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SCHOOL OF BUSINESS, ECONOMICS AND LAW

Master Degree Thesis in Innovation and Industrial Management

Combining Agile methods and a Stage-Gate model within the product development process

A multiple case study

Graduate School
Authors: Nicklas Dackhammar & Julia Ek
Supervisor: Daniel Ljungberg

Abstract: Hardware development and software development traditionally differ in how they manage their product development processes. The development of hardware is characterized by the use of a Stage-Gate model while Agile methods, such as Scrum, are the most common ways of managing software development. Today product development at many companies includes a combination of both hardware and software which raises the question of how this type of product development can be managed. Therefore, the purpose of this study is to examine how product development combining both hardware and software can be managed with regards to a Stage-Gate model and Agile methods. This was investigated through a qualitative multiple case study with four case companies. Findings show that two hybrid models have been identified where Agile methods and a Stage-Gate are combined. The hybrids both use a Stage-Gate at a strategic level but at an operational level they differ. In *Hybrid 1* the hardware development uses the Stage-Gate model and the software development uses Agile methods while in *Hybrid 2* Agile methods are used for both the hardware and software development.

Keywords: *product development, Agile methods, Scrum, Stage-Gate, hybrids models, hardware development, software development*

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1. Introduction

1.1 Background to Research Field

Organizations these days are facing a turbulent, uncertain and complex environment (Tseng and Lin, 2011). The fundamental nature of an open market society, according to Schumpeter (2013), is that it doesn't allow for a status quo over time due to competitive pressure. This means that firms need to constantly adapt to changing industry conditions by transforming their way of doing business (Johne, 1999). This process of adapting to the changing environment can be a challenge, while at the same time possibly offering great competitive potential for those able to capture and implement the opportunities before others (Johne, 1999). With a future that is increasingly difficult to predict, some companies today are trying to put so called Agile methodologies in place with the objective to become more adaptive instead of predictive (Fowler, 2005).

The concept of Agile methods arose from the software industry at first, as a contrast to more plan based traditional methods and has been widely adopted amongst software developers (Beck et al. 2001). The model known as the Stage-Gate has in contrast been the go-to method for hardware product development and was invented to be used as a tool to manage and assist in complex product development processes (Cooper, 2001). While the Agile methods were originally a software phenomenon, and still are, the success of these methods has also spread and is now applied to other areas, such as manufacturing of physical products (Serrador and Pinto, 2015), meaning that the traditional Stage-Gate method is no longer the only way to go. Curiosity of Agile methods has begun to spread to companies beyond those which exclusively produce software. (Cooper 2008, 2014, 2016; Sommer et al., 2015; Cooper and Sommer, 2016). Many companies today have both hardware and software in their products, hence also in their product development, and as Cooper (2014) explains, these are often integrated both in the product and in the process. Conforto and Amaral (2016) argue that there is a lack of empirical studies on the subject of how a Stage-Gate and Agile methods can be combined in product development. A question that remains is if Agile can be combined with traditional gating processes and work well and symbiotically or if the two approaches are rather mutually exclusive or incompatible (Cooper and Sommer, 2016). With that said there is evidently a research gap and a possibility exists to contribute to this field. With this background, the authors of this thesis think it is an interesting topic to dig deeper into.

1.2 Background to Master Thesis

The authors came in contact with a consultancy firm named Goovinn that is based in Gothenburg, Sweden and that works within three fields; Strategy & Business Development, Product Management & Development and Project Management. The company was founded in 2008 and their mission is to turn strategy into action through project excellence. According to Goovinn, all companies are exposed to changing requirements from customers, competitors' improvements and technology or other trends that create new possibilities as well as challenges. Goovinn sees product management and product development as the key to success in many companies. Having effective tools to manage product development and product portfolios on a strategic level and an operational level is critical. Goovinn helps to define, develop and realize effective ways of working within these areas. Lately,

Goovinn has noticed that product development within companies is frequently characterized by a combination of both hard- and software which ultimately creates a challenge of how these activities can be coordinated and managed. This has been the spark for the topic and research area for this thesis which will examine and explore the question of how these combined product development projects can be managed.

1.3 Purpose & Research question

The purpose of this thesis is to find out how combined hard- and software product development can be managed, with regards to a Stage-Gate model and Agile methods. We will aim to find out how a Stage-Gate model and Agile methods are used within this type of product development environment. Stage-Gate originates from a hardware manufacturing environment and Agile methods from a software environment hence product development that involves both hardware and software end up in a gray zone.

With this background the authors have formulated one main research question that is strongly connected to the aforementioned purpose. Further, two sub questions are meant to provide a context of the product development that will bring us to be able to answer our main research question with a sufficient understanding.

Research question: ***How can product development with combined hardware and software be managed with regards to a Stage-Gate and Agile methods?***

Sub question 1: ***Which factors influence the product development process at the case companies?***

Sub question 2: ***Which are the benefits and challenges of the product development process at the case companies?***

1.4 Delimitations

This thesis will exclude and limit itself to some criteria, in order to maintain a focused approach throughout the research process. First of all, an important limitation that has been made is that all case companies must share the common trait of producing products that are a combination of hardware and software. The intended companies should work with product development with mass production hence companies working towards specific customers who could steer and direct certain projects will not be included. Further, the study will limit itself to the Research and Development (R&D) departments within the case companies and the respondents chosen for the empirical study either work in this department or are strongly connected to it. Additionally the authors have chosen to only investigate companies with a maximum of one hundred employees in the R&D department. Our case study will limit itself to companies operating in the region of Sweden and more specifically in and around Gothenburg.

1.5 Disposition

This thesis layout is divided between six chapters and follow the structure as Figure 1 show.

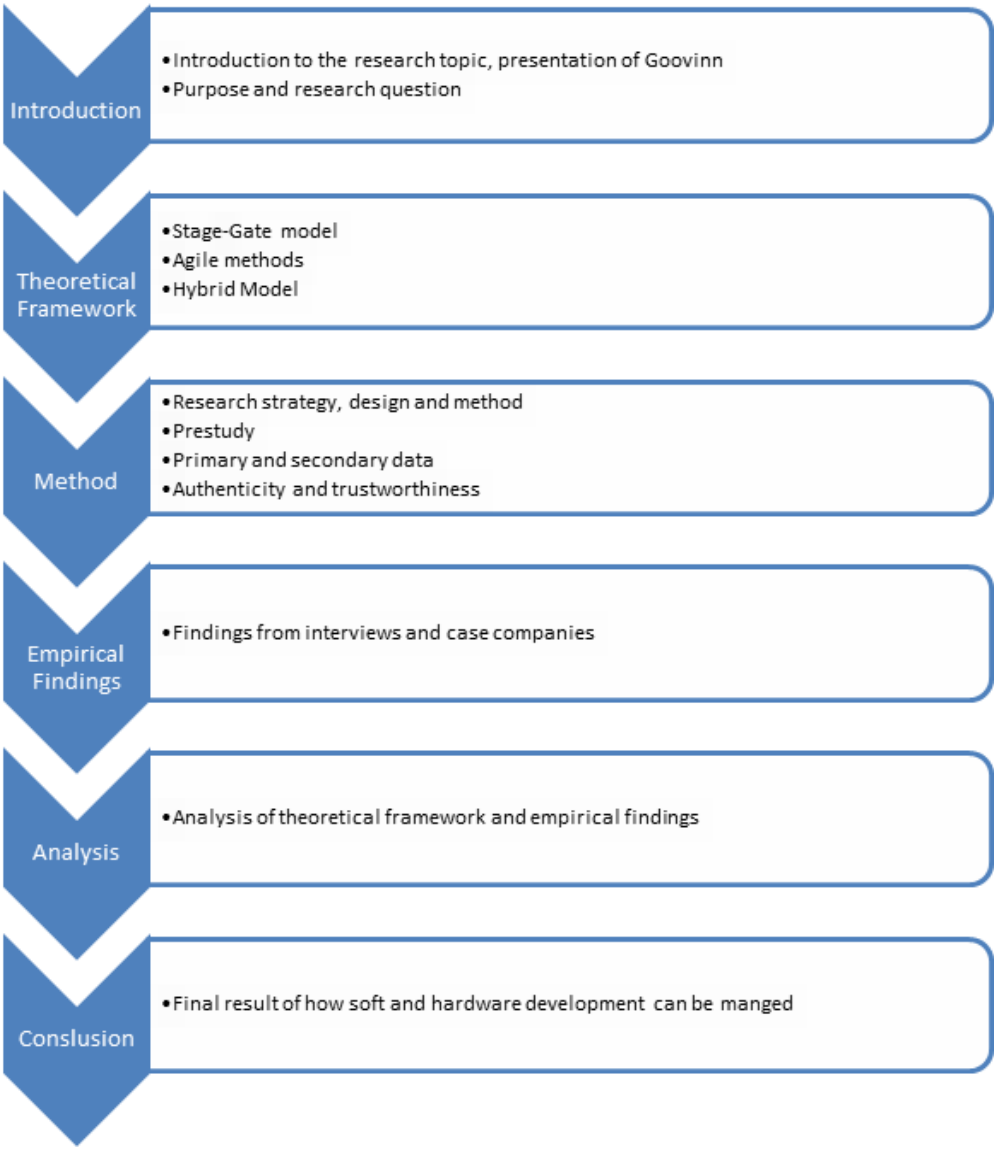

Figure 1. Disposition of the thesis.

2. Theoretical framework

In this chapter, some established theories will be presented regarding project management methods of product development. First off, the more traditional Stage-Gate model will be presented, followed by Agile methods in general and further the specific Agile methods and tools relevant to this study. Currently a trending topic within product development regards the possibilities of a hybrid version of Stage-Gate and Agile methods. Consequently, this will also be discussed towards the end of this chapter.

2.1 Stage-Gate

2.1.1 Values and principles of a Stage-Gate model

The Stage-Gate process founders, are often thought of as being Cooper and Edgett but as early as 1960 NASA developed a first generation scheme for product development named Phased Project Planning (PPP) today often titled Phased Review Process (Cooper, 1994). However, Cooper and Edgett's second generation Stage-Gate became widely adopted by the world industry around 1990 and proclaimed that product innovation is a process, and like all other processes, it can be managed. A study by Griffin (1997) containing 211 companies supports this statement as 60 per cent of the responding new product development functions were using some sort of Stage-Gate. From that time, it has been a popular method to drive product development projects. The model aims at creating a culture of product innovation quality and to be the foundation for a product life from idea to launch. Phillips et al (1999) describe the Stage-Gate model as a tool to bring an idea to launch. During the last two decades scientists have accumulated evidence that a disciplined product development process, with formalized processes, promotes a higher performance hence a higher success outcome (Adler et al, 1996; Ettlie and Stoll, 1990; Sosa et al. 2004). From a large scaled study done 2005 with 1000 companies named Booz Allen Hamilton Global 1000, showed that effective innovators tightly manage the innovation process, and they execute the four principles for a product development lifecycle, Ideation, Project selection, Product development and Commercialization with a tight overlooking grip. The conclusion from the report was that the actual spending on innovation did not correlate with a higher success ratio, rather a superior organizational innovation process quality did. (Jaruzelski et al. 2005) The Stage-Gate model further breaks down the product innovation process into smaller stages that follows a sequential flow but where the actual activity could and often is performed in parallel between different functions. (Tingström et al, 2006) Each stage is followed by a gate where a decision to either go/kill/hold or recycle is taken, to ensure that quality is adequate. This arguable will help to reduce the risk and uncertainty as the cost tends to increase the longer you advance in the process. (Cooper, 1990)

Cooper (2012) found some essential attributes that an organisation needed in order to implement and use a Stage-Gate effectively: First, the project needs to be operational, while processes needs to be accessible and documented at an operational level. Secondly, the organisation must support the product development process with sufficient resources for the team during the whole process of taking a product from idea to commercialization. Third, that the model is actually used, and not just there to be a "dusty" scheme of how to manage product development. This argument is further

backed by O´Connor (1994) that also state that a well implemented stage gate can energize and speed up the product development.

