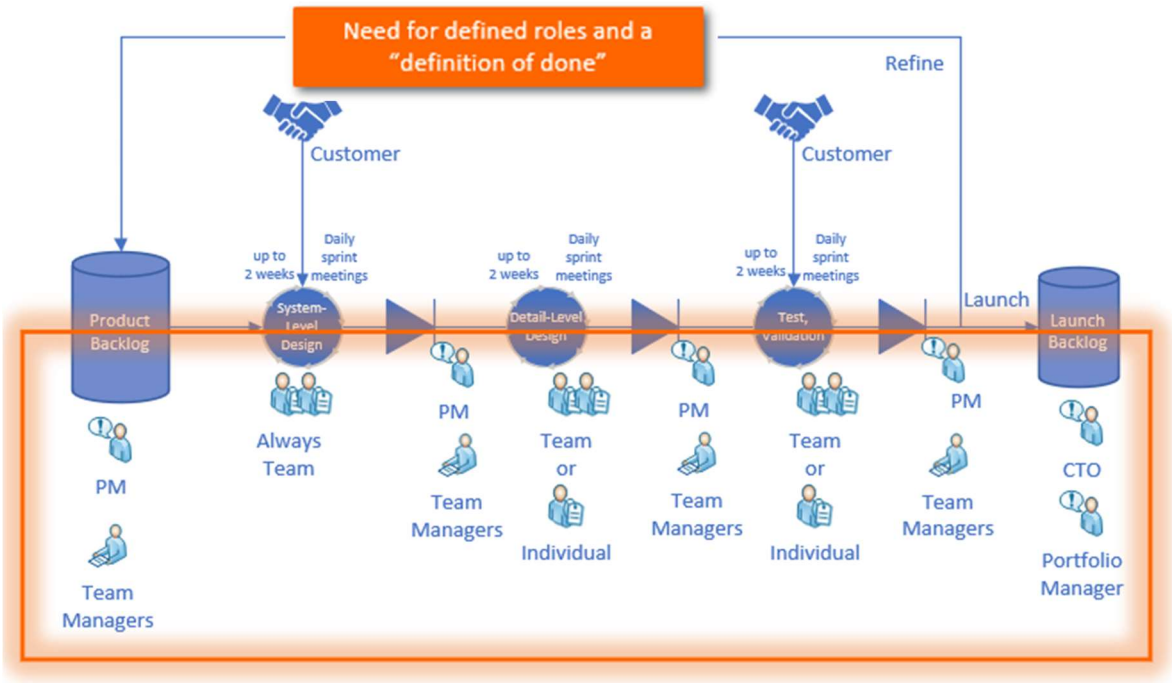

Figure 28. "Need for defined roles and a "definition of done" – finding implemented into initial proposal.

Figure 28 illustrates the proposed solution to address the third major element from the current state analysis – the need for defined roles during the process and a "Definition of Done". All issues to be developed are first founded into the Product Backlog where it is a requirement to issue a "Definition of Done" prior to starting any kind of development project regarding that specific issue. Between each stage - which are the system-level stage, the detail-level stage and the test stage - is a gate where the result from the previous stage is evaluated against the "Definition of Done" inherited from the Product Backlog. A vague or poor description of the "Definition of Done" will cause challenges for the gate evaluator(s) and, therefore, it is in all parties' interest to make sure the issues to be developed are well defined.

In the proposal, the roles and responsibilities were created for each stage and gate with the Product Manager responsible for the decisions at the gates between the stages, and the development team responsible for the decisions during the stages. The Product Backlog and the decision to move the completed issue forward to launch or back to the Product Backlog is made by the Product Manager with consultancy from the Team Managers.

Based on the above, the study will propose a process to develop existing products for the stakeholders in order to gain validation for the proposal.

6 Validation of the Proposal

"This process will be the beginning and will be developed during time. Important is to create the first version so others have a possibility to begin changing it" – Systems Manager

This section describes how the initial proposal was prepared and presented to the company management. The section also describes the feedback received from the management and how the feedback impacted the initial proposal. The section ends with a visual representation of the final proposal.

6.1 Overview of the Validation Stage

A draft proposal was built by reflecting data from the current state analysis onto the conceptual framework created from relevant literature. This draft proposal was further crafted into the initial proposal by co-operating with the key stakeholders from the company. The co-operation took form as two separate workshops. The initial proposal was transformed to the final proposal in three steps.

First, before addressing the company management for their input, the initial proposal was validated by the workshop participants. This was done to ensure the commitment of the key stakeholders for the process to be proposed. The commitment of the key stakeholders is seen as crucial for the success of the proposed process to be implemented into the day-to-day business inside the company. The stakeholders represent the resources who will most likely start using a process for developing existing products. Hence, they need to feel commitment and ownership in the creation of this process.

Secondly, the initial proposal was brought to the attention of the company management through a presentation (presentation examples shown in Figure 29) with the group discussion.