The stages are intended to gather specific information to enable the project to advance to the next stage or to a decision point (gate). The stages are defined by the certain activities within it and according to Cooper and Edgett divided by Idea discovery, Scoping, Build the business case, Development, Testing and Validation and finally Launch. (Cooper, 1990)

As described, the gates are quality checkpoints and are often characterized by a set of inputs, exit criteria and an output. The most important deliverables that the Project Manager must bring to the gates are the input, that later is judged by the specified criteria. These criteria are the requirements that the Project Manager must achieve in order to open the gate and enter the next stage of the product development. Lastly the output is defined as the decision made based upon the criteria stated known as go/kill/hold/recycle. (Cooper, 1990)

Based on Cooper (1990) the authors will below describe the "original" Stage-Gate as it was first introduced, with each stage and respective gate, and what type of actions and activities that take place within them.

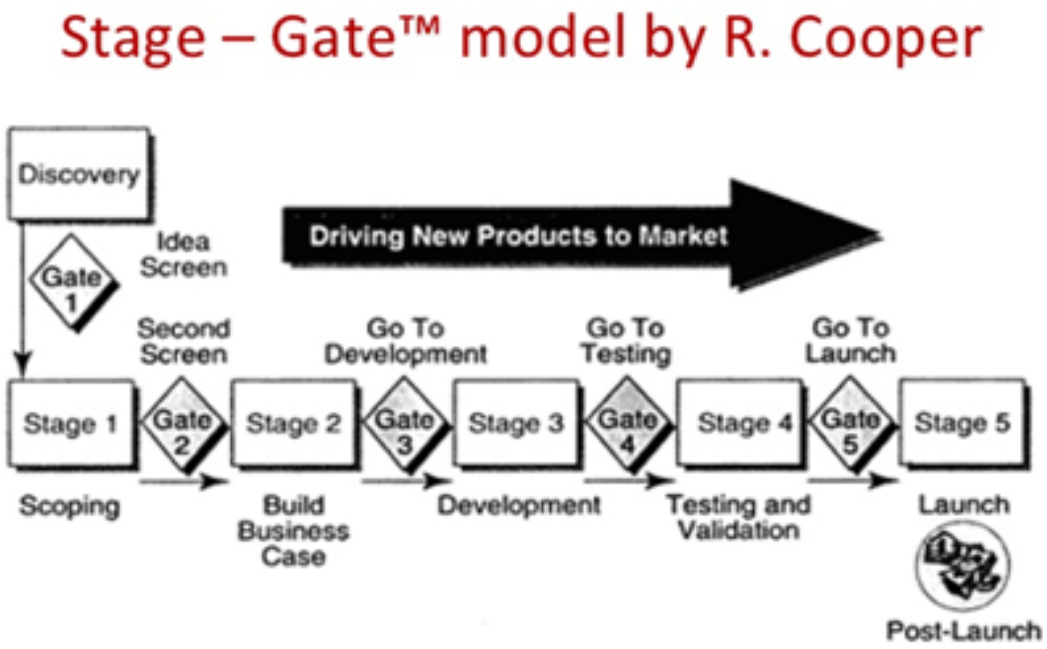

Figure 2. Stage-Gate model. (Cooper, 1990)

2.1.2 Stages

Idea discovery

Cooper and Edgett states that roughly 1 out of 100 ideas leads to a successful launch and creation of a product so in order to facilitate a sustainable new product development process many ideas have

to exist (Cooper, 1994). This phase is designed to discover business opportunities and produce new ideas. To increase the possibility of finding ideas (Chesbrough, 2003) argues that by open innovation a company could gather ideas both internally and externally. This trend is growing and to open up the idea generation process and collaborate with customers/user is in fact common these days. Though, Cooper and Edgett state that finding possible business ideas from customers often is tougher than just asking them, therefore the need to develop a more in-depth relationship with the customer is essential. (Cooper, 1990)

Scoping

This phase aims to build a more robust understanding of the project rather than just an idea hence a preliminary investigation takes place alongside setting the general scope for the product development. The phase is characterized by inexpensive activities such as; library research, customer contact, identifying focus groups, and eventually a small concept test. At the same time a preliminary technical evaluation is carried out, testing the feasibility of product in order to roughly elaborate potential costs and a time frame. (Cooper, 1990)

Build a business case

The previous ideas are further tested and developed in regards of financial, market, technical and operational aspects. This process aims to make sure that the product is matched to the real world to know that it corresponds to the market requirements. The R&D department identifies strengths and weaknesses and start to build a concept of what the product will offer. Another step is to further understand the present market threat and competition to facilitate material for management in order to make proper and well analyzed decisions, if a kill or go decision should be made. This is often the final stage before additional substantial funding therefore the project must be clearly defined. (Cooper, 1990)

Development

When entering this phase the product has generally only met major criteria to further advance but now the details starts to matter and take place. In this phase the detailed design is narrowed down and fine-tuned meanwhile the operations is developed in order to meet the forecasted market demand and possibility of reaching full scale production. (Cooper, 1990)

Testing and validating

A complete prototype is tested and validated by the market to see any required changes before entering the last stage in the product development process. The validation process also takes place in the factory to finalize the upcoming production. Another activity during this phase is the validation of the marketing and branding activities, to make sure that the right segment is reached in order to correlate with targeted sales. (Cooper, 1990)

Launch

The product is complete and the launch takes place. The commercialization begins with a complete operation of production, marketing and sales. (Cooper, 1990)

2.1.3 Gates

In contrary to the stages the gates are the doors that either allow the project to move on into the next stage or reject and eliminate it. There are several methods in judging the ongoing process but the original authentic measures incorporate six proven criteria: Strategic Fit, Product and Competitive Advantage, Market Attractiveness, Technical Feasibility, Synergies/Core Competencies, Financial Reward/Risk. These criteria should be the basis for the judgement and work as a tool to decide if the product will become a winner or loser. (Cooper, 1990)

Gate 1

The first screening of the ideas takes place and if the project receives a go, a handful of "must meet" or "should meet" criteria are defined. The main objective of these criteria is to mitigate the risk to reach strategic alignment, project feasibility, market attractiveness and to exploit synergy with core business and resources of the firm. (Cooper, 1990)

Gate 2

This gate has similar characteristics and objectives as the previous one now taken with additional information acquired during stage one. The project is judged on the previous "must meet" and "should meet" criteria and if approved and accepted new requirements are formed. Sometimes there is also a simple financial calculation in this gate, ex net present value or payback period. (Cooper, 1990)

Gate 3

This is the final gate before the development stage and accordingly the heavily spending as discussed above. The project is once again subjected to "must meet" and "should meet" requirements stated previously. The review often contains active involvement by reviewing both the action but also the quality of activities. Due to the required financial muscles in forthcoming stages a thoroughly financial assessment takes place with the demand of a positive result. Additionally, a number of the most significant key items and attributes have to be agreed upon before advancing into the development stage. (Cooper, 1990)

Gate 4

The development activities are reviewed and analyzed, ensuring sufficient quality is reached. Financial requirements previous given have now been additionally investigated and a reversed, more complete financial analysis takes place. The upcoming tests and validation actions taken place in the next stage are formed to enable a direct implementation meanwhile a comprehensive checklist for the market and operation strategy is shaped. (Cooper, 1990)

Gate 5

The final gate before commercialization hence the final point of where the project can be killed/hold or recycled. The gate mainly focuses on the quality of previous activities in the validation stage and their respective results. The financial projection of the product is vital in the process to take a "go" call and enter the last stage. Lastly, the marketing and operation plans are reviewed and accepted for the implementation stage. (Cooper, 1990)

2.1.4 Roles

In all organizations employees need to know how the day-to-day work should be completed and what specific roles and responsibilities there are within the organization. It enables employees to contribute to the company and also facilitate a transparency within the organization by knowing what other people are doing and why. Cooper (1994) argues that teams should be put together cross functional as no competence team fully own the stage. According to Cooper (1990) there are some typical needed roles if to successfully implement a Stage-Gate process: *The Executive sponsor,* the *Gatekeepers* or *Decision makers,* a *Project Manager and Team members*.

The sponsor is often the owner of the product, and in most cases the client making sure that the project delivers upon the agreed business profits that the specification showed. This sponsor is often a manager or executive and ultimately has the overall responsibility for the project. The sponsor further needs to communicate and coordinate between different groups within the project such as the business community and the decision makers and project-leader. (Buttrick, 2002)

The gatekeepers or decision makers are solely responsible for deciding upon a project's future by controlling the funds needed for the next stage. Typically, these persons are senior experts and often trusted by the company since approving a project will often mean a substantial economic investment. The gatekeepers could be changed between different gates in order to have the accurate competences to make the right decision since each of the different stages and their respectively gates have various problems hence different skills are needed. Cooper (2012)

The Project Manager is in charge from the idea to launch have to responsibility of managing and communicating with and between diverse functions or teams to make sure the project is developing at the forecasted speed (Walker, 1997). Sommerville et al. (2010) explain that a Project Manager is the person responsible for delivering a project in a safely, on time, not overdraw budget and at the same time maintaining the predetermined quality. Further the Project Manager often has a very active role and involved and engaged in the engineer's day to day operations rather than receiving reports, consequently often is a supporting hand when difficult decisions has to be taken. As discussed the Project Manager has many different responsibilities hence many qualities needed. Mintzberg (1970, 1971, 1973, 1975) discuss these qualities a Project Manager needs as a set of 10 "work-roles" she has to embrace. Those includes three inter- personal, three informational and four decision-making roles. Though, there is no exact and precise standard function or role set for a Project Manager, which implies that the role need different qualities at different times.

Finally, the team members that together are the larger part of the human resources in the product development process, often put together as teams working either by separate functions or cross-functional groups depending on project and company organizational setup. They posses expertise and particular skills in areas that are required to complete the project tasks, often specialists within an area. The team member could be characterized as a core team member, working full time on the project often especially important for the project, though not necessary through the whole duration. Secondly the extended team member, working part time of the project. (Akhilesh, 2014)

2.1.5 Critique of the Stage-Gate

Naturally, the model has meet some tough criticism from its birth until today and not surprisingly as mentioned above also been updated by Cooper himself. In some cases, the critique has been answered and met. The main arguments against the method discussed by Grönlund et al. (2010), is that it creates bureaucratic procedures, no provision for focus and restriction of learning opportunities. Tingström et al (2006) argues that the Stage-Gate only facilitate guidance and structure for large projects and says that the model is superfluous and cumbersome for smaller projects. The model does not take into account what resources that are available, hence the prioritization between projects that are accepted (Cooper, 1994; Grönlund et al. 2010). Additionally the Stage-gate could remove project members own ability to think independently, by having a too standardized process (Cooper, 1994). This is also something Cooper tried to mitigate with the rise of the third generation stage gate described further in Hybrid methods.

2.1.6 Conclusion Stage-Gate

Overall the Stage-Gate has been proved to be a successful method for taking products to market, but the method per se is not a micro-management tool where daily operations are controlled. The method is rather a comprehensive idea-to- launch roadmap which facilitates macro planning for an organization. The model is thought of as being generic and possible to apply in different projects. As discussed above, within the stages several departments need to collaborate and co-work since no department owns each stage separately. This implies the need for cross-functional teams working together, to enable the project to move forward at a higher pace but also makes it challenging in regards to communication and coordination. Moreover, the Stage-Gate helps mitigate the risk problems which are quite evident talking about new product development by separating activities and adjusting funding based upon certain predetermined criteria.