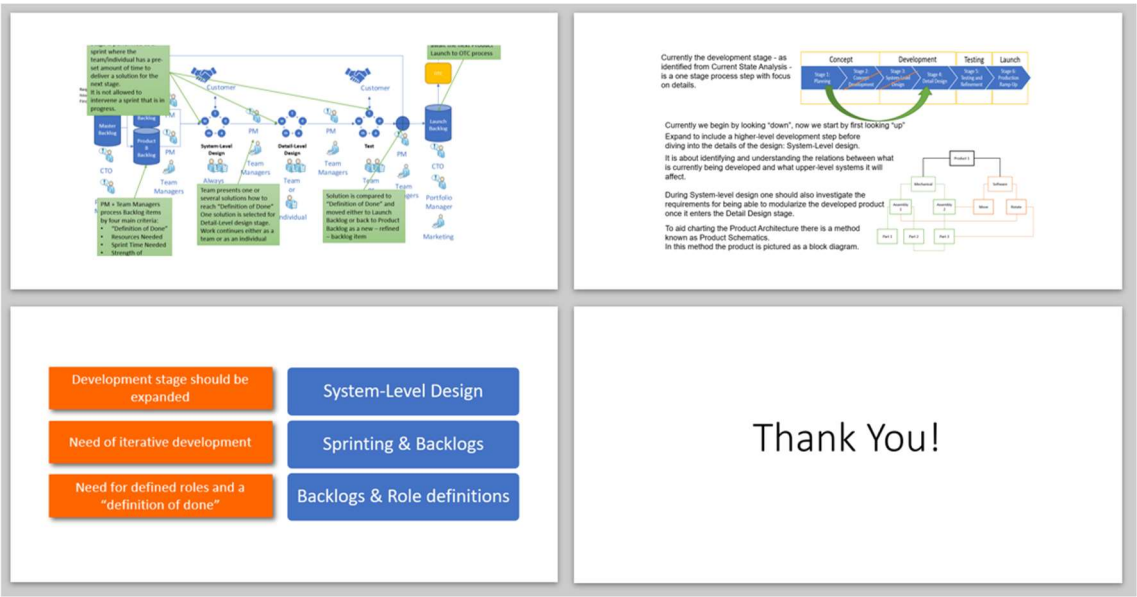

Figure 29. Presenting the proposal for the company management

During the meeting, the study presented three key findings that were identified as needing the most urgent attention. These three key findings are identified in Section 4.4, Figure 16, of this study. The presentation continued with identifying the methods with which to handle the key issues and ended with presenting the total proposal for a process to develop existing products. The proposal was discussed and commented by the managers.

During the third step, the initial proposal was modified according to the feedback received from the management group discussion. The result is the Final proposal which was handed over to the company managers as the result of this study.

The following sub-sections will discuss the data gathered from the second step (group discussion with the managers) and the result built during the third step.

6.2 The Verdict

The managers were in general pleased with the proposal, giving many constructive comments that indicated where they saw need for improvement and where they saw good potential. The managers` group consisted of three persons. The first was the Chief Operations Officer (COO) who is responsible for the Order-to-Cash process and is the initiator of this study. The second was the Product Portfolio Manager, whose task it currently is to create the development processes for the company, hence, the Product Portfolio Manager is the internal customer for this study. The third manager was the Chief Technology Officer (CTO), who is the superior of the Product Portfolio Manager and the final

decision-maker of what development processes the company will ultimately take into use.

The following paragraphs illustrate some of the comments that the study identified as being focus points for evolving the initial proposal to a final proposal.

The CTO commented following: "*this approach itself, I like it…I have been finding some (higher-level) documents (myself), but these details are missing, and I will definitely use something (from this proposal)*". Another CTO comment "*the problem is such that it should be adaptable to…other project categories*" gave indication of an important issue. The study identified this later comment as a root cause that needs to be addressed in order to be able to validate the proposal in a broader scope - instead of having the proposal become a "basket of ideas". This is since the aim for the study is to create a usable process, not only to give ideas.

Identified important comments from the COO are as follows:

> "*We need to separate the (engineering) resources…the customer project has certain resources allocated…and other resources are developing*".
>
> "*I want to read this diagram (process) so that (the stages) takes place separately from the customer projects…it goes to Order-to-Cash with the data*"
>
> "*We (should) have (products) commercialized before we sell to the customer, we (should) develop those before the customer (even) ask for those*"

In the following paragraphs, the study discusses the background of the company procedures that gave reason to the comments during the presentation. After describing the backgrounds, the study will discuss how to address these issues.

The company has, according to the CTO, four different categories of development projects. The first type are the Regulated projects, which are projects with government or institution funding. The second type of projects are the New Technology projects where the company develops internal technologies without customer involvement. The third type are the Product Development projects, where the company improves its existing products to support its Product Portfolio (focus of this study). The fourth type are projects

where customization is done to an existing product because of a single customer requirement and as part of a customer delivery project. By commenting "*the problem is such that it should be adaptable to…other project categories"* the CTO expressed that each and every project type cannot have a different format. There is a need for a development process that can address most – if not all – of these four types of projects. Thus, the engineers will know how to perform the development and not get confused whether to perform by sprinting or whether to perform by some other method as development cases vary.

The COO comments about the need for a separate development process outside the Order-to-Cash derive from the known challenges the delivery projects face when including customer modified items. With tight assembly schedules and high workload, one delayed project has a significant change to cascade the delay into other projects. This, because work centers or packing areas cannot be released to the next project as planned.

The current process for handling these customer development projects is the Sales Case Review. The Sales Case Review takes place during the offer stage and resides inside the Sales process. The review, as described in Section 4.2.1 and 4.3.1 of this study, is a lightweight validation gate where dedicated stakeholders review the case based on best knowledge what they have at that time at disposal. As it is purely a concept evaluation stage, there is no test of concept nor other proofing taking place. The result is an estimated risk level that will be taken into account as an increased length of the project once the sales actualizes.

As described in Section 1.2, a good portion of the company`s offerings are of these customized types of projects. Hence, the Order-to-Cash process faces constant challenges for planning and executing the deliveries.

6.3 Validating the First and Second Findings of Proposal: Expanded Development Stage and Iterative Development

The introduction of the System-Level design phase was greeted as an important step to be implemented before diving into the details of design. The company has an ongoing project to modularize and standardize products, and the System-Level design phase has the tools for handling those requirements.

The iterative approach of the proposal, that is built utilizing the modified sprints, was viewed as an interesting approach and approved by all managers. However, the suitability of sprinting for several different project types was questioned and needs proof for validation. Of the four project types identified by the CTO, one common method is needed for three of the project types: New Technology projects, the Product Development projects and for the projects where the product is customized due to customer project specific requirements.

The Product Development project was the focus of the proposal and thus it was also identified by the managers as suitable to be performed according to the proposal process method.

The New Technology project, where the company develops technologies without a direct customer need, are identified by the study as otherwise identical with the Product Development projects expect with different stages. The details of these New Technology projects are not within the scope of this study as discussed in Section 1.2 – these projects are innovations of new products. As illustrated in Figure 30, the study demonstrates using classical Stage Gate stages how the proposal process can be executed within an environment of new product innovation.

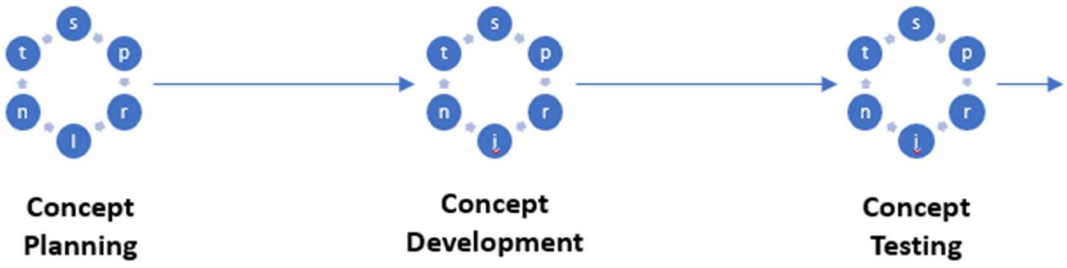

Figure 30. Development process for New Technologies

As Figure 30 demonstrates, the process is similar to the development of existing products except the stages focus on concept generation.

CTO comments *"For the development of completely new product, the sprints would just be longer*" and "A *few feedback loops more and the outcome of the first stage could end*

in: we cannot find a solution" give evidence that the process from the sudy proposal can be utilized in New Technology development.

The COO expressed the need for a separate development process outside of the Order-to-Cash process. This, to be able to plan and resouce customer delivery projects more accuratelty and thus keep promised delivery dates. The Product Portfolio Manager noted that product development inside customer delivery projects increases the risks for unforeseen delays. This risk is proportional to the amount of unknowns at the time of confirming project delivery dates when the sales case is agreed upon between the company and the customer.

To be able to develop and test everything before selling it would be an optimal situation. The CTO commented that this will not be a realized case for the company, as the customized projects are an important feature for the success of the company. Thus, the target is not to minimize customized projects but to adapt the processes to support this "way of doing".

Below, the study gives evidence through the following figures how the proposed process can support the execution of projects with customization based on customer needs.