Theoretical Framework	Key Characteristics	Benefits	Challenges	Researchers
Stage-Gate	Product development tool to control Idea-Launch Product development divided into smaller stages Risk management tool	Transparency between different departments Reduce risk and uncertainty Facilitates for top management to make decisions Higher performance rate and success outcome	Rigid model, all projects are not the same Project members' ability to think independently No consideration between projects	Adler et al, 1996; Akhilesh, 2014; Buttrick, 2002; Chesbrough, 2003; Cooper, 1990; 1994; 2012; Ettlie and Stoll, 1990; Griffin, 1997; Grönlund et al. 2010; Jaruzelski et al. 2005; Mintzberg 1970; 1971; 1973; 1975; O´Connor 1994; Phillips et al. 1999; Sommerville et al. 2010; Sosa et al. 2004;Tingström et al. 2006; Walker, 1997

Figure 3. Systematic literature review, Stage-Gate

2.2 Agile methods

2.2.1 Definition of Agile

In the Oxford English Dictionary (Oxford University Press, 2017) the word 'Agile' is defined in various ways. One of these definitions explains a more general use of the word, explaining how an Agile person or Agile mind is defined:

'Of a person, the mind, etc.: able to think, understand, and react quickly; alert, astute, quick-witted'

The second definition explains the use of the word in a business context and defines Agile as the following:

'Of a company, business activity, product, etc.:
able to change or be changed rapidly in response to customer needs
and market forces; adaptable, flexible, responsive.'

2.2.2 Agile methods in product development

While the dictionary definition may seem quite straightforward, what being Agile in practice actually means is not as clear. However, there have been attempts to pinpoint the main ideas of Agile methods. One such attempt was in 2001 when representatives with connection to common Agile methods came together to discuss alternatives to the documentation driven, heavyweight software development processes that had been used traditionally. It was within software development that these methods first were invented and applied. This group, who named themselves the 'Agile Alliance', agreed and decided upon some core values and principles of Agile software development, which are known as the Agile Manifesto. The Manifesto is still used as a leading point of reference for practitioners of Agile methods. The manifesto that they agreed upon highlights four values that are seen below. While there is value in the items on the right, the items on the left should be valued higher and emphasized in Agile development. (Beck et al. 2001)

- **Individuals and interactions** *over processes and tools*
- **Working software** *over comprehensive documentation*
- **Customer collaboration** *over contract negotiation*
- **Responding to change** *over following a plan*

Aside from these four values mentioned above, they also published twelve principles that lie behind the manifesto. These principles include *(1)* satisfying the customer through early and continuous delivery and welcoming changing requirements, even late in development, *(2)* harnessing this change to create a competitive advantage for the customers. The principles also include *(3)* delivering working software with an optimal frequency of a couple of weeks, *(4)* bringing together business people and developers to work together daily throughout the project, and *(5)* building projects around motivated individuals that can be trusted to get the job done with the right environment and support. They *(6)* advocate conveying information through face-to-face conversation and *(7)* measure progress by looking at working software. The principles also explain Agile processes as *(8)* a form of sustainable development where it should be possible to maintain a constant pace indefinitely. Further, the principles claim that *(9)* continuous attention to technical excellence and good design enhances agility and that *(10)* simplicity is essential, referring to maximizing the amount of work not done. Finally, they also *(11)* believe that self-organizing teams are the optimal way to reach the best architectures, requirements, and designs and *(12)* promote the activity of reflecting as a team on how to become more effective, tuning and adjusting behavior accordingly. (Beck et al. 2001)

Begel and Nagappan (2007) studied the implementation of Agile methods in IT firms and identified three main benefits of these methods; improved communication and coordination, quicker product releases, and faster response to technical or customer requirement changes. Naturally there have through the years arisen challenges of implementing Agile methods, such as a couple that were found by Boehm and Turner (2003) through a series of workshop studies, where they looked at Agile methods in general and the Agile method of Scrum in particular. One of the key challenges they found was regarding human resources and the position descriptions may that need to be accommodated to match the roles of an Agile organization. It will also require more skills and experience of the development teams in order to perform adequately, as the Agile roles often cross the boundaries between more classic development position job descriptions. (Boehm and Turner, 2003) Also, the members of Agile teams are less interchangeable, hence all competence needed to deliver a task needs to exist within each team (Dybå and Dingsøyr, 2008). Another key challenge that is lifted by Boehm and Turner (2003) is one that may arise specifically in mature organizations and regards how Agile processes can guarantee that companies can maintain their ratings such as CMMI or ISO that are often a result of strict process standards. Further, Ovesen (2012) presents a challenge that through his studies was found to exist among companies using Agile methods and this regards the vague connection of Agile methods to a long term development road map. The short development cycles that characterize Agile methods focus primarily on the immediate and most critical tasks and gives only a "best guess" of the long-term plan, as the whole idea of Agile methods is that the plan should not be set in stone from the start. This can certainly be a challenge since it forces an acceptance of uncertainty and vagueness in the long-term planning.

2.2.3 Applying Agile methods through Scrum

2.2.3.1 What is Scrum?

Scrum is today the most common Agile method and when comparing the values and practices of Scrum to the main ideas and principles of the Agile Manifesto, it is clear why it has gained support amongst Agile developers as they correlate very well (Ovesen, 2012). Scrum is commonly applied to software development as it is this that it was initially created for. However, as Agile methods have transferred into the world of physical products, it also appears to be the Agile method most frequently used by manufacturing firms (Cooper and Sommer, 2016; Sommer et al. 2015). In this thesis, Scrum is the Agile method that has been the main point of reference and when speaking of Agile methods, Scrum is implied.

Scrum was created by Ken Schwaber and Jeff Sutherland in the early 1990s as a method for developing and supporting complex product development. The intention as explained by Schwaber and Sutherland (2016) is that it can help companies improve by clarifying the relative effectiveness of its product management and development operations. It is defined as a suitable framework to address complex adaptive problems, while in a productive and creative way maximizing the value of delivered products. While Scrum is a lightweight framework that is simple to understand it is difficult to master it. (Schwaber and Sutherland, 2016) The Scrum framework can be visualized by the following figure.

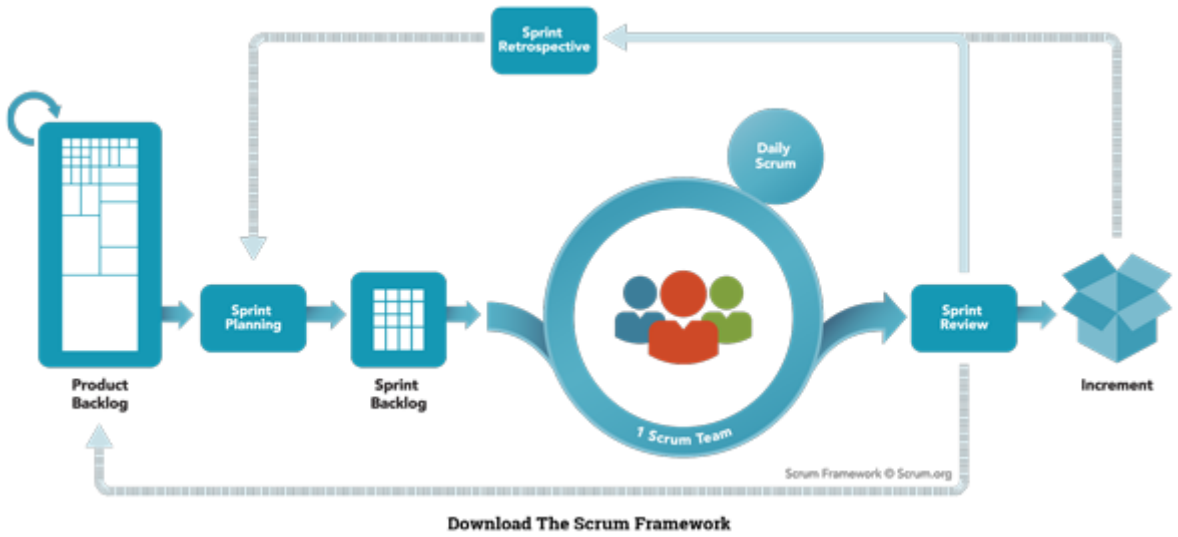

Figure 4. The Scrum Framework. (Scrum.org, 2017)

As Schwaber and Sutherland (2016) explain, Scrum is founded on empirical process control theory which proclaims that knowledge comes from experience and states that decisions should be based on what is known. Three pillars support the implementation of empirical process control and these are the following as explained by Schwaber and Sutherland (2016):

*"**Transparency :** Significant aspects of the process must be visible to those responsible for the outcome. Transparency requires those aspects be defined by a common standard so observers share a common understanding of what is being seen. A common language referring to the process must be shared by all participants and those performing the work and those accepting the work product must share a common definition of "Done".*

***Inspection :** Scrum users must frequently inspect Scrum artifacts and progress toward a Sprint Goal to detect undesirable variances. Their inspection should not be so frequent that inspection gets in the way of the work. Inspections are most beneficial when diligently performed by skilled inspectors at the point of work.*

***Adaptation :** If an inspector determines that one or more aspects of a process deviate outside acceptable limits, and that the resulting product will be unacceptable, the process or the material being processed must be adjusted. An adjustment must be made as soon as possible to minimize further deviation."*

2.2.3.2 Roles

According to Schwaber and Sutherland (2016) the main roles of a Scrum Team are the Product Owner, the Development Team, and the Scrum Master. The teams should be self-organizing rather than being directed by others outside the team, due to the philosophy that the team itself knows best how to accomplish the work. They are also cross-functional which means that within each team they should have all competencies needed to accomplish the work for a product Increment. The objective of having self-organizing and cross-functional teams is to optimize flexibility, creativity, and

productivity. Products are delivered iteratively and Incrementally, which maximizes opportunities for feedback and ensures that a potentially useful version of working product is always available.