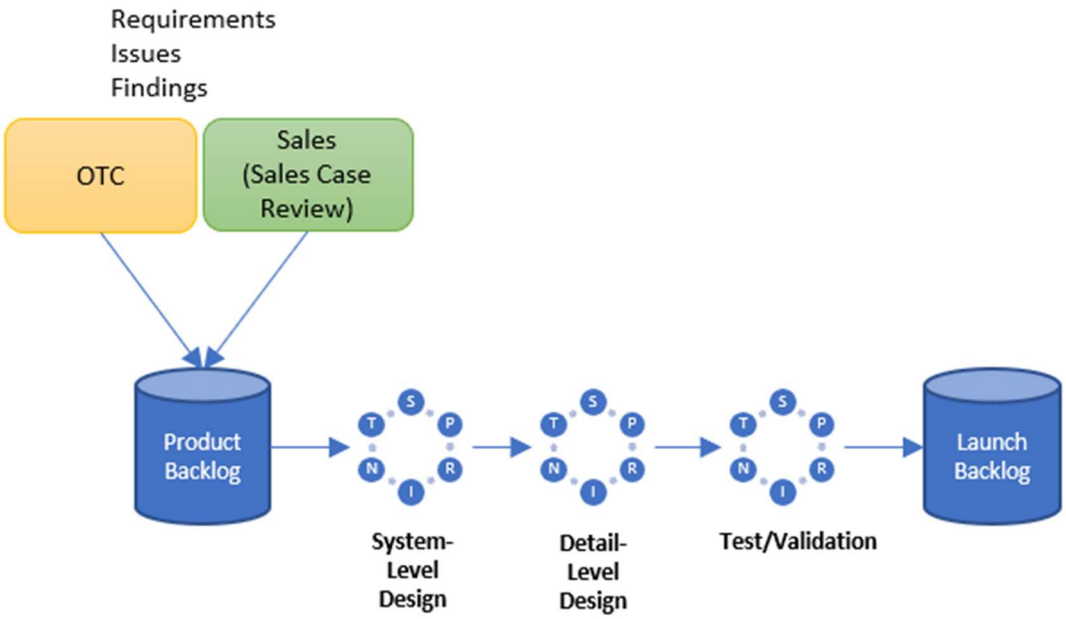

Figure 31. The Product Backlog inputs as indicated in the proposal

Figure 31 shows the inputs identified as providing the content to the Product Backlog. One of these inputs is from the Sales process, with the Sales Case Review being an

important source. The Sales Case Review, as discussed in Section 4.3.1, is a request from Sales to investigate and validate a customer customization request. In the current process, the evaluation is done as a discussion by a committee of various stakeholders. There is a limited time window for the decision with pressure from Sales. Thus, the resulting validation/invalidation verdict has potential to be based on lacking – or even misunderstood- information.

Another important aspect is that the evaluation may not connect properly to the company product portfolio strategy nor productization strategy as it is based on discussions without a process where issues are methodically processed.

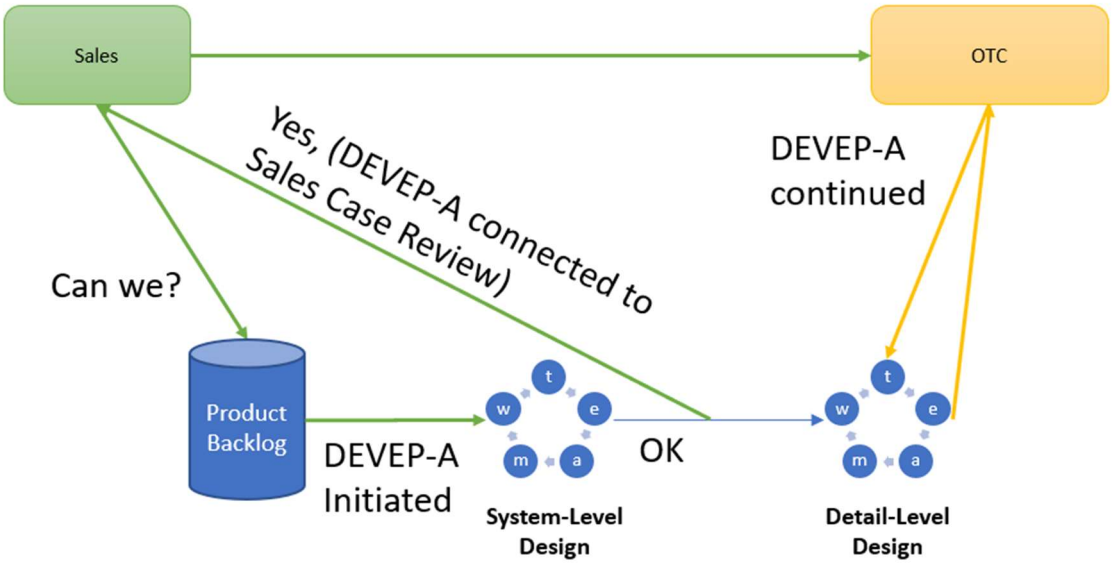

Figure 32. A Sales Case Review executed through the proposal process

As illustrated in Figure 32, the Sales request – or Sales Case Review – is initiated from Sales and transferred to the Product Backlog. From the Product Backlog an evaluation project is initiated. In this demonstration the evaluation project is named DEVEP-A.

The evaluation project is assigned four elements, as discussed in Section 5.4, which are the “Definition of Done”, the resources needed to perform the evaluation, the time needed for the evaluation and the “strength of validation” i.e. importance. After being assigned the elements, the evaluation project starts immediately.

The project is sprinted through the System-Level design. During this stage, the Sales Case Review request will be analyzed from the Product Architecture view point with emphasize on the possibility for modularization and productization. Also, critical components and features need to be investigated and possibly concepted. Once the evaluation is done, the decision is either “Go” or “No-Go”. In the case of a “Go” decision, the evaluation project is linked to the Sales Case Review and continued once the Sales Case transforms to actualized sales.

Once the sales actualize, the development project (DEVEP-A) enters the Detail-Level design stage for further development. With System-Level Design stage processed and finished, the overall time needed for development can be viewed as shorter than in the current “way of doing”. On top of a shorter design time need, the technology risk level can also be viewed as being lower with the evaluation decision based on findings from a methodologic process.

Figure 33 shows an example of how a High-Risk Sales Case can be processed through the proposal development process.

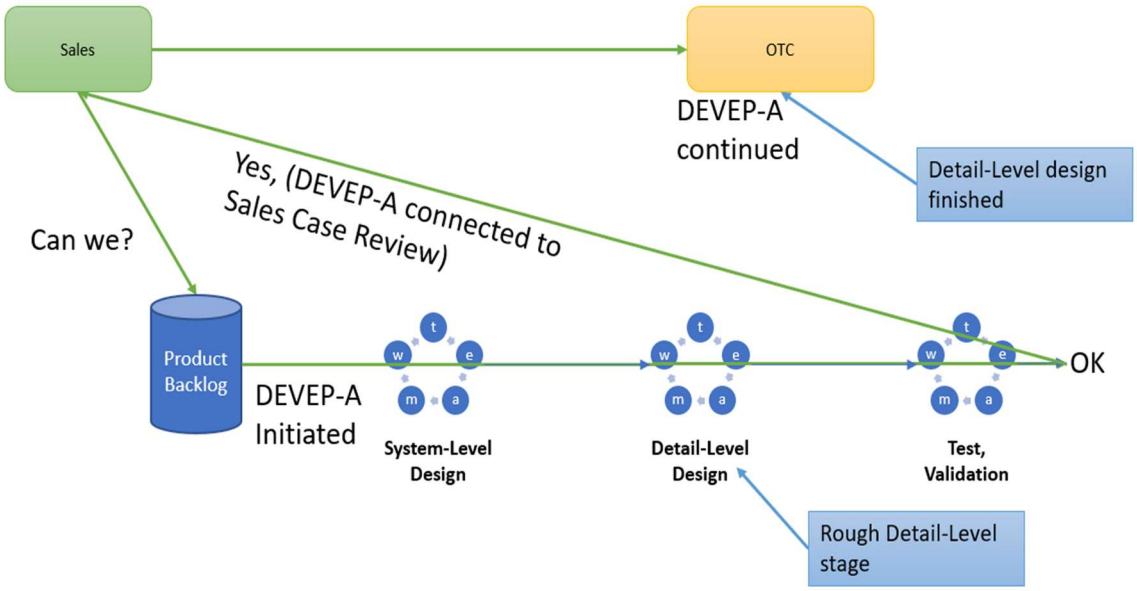

Figure 33. A High-Risk Sales Case Review executed through the proposal process

The study builds on the previous example from Figure 32 with a High-Risk Sales Case Review illustrated in Figure 33 above. In this case, the study proposes an evaluation project (named DEVEP-A in the example) to be executed through all three stages. The

Detail-Level stage and the Test stage can be performed in a lightweight mode with the finishing touches included during the project execution in the Order-to-Cash process. As in the previous example from Figure 32, it can be viewed that the development project enters the Order-to-Cash with a lowered technology risk due to evaluation decision based on findings from a methodologic process.

6.4 Validating the Third Finding of Proposal: Roles and the “Definition of Done”

The third finding of the proposal, which is the Roles and the “Definition of Done”, was received with positive feedback from the managers and with little to add. The need for this was already clearly indicated in data from the current state analysis and the lack in the current “way of doing” had also been earlier recognized. Thus, the main focus for validating the proposal lay in the application of the process method for various company projects types. This the study has evidenced in the previous Section 6.3.

6.5 Final Proposal

The Final Proposal for a process to develop existing products is presented in this section.

The focus of this study, a process for developing existing products, was received by the managers positively. However, in order to be able to validate the proposed process it had to be demonstrated that the process method can be adapted to other company needs such as the New Technology development and the customized delivery projects. This has been visible from in Section 6.3 of this study.

Figure 34 below illustrates the Final proposal for a Process to Develop Existing Products. The process begins with the Product Backlog where the requirements, issues and findings are stored that are deemed to have a potential to develop the product. The major channels providing material for the Product Backlog are identified as the Order-to-Cash process, Sales and Services.

The development process begins with an upper-level investigation of the de the System-Level Design the process moves forward to focus on details, which is identified as the Detail-Level Design stage. Finally, the process proceeds to the Test stage where the development is proofed and evaluated against the objective of the development project.