The Product Owner is a person responsible for maximizing the value of the product and also for getting maximal value from the work of the Development Team by clearly communicating what needs to be done within the Sprints. It is up to this person to make decisions that will drive the development in the right direction to create value for the customer. As the owner of the product in development, the Product Owner is responsible for managing the Product Backlog and prioritizing the tasks within it. No one is allowed to tell the Development Team to work from a different set of requirements, and the Development Team isn't allowed to act on what anyone else says. (Ovesen, 2012; Schwaber and Sutherland, 2016)

The Development Team consists of the professionals who do the actual development work and are all known as "developers", with no hierarchic structure in the team. The responsibility of the Development Team is to deliver a potentially releasable Increment of a product at the end of each Sprint based on what is agreed upon beforehand. Once a Sprint has started, the Development Team's tasks should be set and nobody is allowed to further burden the team with additional tasks during th course of the Sprint. The team is authorized to structure and manage their own work and it is hence up to the developers to decide how they will solve the task of turning Product Backlog activities into Increments of potentially releasable functionality. This is meant to optimize the Development Team's efficiency and effectiveness. While members of the team may have specialized skills and areas of focus, no sub-teams are to be acknowledged. Accountability belongs to the whole team and they collectively commit to a certain workload at the beginning of each Sprint, making it important that the tasks can be solved by more than one certain person. Optimal size of a Development Team is normally between three and nine members; aiming to maintain it small enough to be nimble and large enough to complete sufficient work within a Sprint. The Development Team is often co-located, meaning that they work in the same physical environment which facilitates clear and constant conversation in the team. (Ovesen, 2012; Schwaber and Sutherland, 2016)

The Scrum Master is the person who makes sure that Scrum is understood and applied in the right way. Scrum Masters do this by ensuring that the Scrum Team works in accordance with the theory, practices, and rules from Scrum. This person also helps the rest of the organization outside the Scrum Team to understand how their actions can help maximize the value created by the Scrum Team, hence acting as an information officer to the environment. The Scrum Master should also, as a representative for the Development Team, be the link to the Product Owner and make sure there is adequate cooperation regarding the Product Backlog. Further, the Scrum Master is a gatekeeper to the Development Team that should make sure no extra assignments from the surrounding organization reaches the team. The Scrum Master is often, but not always, one of the developers in the Development Team. They are responsible for maintaining a certain flow in the development process which means assembling the Development Team for daily meetings and making sure there is a common understanding amongst team members of the vision, goals and tasks within each Sprint. (Ovesen, 2012; Schwaber and Sutherland, 2016)

2.2.3.3 Scrum events

Sprints, which are known as the heart of Scrum, are time-boxes of maximum one month during which a product Increment is created that is optimally both useable and potentially releasable. Sprints can be seen as short projects that consistently follow after each other, as the end of one Sprint is followed by the start of the next. All Sprints within a development effort should have the same duration and the duration cannot be adjusted once a Sprint has begun. If a Sprint is too long it increases complexity and risk while a shorter Sprint increases predictability. The work is inspected and adapted every few weeks and the risks, such as costs, are limited to this time frame. The Sprint can be seen as a container for other Scrum events such as Sprint Planning, Daily Scrums, the development work, the Sprint Review, and the Sprint Retrospective. The reason for these events is to generate opportunities to inspect and adapt the work, creating critical transparency. The events also create regularity which minimizes the need for meetings and just as the Sprint itself, each event within it also has a fixed duration. (Schwaber and Sutherland, 2016)

The **Sprint Planning** is an event where the work to be accomplished in the Sprint is planned and this is done in collaboration with the whole Scrum Team. In this event, strategic considerations regarding *what* can be delivered in the Sprint are decided upon and further tactical considerations are made regarding *how* this will be achieved. In order to set the plan for the Sprint, the Scrum Team looks at the Product Backlog, the product Increment delivered from the previous Sprint and the capacity and past performance of the Development Team. In the Sprint Planning the Development Team decides how many items that are selected from the Product Backlog for the Sprint and based on this limitation, a Sprint Goal is set. The items that are chosen from the Product Backlog create a Sprint Backlog, and a plan is made for how to deliver them as a "Done" Increment by the end of the Sprint. (Ovesen, 2012; Schwaber and Sutherland, 2016)

The **Daily Scrum** is a 15-minute event where the Development Team gathers to synchronize the work and create a plan for the coming 24 hours that will make sure they are on the right track toward reaching the Sprint Goal. It is a key event to inspect and adapt the work being done. It is up to the Scrum Master to facilitate the meeting and to make sure all the team members' voices are heard. The Daily Scrum should be held at a permanent place and time each day and should contain an inspection of the work done since the last Daily Scrum, a forecast of the work that should be completed until the next one and a discussion of any obstacles that may be in the way. The Daily Scrums are meant to improve communication, eliminate the need for other meetings, tackle any arisen obstacles, make quick decisions and improve the knowledge level within the team. (Ovesen, 2012; Schwaber and Sutherland, 2016)

The **Sprint Review** is an event at the end of every Sprint where the delivered product Increment is presented and inspected and the Product Backlog can be adapted if necessary. While the Sprint Planning and Daily Scrum is exclusive for the Scrum Team, this meeting is open to a broader audience and other stakeholders. It is more informal and the presentation of the Increment is meant to generate feedback and encourage collaboration in a constructive way. For a one-month Sprint the meeting should be time-boxed to four hours and keeping to the time, as well as ensuring that all attendants understand the purpose is the responsibility of the Scrum Master. The result of the Sprint Review is a revised Product Backlog that describes the anticipated Product Backlog items for the

following Sprint and the Product Backlog may also be revised overall to comply with new opportunities. (Ovesen, 2012; Schwaber and Sutherland, 2016)

The **Sprint Retrospective** is a time-boxed three hour event for one-month Sprints that takes place between the Sprint Review and the Sprint Planning where the Scrum Team inspects itself and shapes a plan for improvements for the next Sprint. It can be seen as an inspection of the process. As with other Scrum events, the Scrum Master is responsible that the Retrospective takes place and that those attending understand the purpose and keep it within the decided time. The main objective of this event is to identify improvements that can be implemented in the next Sprint to make the Scrum process more effective and enjoyable, hence having the Scrum Team adapt to their own inspections. (Ovesen, 2012; Schwaber and Sutherland, 2016)

2.2.3.4 Scrum artifacts

The artifacts of Scrum aim to provide opportunities for inspection and adaptation and also to maximize transparency of key information so that everybody has the same understanding of the artifact. (Schwaber and Sutherland, 2016)

The **Product Backlog** is an ordered list of "work-to-be-done" with everything that may be required for a product and this list is managed by the Product Owner. At the start of the product development, the most fundamental requirements are added and it is then updated and altered constantly, due to how the product progresses or how the environment where it will be used evolves. It is therefore a dynamic and living artifact that is adaptive to business requirements, market conditions and new technologies. It lists all features, functions, requirements, enhancements, and fixes that constitute the changes to be made to the product in future releases. The Product Backlog is refined continuously and details, estimates, and order are added to items in the Product Backlog. The way the Product Backlog is sorted can depend on the development strategy and it can, for example, be sorted by value, risk, priority or necessity. Whichever way it is sorted, the items at the top of the list are of the greatest importance and are always the most detailed, while the ones further down are more "coarse-grained". The items are "groomed" by the Development Team and the Product Owner continuously as the development moves forward. The Development Team is responsible for estimates of how long each item will take to complete and the decision regarding this is up to them, while the Product Owner may help them understand and select amongst trade-offs. Since the Product Owner is the one managing the Product Backlog, the progress toward a goal is checked at each Sprint Review and made transparent to all stakeholders. (Ovesen, 2012; Schwaber and Sutherland, 2016)

The **Sprint Backlog** is a list of items from the Product Backlog that are chosen for the current Sprint and includes a plan of how they will be delivered by the Development Team to reach the Sprint Goal. By looking at the Sprint Backlog, one should see the functionality that will be delivered in the "Done" Increment at the end of the Sprint. In similarity to the Product Backlog, the Sprint Backlog is also a dynamic document, developing throughout the Sprint as tasks are completed and the team learns more about the work needed to achieve the Sprint Goal. It is detailed to the point that is gives a good visibility and overview of the work that remains and the time it will take. It should also be detailed enough so the the progress should be able to be followed in the Daily Scrums. This Backlog belongs only to the Development Team and it is only through them that it can be changed throughout the

course of a Sprint. For the Development Team it is a good planning tool for the current Sprint and it provides transparency of the work process to the Product Owner. (Ovesen, 2012; Schwaber and Sutherland, 2016)

The **Increment** is an artifact that defines the resulting work of a Sprint and is the sum of items that were completed in a Sprint and the value of the Increments completed in earlier Sprints. When a Sprint is completed, the new Increment must meet the Scrum Team's definition of "Done." It is up to the Product Owner if the Increment is used directly as a part of a final product, be changed in a later Sprint, or perhaps not used at all. (Ovesen, 2012; Schwaber and Sutherland, 2016)

Definition of "Done" is, as it sounds, the definition that is agreed upon within the Scrum Team of what should be accepted as a "Done" in the product Increment. Everyone must share an understanding of what this means to ensure transparency so that both those that are creating the product and those that are receiving it have the same way of assessing if the work is completed. (Ovesen, 2012; Schwaber and Sutherland, 2016)

2.2.4 Conclusion Agile methods

Agile methods emphasize short and time-boxed iterative cycles where the teams deliver an output at the end of the set time frame. Agile methods also make a point of having autonomous and self-managing teams that have a large amount of both freedom and responsibility to plan their work. Close customer collaboration is also underlined in Agile methods since it provides the company with many possibilities for feedback and allows for products to be adapted throughout the development process to fit changing market needs. The Agile method that this study focuses on is Scrum, which is built around several key principles and has some noteworthy characteristics. Scrum has a set of roles, events and artifacts that build up the core of the method and give guidance to companies and development teams that want to implement it. These are roles such as the Development Team, Product Owner and Scrum Master, events such as the Sprint and the meetings surrounding it, and the artifacts such as the Backlogs, the Increment delivered after each Sprint and the Definition of "Done". These characteristics of Scrum are all meant to increase the possibility of transparency, inspection and adaptation that is achieved through this Agile method.

Theoretical Framework	Key Characteristics	Benefits	Challenges	Researchers
Agile Methods	Roles Events Artifacts	Flexible organization Autonomous and motivated teams More accurate on time deliveries Better customer integration and product accuracy	Requires broader competence from developers Lack of long time planning Maintaining process standards	Beck et al. 2001; Begel and Nagappan, 2007; Boehm and Turner 2003; Cooper and Sommer, 2016; Dybå and Dingsøyr, 2008; Ovesen, 2012; Schwaber and Sutherland, 2016; Scrum.org, 20176;

Figure 5. *Systematic literature review, Agile methods.*

2.3 Integrating Agile methods in a Stage-Gate process

Currently, an idea that is trending is that Agile methods can be used within a structured innovation process with milestones and decision points, such as the Stage-Gate. This hybrid approach is meant to deliver the best of each model and has been called a "new generation Stage-Gate". (Sommer et al. 2015) A reason for implementing Agile methodologies within a Stage-Gate model is to achieve both agility and discipline (Boehm & Turner, 2003). As said by Cooper (2014), the Stage-Gate framework can provide important support for Agile development and does not at all mean abandoning Stage-Gate completely. Sommer et al. (2015) agree with this and learned through their study that implementing an Agile method such as Scrum does not necessarily mean abandoning Stage-Gate but rather that the method can be added to it in a way of incorporating features of both and as Cooper (2016) says, the hybrid model balances the benefits and challenges of the two approaches.

One type of hybrid version is that Agile methods are integrated in the software development while the remaining areas of a development project are managed within contexts of a Stage-Gate model. Karlström and Runeson (2005; 2006) conducted a qualitative study of three Swedish IT companies that integrated Agile methods in a gated system. Through this study they found that it is possible to integrate this Agile method in a Stage-Gate model context successfully and concluded that they are compatible. Agile brings efficiency and focus and is a powerful micro planning tool for day-to-day

control and reporting progress while the Stage-Gate provides a way to coordinate amongst teams and communicate across departments and company levels. Some of the main benefits found through including Agile methods were that exchanging written document for face-to-face meetings improved communication and the receival of quick feedback from customers improved the efficiency of the product and project. As the researchers explained, the software in embedded products is only one part of a development project as they exist in an environment that is also composed of hardware development, marketing, production planning etcetera. When a subproject is managed through Agile methods, these areas must all manage to coexist. The Stage-Gate is here a helpful tool to support the communication both within a project and with the decision-makers who sponsor the project. Some key success factors for this to be successful are that the interfaces towards the Agile subproject are functioning and that the management has a positive attitude toward the Agile approach. (Karlström & Runeson, 2006)

While the IT industry was the first to realize that a Stage-Gate and Agile methods complement each other, the idea of integrating Agile methods has gained growing attention from manufacturing firms that have more traditional gating processes and that develop physical products. (Cooper, 2014; 2016; Ovesen and Sommer, 2015) After being first adopted by IT departments and R&D departments with almost exclusively software development, companies with a main focus on hardware development have started to experiment with Agile implementations, modifying the method to fit their different needs (Sommer et al., 2015). Cooper (2016) says that Agile was initially created to respond to problems facing software developers and hence feels that is is also relevant for cases where a product includes both hardware and software and there needs to be an integration between the two. Using both the Agile methods and the Stage-Gate approach can help these companies respond to the needs of each component but also integrate the efforts. To a certain extent the application of Agile methods through tools such as Sprints has been enabled by the fact that some areas of hardware development have become more like software development in the way that they allow for short and quick iterations. Traditionally hardware development is affected by long lead times in the development stage but thanks to new technologies such as computer simulations and 3D printing, it is increasingly possible to receive working prototypes much faster (Cooper, 2016).