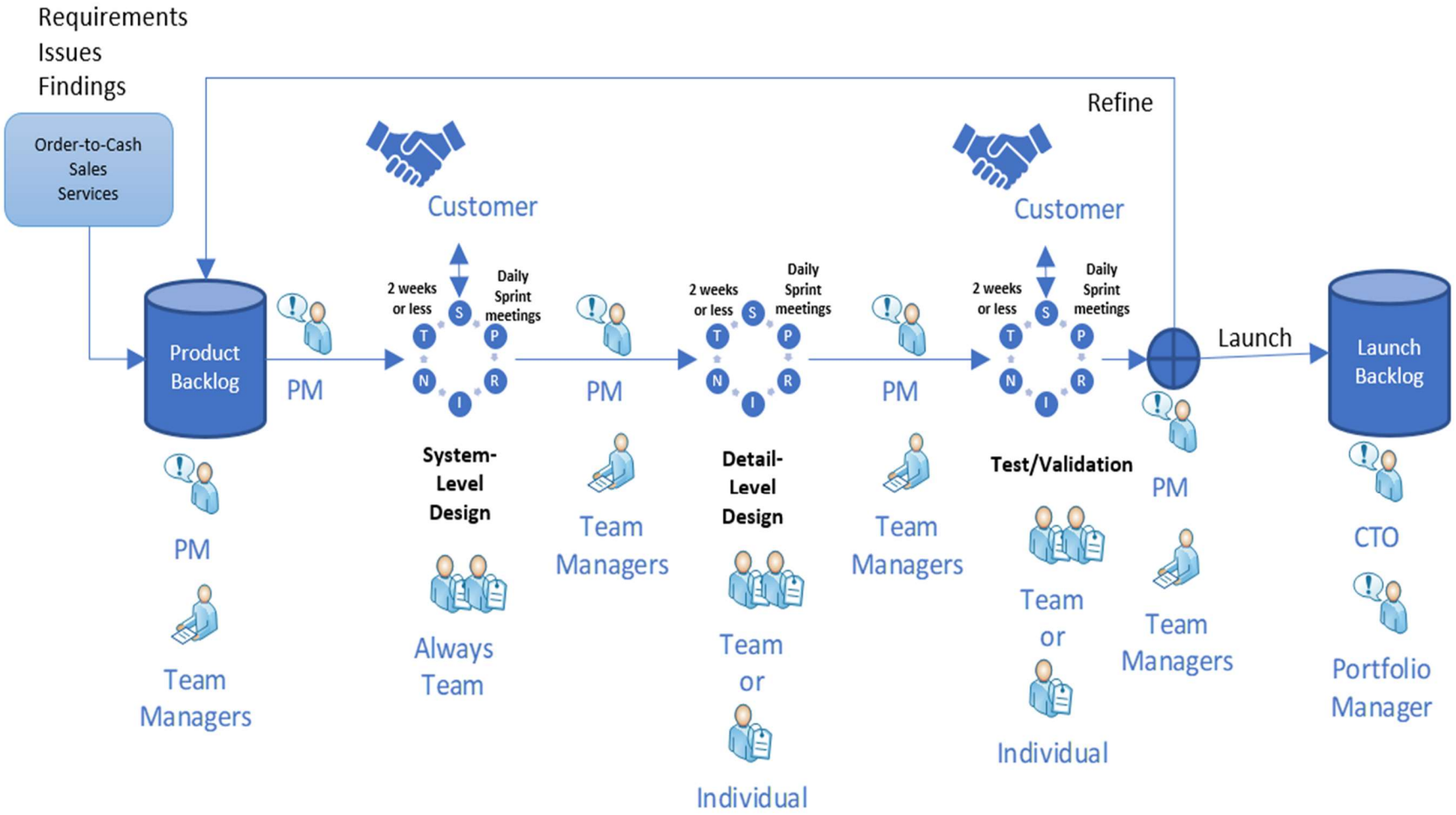

Figure 34. Final Proposal for a Process to Develop Existing Products.

7 Conclusions

This section discusses and concludes the findings and outcomes of this study. It starts with summarizing the study, then continues discussing the findings and outcomes. The section ends with an evaluation of the study objective versus outcome.

7.1 Executive Summary

The objective of this thesis is to create a process for developing existing products for the case company. The need for a documented process has arisen in the company due to a significant growth during the recent years. As the company has grown, so has its mix of products also increased. This, because a significant number of products are sold as customized solutions. On top of an increased number of product variants, the customer base has started to shift towards the more generic business sector (i.e. semiconductor industry) from the company`s traditional R&D sector. The new business sector demands high quality (especially repeatability) together with fast delivery times. This development calls for documented processes in lieu of the current ad-hoc “way of doing”.

The study is conducted using the Design research method where the purpose is to not only understand a phenomenon but also to influence and improve it, thus creating a change. The researcher does not merely observe, but also participates in the researched phenomenon. The change is created by co-operating with key stakeholders from the company. The study collected data at three points. The first data collection was collected from the key stakeholders and the company quality documents so to be able to form an understanding of the current state and future needs. The second data collection was achieved through the workshops with key stakeholders. The purpose of the workshops was to co-operatively create the initial proposal for a process to develop existing products. The third data was collected from the company managers from their evaluation of the initial proposal. Together with the data collected during the study and the feedback from the managers, the Final proposal was created.