One of the first models of an application of a hybrid version on areas other than software and IT was Cooper's (2008) idea of 'Spiral Development', a model meant to make Stage-Gate a more adaptable development process, believed to be especially suitable for innovative new products or uncertain and changing market conditions. The model builds primarily on getting mock-ups or prototypes in front of customers early in the process and receiving fast feedback. This close feedback from customers allows for fast and smart failures in a relatively inexpensive manner and also allows for flexibility and agility to adjust the product's design when new information arises and market conditions and requirements change. In practice this is done through a series of "build-test-feedback-revise" spirals with the customer during the course of the development process. (Cooper, 2008)

Cooper (2014) saw that compared to how the world was when the first Stage-Gate system was implemented it has now changed into a more fast-paced, competitive, global and less predictable environment. He therefore continued to develop ideas of how the Stage-Gate could be updated and in 2014 presented what he called the Triple A, that builds upon three goals; to be adaptive and flexible, Agile, and accelerated.

A1, adaptive and flexible, refers to the idea of spiral development from earlier years and the "build-test-feedback-revise" spirals, getting something in front of customers early and often. It also includes using context-based stage definitions and activities, risk-based contingency models to drive decision making and flexible criteria for Go/Kill decisions. A2, Agile, refers in large part to the rapid development system developed by the software industry and the ideas of the Agile Manifesto (2001). It involves applying Sprints and other ideas from Scrum as a part of this new system, using time-boxed Increments ending in a deliverable result after each Increment. It also takes inspiration from lean development where a system with less bureaucracy and unnecessary activities is a strong objective. A3, accelerated, refers to accelerating the development process and maximizing speed to market, in part by making sure that projects are appropriately resourced and staffed by dedicated cross-functional teams and also by allowing for stages to overlap. (Cooper, 2014)

Sommer et al. (2015) conducted in-depth case studies of companies that manufacture products with a high degree of complexity and looked at their product development processes and the consequences of adopting Agile-Stage-Gate Hybrids. The conclusions of their study were in line with many of the realizations made by Cooper (2008, 2014) as they realized that a combination of Agile and Stage-Gate approaches generated a healthy tension between fixed planning and iterative problem solving. Improvements in performance and other advantages were found to be a result of combining a Stage-Gate model at a strategic level and the Agile method, Scrum, at the execution level.Cooper and Sommer (2016) have in a collaborative article discussed some positive examples of both IT firms and manufacturing firms that have gained benefits from integrating Agile and Stage-Gate when developing physical products. They feel that this new hybrid approach may very well be the most significant change to how product development is conducted since the Stage-Gate model was introduced 30 years ago. As they see it, the benefits of this hybrid model are a faster and more adaptive response to changing customer needs, better integration of voice-of- customer, better team communication, improved development productivity, and faster to market. Further, Cooper (2016) explains that a hybrid provides flexibility, speed and improved communication. It gives faster product releases, better response to changing customer requirements and improved team communication and morale.

There are however some negatives as well and therefore manufacturers must make modifications to Agile in order to adopt it successfully to physical products. (Cooper and Sommer, 2016; Cooper 2016) One such challenge is that while the internal communication within the dedicated teams is enhanced, there is a risk that they become isolated from other parts of the company. Another risk is that the current Sprint takes so much focus from the team that the long-term planning is neglected. Further, the creation of self-managing teams requires managers to give up some control of the development process, setting the organization up for potential conflicts and resistance. Finally, another challenge for manufacturers when adopting these Agile methods into their gating processes can be the escalation in number of meetings. (Cooper, 2016) Cooper and Sommer (2016) say that several questions still remain regarding these new hybrid versions as it is relatively new phenomenon and mention that one such question is if it can be combined with traditional gating processes and work well and symbiotically or if the two approaches are rather mutually exclusive or incompatible. If a combination is used, it remains to be determined if it will always provide more benefits than either model employed on its own and especially what the case is in a manufacturing world, which uses a gating process for physical product development. (Cooper and Sommer, 2016)

3. Methodology

The following methodology chapter will begin by explaining the decisions made regarding the qualitative research strategy and the multiple case study research design. Further, it is explained how both primary and secondary data has been gathered, both in the pre-study and in the main data collection phase. Finally, a discussion is held regarding the authenticity and trustworthiness of the conducted research.

3.1 Research Strategy

This thesis will use a qualitative research strategy in order to fulfill the purpose of the study, to examine how hard- and software product development can be managed. This field is characterized by a low epistemological degree hence suitable for this research strategy (Bryman and Bell, 2015), (Yin, 2014), (Eisenhardt, 1989). Also, when a research question is characterised by a "how" nature, a qualitative research strategy is most appropriate (Miles & Huberman, 1994). Further, the objective is rather complex and will need an in-depth study where the authors are able to observe the current situation simultaneously as respondents are free to express their thoughts and opinions and allowing the environment and context to affect the research (Yin, 2014). A possible drawback to using this strategy is that it could result in a biased result, and additionally the difficulty of generalizing since it only captures a part of the environment (Bryman and Bell, 20015). This will be further discussed in section Authenticity and Trustworthiness where the authors explain what was done to mitigate these potential issues.

3.2 Research Design

A case study design enables a detailed and intensive study of a problem that can take form in a case, or multiple cases. Stake (1995) argues that case study research is suitable if there is a high complexity and a particular nature of the case in a question. As previously discussed, the field is rather unexplored which demands the study to be rather exploratory and generate theory rather than to test theory (Bryman and Bell, 2015). Using a multiple case study can provide a more robust outcome than a single case study, hence provides a more compelling evidence even if generalization is hard (Yin, 2014). A multiple case study enables comparison between cases, although maintaining focus on the individual cases and their unique characteristics (Bryman and Bell, 2015). For these reasons, a multiple case study design was chosen for this thesis.

3.3 Research Method

The research method describes the used technique for the data gathering procedure. Bryman and Bell (2015) states that it should guide the execution of the research strategy but also monitor the analysis of the collected data. Once the cases were selected, the research method guides the way in which we are collecting the data from the respondents. Bryman and Bell (2015) name some of the most used techniques to gather data could be from observation, interviews, examining documents or sending out questionnaires. In order to fulfil the purpose of this study, there was a need for a flexible strategy that enabled rich in-depth answers. Therefore, interviews were found to be a highly appropriate method for gathering the primary data.

3.4 Pre-study

With the specific task of exploring how combined hard- and software product development can be managed, the authors started by carrying out a pre-study in order to understand concepts, obstacles in product development but also what processes that are affected. Due to the authors' limited initial knowledge within the area, a pre-study enabled a stronger understanding of a suitable scope for the research and guided in finding areas for further exploration. (Bryman and Bell, 2015)

The pre-study contained three phases; a literature review, unstructured interviews and results.

The initial literature review provided us the base of information regarding product development characterized by both hard- and software element. Information of how this data was gathered is covered in section Secondary data. Further information and motivation about the qualitative unstructured interviews will be found in section Primary data collection.

The result of the pre-study is:

-Deeper understanding of the Stage-Gate model and Agile methods
-Deeper knowledge in product development and its characteristics
-Organizational architecture with roles and responsibilities

The result of the pre-study enabled the authors to build an empirical ground to further continue and develop the task of thesis. With knowledge of product development characteristics, the most vital models and methods used and how organizations structure themselves in order to be as successful as possible, we developed the research question.

3.5 Case companies and Respondents

The respondents in the pre-study were chosen as they had comprehensive competence within the field of product development. Further Agile methods and Stage-Gate model were known models that they both had been or are working with. The authors felt that these three respondents provided us with sufficient information in order to bring the study to the next step. In the figure below, the respondents included in the pre-study are presented.

Position	**Date of Interviews**	**Duration of Interview**	**Location**
CEO Software Company	2017-02-01	90 min	Goovinn
Agile Transformation Consultant	2017-01-31	90min	Goovinn
Product Development Consultant	2017-02-02	90 min	Goovinn

Figure 6. Respondents in the pre-study.

Moving on to the main study that followed the pre-study, four companies were chosen for the multiple case study. These companies are different from each other when it comes their industries and products, yet a similarity that they share is that product development is a key process for them. The companies were also chosen for this study as they have products consisting of both hard- and software and a R&D department of maximum one hundred employees.

The respondents were carefully chosen from the four case companies with the criteria that they should work in the R&D department or have a close connection to it in their work. The authors tried to reach respondents with similar positions and roles within each company to justify and enable a comparison later. This also provided a complete and honest picture of reality to make sure we got a comprehensive picture that would reflect the situation. As described in the Theoretical Framework, the roles and positions that companies designate differs depending on which methods and models they follow. Exact matches in what the roles and positions are officially called are therefore hard to find but the responsibility relating to the roles has rather been the most important aspect. The respondents and respective roles included in the main study are revealed in the figure below.

Company/Position	**Date of Interview**	**Duration of Interview**	**Location**
Company A			
Vice President R&D	2017-05-08	90 min	Company A
Project Manager	2017-03-07	90 min	Company A
Manager System Development	2017-03-07	90 min	Company A
Company B			
Manager System, Software, Welding	2017-02-10	90 min	Company B
Manager Team Power Source	2017-04-04	90 min	Company B
Platform Owner	2017-04-04	90 min	Company B
Company C			
Director R&D	2017-02-08	90 min	Company C
Manager PMO	2017-04-05	90 min	Company C
Manager Software	2017-03-09	90 min	Company C

Company D			
Director R&D	2017-04-03	90 min	Company D
Director PMO	2017-02-06	90 min	Company D
Project Manager	2017-03-29	90 min	Company D

Figure 7. Respondents in the main study.

3.6 Primary data

The primary data was collected through qualitative interviews with respondents from three consultants working within product development and from our four case companies more specified in section Case companies and Respondents.

This study consisted of two different data collection periods, and as mentioned in the pre-study unstructured interviews were conducted with three respondents. The unstructured interviews, are characterized as interviews with no formulated questions but could have some guidelines and are appropriate when knowledge of the field is limited and a lacking theoretical background is available (Bryman and Bell, 2015). The interviews provided us with an understanding of the real nature in the product development and what challenges organizations have.

The general topics that were used during the pre-study interviews were:
-Product development, and its processes
-Roles and responsibilities, organizational structure
-Combining hardware and software product development

In the second interview phase, post pre-study, the authors used semi structured interviews which consists of a series of predetermined questions but with allowance for follow-up questions. This structure enhances the flexibility of the interviews and leads to a more detailed and richer answer from the respondents. It will also enable the authors to dig deeper in each of the respondents' area of expertise, hence find real and valuable input and information for the study. (Bryman and Bell, 2015)

An interview guide (Appendix 1) for the semi-structured interviews was developed with focus on the thesis's research question and sub-questions but also to cover areas discovered from literature. The guide of questions was produced and developed in an iterative process derived from the findings from the pre-study combined with the updated theoretical framework and before put in action tested together with experts from Goovinn. The questions are characterized as open-ended to avoid leading questions and in that way get a biased answer.

All interviews were recorded with a microphone and afterwards directly transcribed in order to not miss out on important data. We also sent out the predetermined questions in other words the interview guide or the checklist used in the unstructured interviews to the respondents in advance to let the interviewees prepare and think about the questions/ areas, this aimed at increasing the

validity of the answers. (Bryman and Bell, 2015)

To mitigate the risk of gathering biased data, several techniques were applied. All interviews were carried out with at least three persons at each company. This led to a more accurate understanding but also enabled the authors to find differences within each company. The respondents also had different titles, roles and responsibilities which further lowers the risk of biased data as the authors could grasp a comprehensive top-down view in the companies. (Bryman and Bell, 2015)

The interviews were performed on site at the business unit or at Goovinn and scheduled for one and a half hour each. According to Bryman and Bell (2015) and Holme and Solvang (1997) meeting face to face increases the chance to facilitate a mutual understanding and avoid possible misinterpretations. Bryman and Bell (2015) further state that by allowing the respondent to meet in her home environment it tends to make them more relaxed which further will contribute to a higher quality of the interview.

3.7 Secondary data

Throughout the research process, secondary data has been gathered in order to gain an understanding of past and present knowledge within subjects relevant to this study. According to Bryman and Bell (2015) this is a crucial part of any dissertation. It is meant to provide a basis on which to justify the research questions and research design and enable the authors to analyze the data in an informed way. A narrative review was conducted due to the qualitative nature of this study, where the basis lies in an interpretative epistemology. This was therefore found most suitable in comparison to a systematic review, as the narrative review is more wide-ranging in scope. (Bryman and Bell, 2015) There is a risk when conducting initial literature studies that the authors may become biased or that they may influence interviewees with their opinions. However, the best practice is that a literature study will support the relevance of the final result (Yin, 2014). The authors of this study felt this to be true, as it also allowed for an understanding of the language within these areas of research, a crucial aspect in order to optimally interpret the empirical results.

The majority of secondary data was collected from Gothenburg University library and useful databases such as EBSCO Business Source Premier, Emerald Insight and Scopus. As explained by Bryman and Bell (2015), these databases are an invaluable source of journal references.

Some virtual documents were also used, in other words documents that appear on the internet. When using these virtual documents, judgement was made regarding their authenticity, credibility, representativeness and meaning, mentioned by Bryman and Bell (2015) as good criteria by which to judge these types of sources.

Another type of resource used was information provided by non-academic institutions that publish policy-oriented research on issues related to business and management. According to Bryman and Bell (2015) these types of resources can be useful when researching a currently emerging topic in management and business. However, we realize the risks of having used search engines such as Google to find this information and have carefully evaluated each source. As suggested by Bryman and Bell (2015) the sites were evaluated based on who the author of the site is and his or her motive

for publishing and also the background of the site in regards to its URL (academic site = (.ac), government site = (.gov), non-commercial organization = (.org), commercial site = (.com or .co)). The sites were also checked to see if they were recently updated and if they seem to be continuously managed.

3.8 Data Analysis

In order to analyze the complex situation of product development the authors have relied on grounded theory. Grounded theory work as a tool to analyze the qualitative data, characterized as an iterative way of developing the analysis and data collection in tandem. This being said, the authors did theoretical reflections at the same time as conducting a multiple case study of product development. The gathered data was interpreted and coded through a thematic analysis during the research process. As the interviews were both recorded and transcribed it enabled the authors to double-check the information and correct possible mistakes or misinterpretations. The authors believes that this is the only way of making the coding as correct and accurate as possible, that consequently increases the reliability of the study. (Bryman and Bell, 2015)

3.9 Authenticity and Trustworthiness

Validity and reliability are a known measure to evaluate the quality of a thesis. Among researchers different thoughts regarding qualitative studies exist and according to Bryman and Bell, (2015) other criteria are better suited to measure this quality. Lincoln and Guba, (1985) and Guba and Lincoln, (1994) argue that two other measures, authenticity and trustworthiness, are more fitting for qualitative studies. The latter of the two is divided into four parts: credibility, transferability, dependability and confirmability. These five concepts together create the foundation of critically judging the quality of a qualitative research.

Authenticity considers the wider political impact of research and includes aspects such as fairness in portraying different viewpoints. We believe that we minimize this issue by conducting interviews with respondents with different positions within each company. This will provide a fairer picture for the study as the situations are looked upon from different viewpoints. Having semi structured interviews further strengthens the fairness in the study by enabling the respondents to add additional thoughts. Recording interviews will also ensure that data is described as correctly as possible.

Credibility is one of the pillars of trustworthiness and refers to how believable the research is and the quality of the gathered information. In order to maximize credibility, close contact was maintained with Goovinn who aided in making sure the questions for our interviews were formulated in an understandable way. The topics for the interviews were also sent in advance to the respondents, allowing for higher quality by receiving more thought-through answers. There was also a clear idea when constructing the interview guide that aimed to build up to the main questions, making sure to begin with more general questions. This was done in order to make the respondents feel comfortable and hence provide us with truthful and genuine answers. The clearer and more honest the answers are, the more believable and credible the data will be.

Transferability describes whether the findings can be applied to other contexts or not, and although qualitative research cannot be fully generalized, there are things that can be done to increase the level of transferability. This study will look upon four companies that are limited by predetermined characteristics described in section “delimitations”. Deciding upon some delimitations in this way increases transferability to other companies with the same profile, although not to be mistaken as generalizability to a large degree.

Dependability refers to the chance of receiving the same result if conducting the same study a second time. It takes into account the consistency and transparency of the findings and judges how well the processes in the study are accountant for. The interview guide will strengthen this criterion by having the same foundation in the questions. However, using a grounded theory that enables authors to move back and forth between interviews limits the dependability. To mitigate this risk, interviews will be recorded, transcribed and thematically analyzed to minimize the risk of losing data.

Confirmability refers to objectivity and is reduced if the researcher lets their own values affect the results of the research. Bryman and Bell (2015) argues that it is almost impossible to gain a complete confirmability in a qualitative research. In this case, neither of the authors had much existing knowledge regarding this area of study, providing an advantage in the sense of coming in with an open mind. Additionally, to enhance the confirmability the authors tried to search for extensive literature that had different reasonings to confirm what is what and to eliminate the connection with the gathered empirical findings. Bryman and Bell (2015) further state that having a log and discuss the topic with experts within the field gives objectivity.

4. Empirical findings

This chapter presents the findings from the interviews conducted with the respondents from the four case companies involved in this study. The companies are presented one by one to provide a logical understanding of each company's current development process, the recent changes that have been made, the factors that influence the way they work today and the benefits and challenges that they experience. For every section that is discussed, a summary of each respondent's' answer is given.

4.1 Case companies:

4.1.1 Company A

Company A offers services within the orthopedic and aerospace industries with their additive manufacturing solutions. Their range varies from 3D machines, auxiliary equipment, software, metal powders and service and training to customers. The operation and sales take place on a global arena but the headquarter and R&D section are centralized in Mölndal, Sweden.

4.1.1.1 Respondents

A1: A1 is the Vice President R&D at Company A since March 2016 and is responsible for the full research and development of their Electron Beam Melting systems, their system for 3D-printing. The development encompasses software, electrical and mechanical development, as well as test and verification through the R&D laboratory.

A2: A2 is a Project Manager at Company A since 2014, in charge of development projects and process projects, mostly within product development. A2 is responsible that the delivery of a project meets the set expectations to a certain time and cost. In this role A2 synchronizes different functions such as development, production, aftermarket etcetera.

A3: A3 is the System Development Manager at Company A and has had this role since August 2015. The main responsibility is to manage the hardware development teams which consists of electrical and mechanical development. A3 makes sure that the teams have the right competencies to be able to deliver to the projects and manages the work process of his competence teams.

4.1.1.2 Product Development

Respondent A1

The model they have today is a hybrid. At company level they have a Stage-Gate and this is something they will maintain. In R&D however the development teams plan their work based on Agile development methods. They are Agile in the way that they work in Scrum Teams and plan their work according to 3-week Sprints, prioritizing different tasks within these Sprints. All the teams have the same rhythm and start and stop their Sprints at the same time. Disturbances can occur and in those cases they need to adjust to handle them but in general they try to change as little as possible

in the scope during the course of a Sprint. The software team has been working with Agile methods since two years back but for the hardware teams this is a new way to plan their day-to-day work.

The largest difference from a fully Agile organization according to A1, is that the teams should optimally be able to deliver a function, product or customer value directly from the team. That is not the way they have it today as the teams are competence based (software, mechanics, electronics). This leads to a need for a lot more synchronization at the higher level in order to decide what needs to be done within these teams. They have not been able to divide them into functions or subsystems, although this is a long-term goal, but this is today due to that their products are not built in that way. In order for this to happen they would need to divide the product architecture into subsystems and then use this to design appropriate functional teams with a couple engineers from each competence team. These teams would become responsible for a certain function/subsystem and own it completely, both when it comes to developing it and maintaining the existing. This would require a system level where every function is integrated and then released. They are however not there yet and hence work in the hybrid model with competence teams working in a common rhythm and through common releases merge their work to create a functional result. When they develop a new product, they have many Project Managers that are responsible for different parts and a program manager at system level that holds it all together. The Project Managers deliver to the program and this is where the integration happens.

Another main aspect of the product development today is that they have taken a large step towards having the line deliver to the projects and the ownership of the delivery belongs primarily in the line, not in the project.

R&D is most involved in the Stage-Gate in the development phase but also in specification and concept development. Once their work is delivered to production they become more of a support function. While the company follows the Stage-Gate model quite strictly, for the engineers they get a set of tasks that need to be done and it is not so important in which stage they are doing something in a gate model. It is up to the Project Managers to make sure the tasks that need to be completed before a gate are added to the Backlogs and completed within that time frame.

In an Agile organization the Product Owner is the sole person responsible of setting the priorities for the team in the Backlog but today they do not have that role. They want to have this role in the future by making those who are currently managers for the competence teams into managers for a certain competence team and giving them this new role as Product Owner for that team. However, as of now they work in what they call “Strategic Buckets”. Each team spends 40% on New Product Development, 30% on maintenance of existing products, 20% on potential ideas for the future and 10% on improvements. For the 40% that regards new products, the Project Managers get to decide what the teams should focus on and for the rest of the time the line manager decides. When there is too much to do the Project Manager and Line Manager need to sync and decide what is best to focus on. To decide what to prioritize amongst the 40%, the Project Managers need to communicate with each other. It is all about communication, irrelevant of which work process is chosen. It is all about creating transparency in the organization.

Respondent A2

A2 explains the product development method as a Stage-Gate based method including six gates. Within this gated model, the whole R&D department works in three weeks Sprints. In order for the development work to be manageable and overlooked, the R&D department has release dates that apply to all function teams within the department. The predetermined dates control at what times things need to be done in order to be able to send it further onto validation.

A2 says that all departments commit to a Stage-Gate but the R&D department also commits to their Sprints which creates confusion sometimes. Within Company A, R&D is the only department that works with Agile methods. Today the function team delivers completed tasks to the project as opposed to before when function team members were allocated as resources to the projects. To match the capacity with the demand Company A has created quarterly meetings, in order to plan and schedule with a longer horizon. Additionally it create an opportunity for the function teams to structurally coordinate between each other to match the tasks within respective function team's Backlog.

They have a Scrum Master in each competence team. They do not however have Product Owners who drive the Backlogs. The Project Manager is rather the one who decides which tasks relating to their projects should be added to a Sprint and the prioritization amongst these tasks.
A2 emphasizes that they have a need for somebody who coordinates between the teams, such as a Chief Product Owner.