The study started with search for good practices from relevant literature. A conceptual framework was formed onto which the findings from the current state analysis were reflected upon. The key three findings from this are:

First, there currently exists an *ad-hoc* concise Stage-Gate method with a focus more on details than the larger picture.

Second, the current way of developing is somewhat rushed as the development takes place inside the Order-to-Cash process, and thus is subject to stringent delivery deadlines

Third, the roles, responsibilities and the “definition of done” during development are somewhat faintly perceived by the participants and can thus cause confusion.

To address the findings above, the study introduces the following three elements:

First, document the current *ad-hoc* Stage-Gate method and expand it with the inclusion of a focus on the larger picture, i.e. modularization study and a review of how the developed object impacts upper-level issues (System-level design).

Secondly, transfer the development process outside the Order-to-Cash and introduce the concept of sprinting (empowered and self-guided teams executing the tasks).

Thirdly, define the roles during the stages (the dedicated teams) and during the transfer from a stage to another stage (the gatekeepers). The importance of the “definition of done” is emphasized in the form of Product Backlogs as the development cannot start nor move from a stage to another stage without a measurable “definition of done”.

The proposal was validated by co-creating it with key-stakeholders and then by a separate verification by those same stakeholders before addressing the managers. The managers reviewed the proposal and gave constructive feedback. From this feedback, two major concerns regarding the proposed process were identified. First, would the proposed process be adaptable to other development projects than just the development of existing products. Second, how would the process function together with the Order-to-Cash process, as it was transferred outside of it. The study demonstrated the two points of concern by providing alternative process flow descriptions of both cases.

The business impact for implementing a process as proposed by the study can be viewed as essential. The significance is grounded onto two aspects. First, having a documented process in place of an “*ad-hoc* way of doing”. With a documented “way-of-doing” one is more likely to achieve the same result repeatedly than by performing in an *ad-hoc* way. Secondly, by performing as a team (sprinting) the result is more likely to meet the needs than by performing as an individual. There are few black-and-white needs with more needs being grey. To understand the need, it can be more efficient to tackle it from multiple directions (team member expertise’s) than just from the viewpoint of one-person expertise.

7.2 Next Steps

The process introduced in this study aims to address some important aspects of business: to perform development in a timely manner with results based on validated necessities.

Nowadays market needs emerge swiftly and those needs also change swiftly. To be able to compete on these markets, companies need to respond promptly to the changing needs so as not to miss the opportunity for business.

Development is usually viewed as an investment with possible economical value gained in the future. With limited resources – as is the case in most companies – the development projects that are initiated need to be carefully selected so as to maximize the possibility of future economic value gained. To be able to perform well in this selection, the market needs (necessities) should be correctly understood.

First, the study proposes that the concept of the Backlog be introduced to the company way of doing. A Backlog functions in the same way as a library where needs and requirements regarding the product are collected. An important aspect to notice is that these requirements derive from multiple sources both internal (company findings) and external (customer findings). Put together, the aim is that they begin depicting a larger “map” of needs and thus act in helping to decide what paths to strive for the concerned product.

A practical way of introducing the Backlog is to start collecting issues and requirements for a well-established company product and record them to the company central document archive. The layout of the Backlog is not crucial at this point as the focus is in introducing a new, company-general, way of logging data. Instead of having information regarding a product scattered across teams and operations it is collected to a master database – the Backlog. A single individual is tasked to oversee and arrange this Backlog. The study stresses the importance of having one person – e.g. the Product Manager - responsible for the Backlog. Teams have their strengths, but not in this case where a library needs to be kept in an orderly manner. The study concludes that in this case individuals tend to perform more systematically. The introduction of a backlog keeper also touches the current need for defined roles and responsibilities.

Secondly, the study proposes to introduce the concept of sprinting to the company way of doing. The thought behind sprinting is that highly educated people – as the main workforce of the company consist of – are at their best when performing self-governed towards a clear goal. The other aspect of sprinting to underline is the pre-allocated time

limit. A sprint has a set time to be performed after which the team must present “something that can be evaluated”

To further elaborate on the sprint, a task is defined then given to an empowered team of experts. The team decide between the team members themselves – based on their shared experiences – what path to carry out to be able to fulfill the assigned task. At the end of the sprint, they introduce the outcome to an evaluator or committee who decide how to proceed. Again, this touches the current need of defining roles and responsibilities. It also creates an inbuilt need for a pre-determined “definition of done” – the success of a sprint cannot be evaluated and thus moved forward without a “definition of done” against which to measure the outcome.