To start a project a prestudy is often carried out. This study tries to reach a point where success assured is reached, in other words where the product is almost sure to be a success on the market and the project will end up with a positive net present value.

Respondent A3

A3 explains Company A's product development method as following a Stage-Gate model. The process follows a traditional sequence where they start with a project request that, if accepted, turns into a Requirement phase. At this point a Sponsor is chosen in relation to what importance the project has for the firm. The Project Manager further brings the project to the next step by fine tuning the details such as timeframes, product specifications, resources needed, etcetera. The next phases before Launch are Concept development, Product and test development, Validation and Industrialization.

A3 states that this method gives a clear expectation of a delivery from the team both in regards to quality and time, meanwhile the organization is better in-line and in-sync working with the same language and philosophies.

A3 explains that on a day-to-day basis Company A follows Scrum, with Sprints. Every Sprint starts with a meeting, created by the Scrum Master, with the Line Manager for the competence team and the Project Manager. Together they decide how many points activities will be given, to decide how many tasks that is feasible to complete during the Sprint. For every Sprint there is a Backlog grooming with the Project Managers on Tuesday, a Backlog grooming with the competence team's

Line Manager on Wednesday and on Thursday a joint conflict review. If a conflict occurs, the Vice President R&D currently is the one deciding how to proceed. On Fridays, the competence team has a retrospective meeting, deciding what went well during the Sprint, what went wrong during the Sprint, and what could be done differently to improve.

An argument that A3 often gets confronted by, is that it is tough to work with Agile methods dealing with hardware, due to long lead-times, high costs, inflexible material etcetera. A3 says that even if Hardware has those characteristics, you can still plan and execute activities within a Sprint format. It is rather about finding a Definition of ”Done” that fits the situation, perhaps not always delivering a complete product. What could be accepted as a "done” Increment at the end of a Sprint could be things such as the order of a component, control of the tools, examining of material or testing and verifying of a certain component. By changing the mindset that you don't need to deliver a complete working product Increment at the end of each Sprint, hardware is as easy as software to work with Agile methods.

4.1.1.3 Recent changes to the product development

Respondent A1

A project was started before A1 came into the organization that was meant to look over their project model. In the midst of this project, A1 came into the organization with the objective to go from taking resources from the line and putting them in projects into a process with more continuous deliveries from the line. If this was done through Agile methods or not was not the main factor but this was a good way of realizing this and reaching the objective of the line delivering completed tasks to the projects instead of delivering resources. A1 had positive experience of working with Agile methods from a previous company and felt it would be a good way to develop the R&D organization at Company A as well. A1 was brought into the organization in order to help the company go from being a small research company to an industrialized company that needs to be able to be a major player in delivering to the aero industry, the medical industry etc. Based on A1s experience this is a good way to manage product development to reach the new objectives.

Earlier they worked in projects where they pulled together a team, sat them in the same room and then they worked until the project was done. When the project was done - poof! - and the team was dissolved and each person was assigned to a new project and worked with something else.

The Project Manager has a different job since they do not have their own project resources as before. Instead the Project Managers makes orders to the competence teams who then deliver the finished task back to the project. This change has not been entirely positive for them since they are very used to being able to control their team.

What was developed in the project did earlier not land in the line and there was no clear ownership of it afterwards. In the R&D organization there was no clear place to receive these things. They are now organized in Agile teams and a clear difference between these teams compared to the project teams that they have had traditionally is that the project teams only live for a certain time period and don’t have responsibility for maintaining what is created. When the project ends the team is dissolved. With Agile teams the idea according to A1 is to keep them over time. The functional teams

that they want to move towards will organizationally be very similar to the previous project teams but the difference is that they will be stable over time. This would however require a larger R&D organization since the function teams would need to include more than one person with each competence and now they do not have that many employees.

Earlier everything followed a Stage-Gate model with projects. It followed a sequential flow, which is still the case on a company level, but not for the daily work within R&D. Another change is that they today try to create projects that involve all parts of the organization such as aftermarket and production at an early stage. A1 is new in the company but has a feeling that it was earlier very R&D focused. R&D developed a machine and then presented it as "Here it is, now build it, service it, take care of it. Now we've done our part." Now they involve other areas earlier to be able to understand requirements, test-build the machines etc.

Respondent A2

A2 explains that Company A has changed from being a research company producing 3-5 machines per year to an industrialized company producing 40-50 machines per year. Validation has become much more important than before as the reliability of the product is the most important factor for the customers.

In the fall of 2016, Company A started a process of implementing Agile methods throughout their R&D department. While the software team had been using these methods before, it was a large change for the rest of the organization. The Vice President R&D (Respondent A1) is a driver in this change, much due to earlier experience of Agile methods within software development and a current interest in how this can be adapted to hardware development as well. A2 says that the implementation of Agile methods has changed the role as Project Manager. Previously, there were teams fully dedicated to A2's projects and A2 owned these resources. Now the resources belong to the competence divisions and these teams report back to the projects when tasks are completed but the Project Manager has no control over who does what.

Respondent A3

A3 explained that a major change has been the implementation of Agile methods in units other than software, who were earlier the only team using it. A3, who is manager for the hardware team, was positive to the idea of applying Agile methods for these teams and perceived it as a good step towards having a more unified process and method for the whole R&D department. They have now all adopted many aspects of Scrum such as the planning of the work through Sprints, the events surrounding it and they prioritize all their work in a Backlog.

4.1.1.4 Factors that influence the product development

Respondent A1

An internal factor that has affected the way product development is managed today is that A1 came into the organization with positive experience from working with Agile methods and felt it was a good fit for Company A's R&D in the new phase of the company.

Another factor was that when the Agile methods were implemented, the R&D employees were in general positive to the change, especially the line managers and engineers. A1 only articulated a need for continuous delivery from the line to the projects and that the ownership of resources should be in the line, and then it was the mechanics team that decided to realize this by working in three week Sprints as this is the way the software team works, who have worked with Agile methods for two years now. It also came from underneath.

Respondent A2

A2 says, the implementation of Agile methods is the upmost important internal factor that affect how product development is performed. This have led to several changes in the organizational structure, work methods, responsibilities, management etcetera.

Respondent A3

As A3 explained, the Software team was a pioneer in implementing Agile methods and have been doing it for quite some time. Due to the fact that the hardware and software are closely connected in the development of the end product, A3 who is responsible for the hardware competence teams felt that it would be beneficial if they also started working the same way to be able to follow the same rhythm. The close collaboration between hardware and software has hence been a factor for why they are now trying to implement Agile methods throughout the entire R&D department.

4.1.1.5 Benefits of the product development

Respondent A1

A1 says that the way they have it now with a half-half version does not work optimally. However, there are some strong benefits from the changes they have made. It creates continuity in the work through permanent teams and responsibility, ownership among employees, and it helps to keep and spread competence.

By having a team that is self-managing and that feels ownership, the quality of the work increases, especially when they are responsible for the whole process from new product development to maintenance. A1 says: *"If you give people responsibility they will grow, if you give them mandate to make decisions they will make good decisions".* A1 continues and argues that this is not possible by controlling the projects team in detail. Instead A1 explain that one should create a team, give them tasks, and let them figure it out and the end result will be better. It takes a bit of time to get people into this mindset but once it is achieved A1 thinks it is much better.

The teams also feel that there is a security in that the teams need to deliver the tasks together and therefore there is always mutual responsibility and support within the teams to complete the tasks in the Backlog.

The Stage-Gate is suitable for an executive management team to be able to make decisions. It is a good interface for these decisions. A1 says*: "I can set up a fully Agile organization within R&D and still interface this towards a Stage-Gate. This is not an obstacle."* The end of a Sprint does not even need to synch with the gates of a Stage-Gate as the Scrum Teams can also deliver things in the middle of a Sprint. They have a couple different versions of how the gates are and what needs to be

done depending on the characteristics of the project that they adapt to fit the requirements for that particular

Respondent A2

A2 says that today Company A is positioned in limbo, and it is hard to reach benefits by not fully commiting to one method and philosophy. A2 argues that the team spirit may have increased within the competence units but the output has decreased so there is no actual progress.

Respondent A3

A3 argues that due to the implementation of the Agile method of Scrum, the Mechanical and Electronic teams that A3 is responsible for have become more integrated and the communication within these competence teams is today much better than before. Both of them co-work with planning and have developed a mutual way of executing tasks when they are involved in the same projects. Further, it allows know-how to be shared between the team members in a better way than before. A3 additionally argues that the teams also feel more connected and the team-spirit is enhanced.

4.1.1.6 Challenges of the product development

Respondent A1

A1 sees a challenge in making Agile work in a whole R&D organization, due to the different characteristics of hardware and software. Continuous delivery is tricky when it comes to hardware development as the first stages of the process will produce mostly prototypes and testable products, but not products that can be launched to the end customers and market. A1 says they need to find another way to work with this in order to achieve the feeling of continuous delivery.

Another challenge, according to A1, is the role of the Project Managers. In a fully Agile organization, as is found mostly within software, the project concept does not exist at all. However, A1 does not see that the project structure will be removed at Company A in the near future. What does become difficult is the role of Project Manager as they no longer own their resources as before and the teams are now instead competence and deliver to all projects at once. The Project Manager needs to speak to all the different competence teams since they are responsible for the function, for example the improvement of the beam cannon, and this requires people from all competences and for those teams to be synced. This creates a difficult situation and a lot of work for the Project Managers since they feel a need to maintain constant contact with all teams. The Project Managers feel less control than before as they no longer have project meetings with a dedicated group and therefore become insecure regarding what is actually being done within the teams to meet the project requirements. They become more isolated from the operative day-to-day work, no longer detail plan the work, and generally end up with a more administrative role, waiting for deliveries from self-managed teams. A1 feels that the Project Managers at Company A are extremely operative which obviously sets them up for quite a culture clash and this is certainly a challenge. A1 also discusses the risk of double administration due to ambiguous perceptions of the responsibilities of the roles within the product development process. For the Project Managers there are many challenges today that relate to the synchronization points being far too many. A1 suggests that if they instead had functional teams, the project concept and the Project Manager role would not be needed. They could then instead have a

Product Owner for every function, a permanent role for a permanent team. This would mean that the line delivers to a mutual release with their respective functions that through a common interface could be easily pieced together. A1 says that even in a fully Agile organization where the Project Managers within R&D are removed, A1 says that they still need a Project Manager at company level to sync the R&D deliveries with aftermarket, production and other departments, something A1 says could be called a Chief Product Owner or Release Train Engineer in Agile terminology. This person would be the one to sync R&D with all other departments and become the interface of the deliveries of the Sprints at a program/company level. Today the R&D Project Manager is also the Project Manager at a company level.

A challenge that arises when they want to take the Agile methods all the way and create function teams with different competences is that they need to be a larger organization. Each competence area should be represented by at least two people within these competence function teams to make sure there is a possibility to work on things together and exchange knowledge. Today a challenge for this to be able to happen is that the R&D department needs to grow.

Further, a challenge is that they need to find a way to break down their products into subsystems with more modularity because it is these subsystems that will help them be able to put together competence teams that will take care of one or more subsystems. It will be a challenge to find how to break up the full machine into subsystems that can be tested on their own and also find interfaces to be able to test these subsystems together. Today there is a certain difficulty when syncing the competence teams' work into a completed product. When the work from the different teams is put together to create a new product, they have releases where they test it in a full machine, but this step is always a bit messy. Today they have a release/configuration manager that keeps track of the changes that need to be done to the product which is good, but A1 says improvement need to be made.