7.3 Thesis Evaluation

The study made all the efforts to reach an outcome that would meet the requirements for both the case company and the academic study. A Design research approach was exercised where the researcher co-operates with identified key stakeholders to be able to create a change for the case company. First, the study set forth to analyze the current state strengths and weaknesses for which to seek guidance from relevant literature. However, it became quickly evident that this approach would not yield good quality data as the current state is performed heavily in an un-documented *ad-hoc* way. The study could not construct, in the researcher opinion, the questions for the stakeholders that would result in an objective analysis. With basically no common ground between the stakeholders, the interviews turned out to be mainly free discussion about a broad subject. The researcher came to this conclusion after having conducted interviews with four stakeholders.

Thus, the study was started again with a new structure. The study, first, created a conceptual framework as a tool based on best practice findings from relevant literature obtained from multiple sources. The interviewees were asked to reflect the current *ad-hoc* development process onto the concept provided from the conceptual framework. By using this approach, the study was able to form a good quality picture of the current state.

The conceptual framework and the pictured current state were used as a “skeleton” onto which was developed an initial proposal. The proposal was co-created during two workshops with identified key stakeholders. The researcher was involved as a participant in both workshops. However, the researcher made efforts to stay more as a facilitator and less as an active contributor during the workshops. This was done to ensure that the

stakeholders would see their requirements - or handprint - in the outcome, and thus, commit themselves to it. As the identified key stakeholders and their commitment rises the probability of others also committing to the proposed process (landslide phenomena).

The initial objective of the study was to create a process for developing existing products and, based on the decision-maker reactions, it seems likely that the process will be taken into use in some form. Arguments for this statement is that the key causes of worry, as identified during the decision-maker evaluation, were addressed and explained to the decision-makers using the example cases from the company past. The Product Backlog has also already been taken into experimental use for a newly started project to develop an existing product.

7.4 Validity and Reliability

Research in order to be credible needs a check for quality. There exists a various type of criteria to check the research quality. This study accepts a perspective that research must be both valid and reliable in order to produce a credible outcome.

Kananen (2017) categorizes *Validity* as external validity and internal validity. The external validity measures how well the research holds true when tested against similar cases. External validity is important especially in quantitative research. In Design research, the aim is to create a change for a specific case and therefore it is not by default applicable for generalization. Instead, internal validity is measured. Internal validity considers how accurately the content matches the study, and how well the results are grounded to credible sources. In qualitative research studies, such as Design research, validity can be enhanced by using the sources that are evaluated as credible and relevant to the study (Maxwell 1992).

For this study, validity was ensured by checking multiple times against the *apriori* built research design that the outcome matches the study objective. Validity of data was ensured by involving the best available data sources from the case company and its stakeholders from an early point in the study. Company stakeholders also actively contributed, and the company managers evaluated the proposal in order for the final proposal to be created. The proposal is based on existing high quality literature from relevant fields and from information gained from workshops and discussions with company stakeholders. Stakeholder involvement consisted of interviews and workshops with interviews being quite an effective way to gather data – all stakeholders participated in the interviews and

good quality discussion was obtained. The workshops, however, were somewhat challenging. All stakeholders participated in the workshops, but it was evident that their active involvement to the workshop was hampered by a heavy workload caused by their other tasks.

As validity measures how correctly the study is performed, *Reliability* measures how correct the data of the study is (Kananen 2017). Reliability of data is often measured by how well it holds true when tested against similar cases. This can be challenging in design research cases as data can be originating from interviews and workshops and thus contain opinions by people at a certain moment. Quinton and Smallbone (2006) suggest techniques such as using differing data sources, data collection tools and collecting data at different time points for proving the reliability of data.

This study aimed to prove the reliability by conducting the data collection from company stakeholders that have a long history with the company in a high-visibility role such as managers. The reliability of this study was ensured by conducting the data collection at three different time points and from both documented data such as company quality documents and from oral knowledge in the form of interviews and workshops.

7.5 Closing Words

The study set forth with an objective to create a process for developing existing products for the case company. The initial purpose was to identify the current “way” of performing development, document it and improve it with findings from literature. However, after preliminary interviews it became evident that the existing “way” of developing was very much an ad-hoc way of doing with personalized execution. Thus, the study concentrated on introducing a process that would serve as the starting point for a companywide documented development process - a backbone from which to start. It is the researcher opinion that in order to be able to develop something efficiently, it should exist in a documented context. Therefore, the product development process introduced in this study should be viewed as a beginning, not an end.

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Questionnaire for the Current State Analysis interview

Please describe our current way of handling following stages

- Concept& Idea Stage
- Development Stage
- Test Stage
- Production Ramp-up (release):

Do we have other stages?

How is the development process connected to the customer?

Questionnaire for the Current State Analysis follow-up

What are weaknesses and strengths of our current product development process?

- **Concept & Idea stage**

  Weaknesses

  Strengths

- **Development stage**
  Weaknesses

  Strengths

- **Test Stage**
  Weaknesses

  Strengths

- **Production ramp-up (release)**
  Weaknesses

  Strengths

Requirements for the future state product development process:

Final proposal for a process to develop existing products