Respondent A2

For A2, in the role as Project Manager, this new way of working has created a challenge because there is now nobody who is fully committed to each project. A2 personally feels that it was easier to work with projects when the engineers and developers were assigned to certain projects, creating a cross-functional project team. A2 perceives that there is a need for more meetings than before, many which do not add much value. A2 says: *"If you are good at programing, then you should program. Not manage meetings, document tasks etcetera"*. Instead of sitting down one time with the project team, A2 now feels a need to go around to the different competence teams and talk to them one at a time. A2 says that one of the challenges is coordinating an R&D department that works with Agile methods with the rest of the company that does not. For example, when prototypes are needed within a project, these are provided by the production department which is not Agile and therefore does not follow the same pace as the Agile R&D. It is up to the Project Managers to sync the work between these departments but it is not always easy.

Respondent A3

When discussing some challenges generated from the "setup" and methods for product development at Company A, A3 says that by delegating responsibility further down in the organization, the risk of having too many "chefs in the kitchen" increases dramatically. A3 says that

Project Managers often feel that the responsibility of executing a delivery on time are still there but the power they have is substantially decreased. Instead of having a team that they are more or less in full control over, they have now needed to change and become "Agile" Project Managers, something many do not agree upon.

A3 feels that the period of change has been characterized as a bottom-up transformation which absolutely is good, but the executive management needs to adopt and change as well. A3 brings up an example, that the Stage-Gate could be time-synced with the Sprints, hence the gates occur at the end of a Sprint. A3 thinks that the Product Board that creates the orders should take a more active part in the daily operations and schedule to better match the Stage-Gate with the Sprints.

4.1.2 Company B

Today Company B is one of the leading manufacturers in the world of equipment and consumables for welding and cutting industry. They operate within four fields: Manual Welding and Cutting Equipment, Welding consumables, Welding automation and Cutting automation. Company B is further divided into five geographical sale areas, Europe, North America, South America, Asia-Pacific and India but the global product development within the Manual Welding and Cutting Equipment is centralized in Gothenburg, Sweden.

4.1.2.1 Respondents

B1: Respondent B1 has an official role at Company B as Manager for Systems, Software and Welding Performance and has worked at the company since 2013. Beside this role B1 is also involved as a supporting Team Coach for some of the Agile teams within these formerly mentioned areas of responsibility. Furthermore, B1 has taken on a role as Project Manager for one of Company B's largest projects.

B2: Respondent B2's official role is as Manager for Delivery Team Power Source and is in this role responsible for the hardware aspects of Company B's products, in other words all areas relating to mechanics, power electronics, electronics and testing. B2 has worked at Company B since 2011.

B3: Respondents B3's official role is as Platform Owner within Heavy Industry Products. B3 has worked at Company B since 2010, previously within Equipment Automation and Industrial Design. Today the focus has changed towards a more customer orientated role as Platform Owner. The main responsibilities are divided between two areas, ensuring the fit between R&D and Market requirements and secondly act as a Project Manager in smaller projects with no need of an external Project Manager.

4.1.2.2 Product development today and its characteristics

Respondent B1

B1 thinks that as of now, Company B's R&D unit works in an undefined way, as no formal changes have been made but rather many informal changes. Since these changes were made, they use Sprints

which work as a short term planning tool with the most common events such as daily Scrum, Sprint review and retrospective. Yet B1 argues that it is very important not to forget that the long term planning directs and helms the short term planning not vice versa. The long horizon has fixed deadlines whereas the work within the Sprints and the resources are flexible, in other words the Stage-Gate controls and assists the overall plan that consequently controls the Sprints. Further the Stage-Gate provides checkpoints for executive management to make decisions regarding the future of the project.

The current Platform Owners more or less need to act as a former Project Manager. After the Market department decides on the market requirement specifications for a project, it is given over to the Platform Owners who translate these specifications into technical requirements. The Platform Owners later prioritize between the different demands on the function teams. Prioritizing the demand does not mean controlling the team, rather just creating a sequence of priorities but letting the team themselves decide how it should be done. The Platform Owner continuously follows up the projects, keeping track of a checklist of done tasks and also passes that information further up within the organization.

Respondent B2

B2 identifies that Company B is lacking a clear product roadmap and a method for handling their project portfolio. According to B2, they would benefit from a general model for handling the portfolio, in order to better understand and prioritize among projects depending on the current capacity. While the product development projects are maintained within a Stage-Gate model, they work with Agile Sprints throughout the process. These Sprints are full of activities that lead to continuous deliveries, helping to ensure that the rhythm of the work in the Sprints matches with the overall Stage-Gate model. B2 explains that the Definition of Done is slightly different for the Hardware team compared to the Software team as the Hardware team does not need to deliver a complete working product Increment. The Definition of Done for a hardware team could instead be characterized as the placement of an order for materials or the testing of a material or function.

B2 explains that the start of their development process is when the Market department's Product Manager identifies a demand from the market, further develops the idea together with the customers to see which characteristics are important to them, and thereafter sets a market requirement specification. The next step is where the R&D department is brought into the process and requirements are matched with costs. The Product Owner contacts the Platform Owner who in turn contacts a group of senior engineers to further develop the requirements and perhaps adjust them to fit the competence of the engineering department. This process ends in a full requirement specification and the creation of a concept. Throughout the development process there is a constant dialogue with the market division of the company to ensure that the development is moving in the right direction and that there are no misinterpretations in the requirements of the market on the end product. They have Core Teams that consist of engineers and developers from different divisions that handle this dialogue, and it is up to the teams themselves to decide who will belong to which team and which tasks. B2 feels that this is an area where they have adopted Agile methods.

Respondent B3

B3 describes that the Market department starts by investigating if there is a gap in their product assortment where an update or a new product is needed. When such a need is identified, this is interpreted by the R&D department in a requirement specification paper, which finally either becomes a spark for a new project or is rejected/paused until later. The client that places the order per see is the Market department but what is important and not to forget is that R&D interprets these requirements, and formulates a concept. In order to not misjudge this specification, continuous end customer visits are performed, for example by B3 in the role as Platform Owner.

B3 explains that Company B work with five stages after a project has been started, where the start of the project is the need of a customer and the end a project a complete product. During a project sequence there is constantly a battle between the three most important factors when working with product development; cost, quality and time to market. B3 says that the Platform Owner should focus on *what* should be done and the team should focus on *how* it is done. The Project Manager´s responsibilities are time and cost whereas the Platform Owner´s responsibilities are the quality aspects. Company B created the role of Platform Owner to ensure that the quality is kept.

B3 explains that: *"To organize a company with several departments there is a need for some sort of project structure with a clear start and stop for the work that needs to be done."*

4.1.2.3 Recent changes to the product development

Respondent B1

Three years ago a change towards Agile methods was incorporated, that basically pushed a recipe onto developers to work in a certain way. B1 further explains that the teams were forced to divide tasks in smaller pieces and document everything and a feeling of micro management from top management began to grow. Company B changed to working with pure competence based teams, in other words all software engineers belonged in the same team, and all tasks from projects involving software were given to the software team as a whole and not to the software representative on the project team as before.

An additional change was the removal of the Project Manager position. Instead Company B created a core team for each project with representatives from each competence team that are affected by the project. The aim is that these representatives sync the rhythm of their competence team with the other competence teams. During the last few weeks a change back towards reinstallation of the Project Manager role has been a topic at Company B. Currently they have two Project Managers who are used in two big projects.

Respondent B2

A large change that has been made is the introduction of working in Sprints where B2's teams, which work with the hardware aspects of the product, all work in 2-week Sprints which begin and end at the same time and therefore move at the same rhythm. The software division, however, works with a slight variation when it comes to the length of the Sprints, B2 informs.

B2 further explained that another important difference from before is that the employees have been given a larger responsibility and are now trusted to manage their own work and the work of the other colleagues on their team. Nobody else tells them which project they should be working on, for example, as these decisions are decided upon at a team level. The teams are required to be efficient over time which creates incentive for the employees to learn new things instead of only specializing on one certain area, as a broader knowledge bank per employee is often a resource for the team in the long run.

B2 explains that a reason for the change was that there was earlier a habit of sorts within the company where orders and requests came into the R&D department from all parts and departments of the company without much structure. Now they have everything sorted in a Backlog, and the priorities are transparent and clear.

Further, B2 explains a major result of the change being that the new-found autonomy of the employee teams has led to a reduced need for B2 to control in detail the daily work of those divisions which he is Manager for. Also, the Project Managers do not have as much work per project as they did before, also due to these more self-managing teams, which means they can take on several projects at once. Instead of needing to plan everything in detail, Project Managers today can focus on facilitating and ensuring the end delivery and on coordinating with other stakeholders, for example other divisions within the company.

Respondent B3

Today the organizational structure is under construction, after a heavy period of change that started three/four years ago. The change towards using Agile methods was implemented and the roles within the organization changed. As said, this setup has been under construction and Company B is still examining if further changes are to take place. Right now the position as Project Manager is being phased back into the organisation after initially being removed. Without a clear Project Manager B3 feels that there is a clear gap in the communication between the different departments such as R&D, Production, Purchasing etcetera. According to B3, the thought with Agile methods is basically that engineers are supposed to not be disturbed during the Sprints but instead be able to focus on the task. Further, the engineers were also given more responsibility regarding technical issues of the product as the decisions were pushed further down in the organization.

4.1.2.4 Factors that influence the product development

Respondent B1

B1 explains that the former R&D Director that came in was a huge influence towards their current way of managing their product development. B1 argues that the top management puts a lot of effort into optimizing processes while the B1 argues that it is the skill and competence needed for a project that makes the biggest difference. B1 says*: "A skilled Project Manager will manage to deliver a project, with or without a clear and rigid process."* Engineers still have the same job, to construct, and when it comes down to it, it is about common sense, not whether the flow is directed from a Stage-Gate or Agile methods. However, B1 also says that an influencing factor is that the integration between hardware and software at Company B is getting more and more important in their end products and a well-functioning interaction between the teams that develop these functions is

necessary, in large part achieved by using a common method such as Agile throughout the R&D organization.

Respondent B2

B2 argues that the change towards Agile methods was from the beginning starting from the top with the replacement of a R&D Director, but there was also a pull from the engineers. Company B wanted to increase motivation of the employees and one way of doing this was the implementation of Agile methods.

Respondent B3

B3 argues that one of the reasons was the addition of a new R&D Director, that previously came from an Agile environment. There is seldom an external pull for new features in an existing product area from the customers, but there is rather an internal demand from the board. Due to the high quality of the products often a life period stretches many years, hence not too many releases. B3 thinks it comes down to keeping the position at the market and continuing the development work in the company.

4.1.2.5 Benefits of the product development

Respondent B1

B1 thinks that even if the changes that have been made towards more Agile methods have created a turbulent time within the company which at first led to lower efficiency, the end result has been some very good benefits. The engineering teams have developed into becoming "masters of planning", even if each of the teams have found their own specific model. The teams work with Sprints of different lengths and also use different planning methods, to adapt it to their own needs.

An economic benefit of having a more autonomous team is the lesser need of managers to control and steer the organisation. This also minimizes the Project Managers interface by just having a Core Team instead of the whole organization, something that for sure decreases the workload and communication need for the Project Manager.

B1 further says: *"The only thing you know for sure after making a broken down project plan from the beginning is that it for sure will not turn out exactly according to that plan.",* and therefore the implementation of Agile methods has been beneficial for them as it has become a good complement to the long-term planning of the Stage-Gate.

Respondent B2

Respondent B2 emphasizes that a main advantage of their current product development model is that the employees feel ownership of their own activities and a sense of empowerment. B2 says that this has led to better efficiency as the employees are happier and more willing to contribute. B2 states: *"Some developers have even told me that if we go back and leave Agile methods they may quit",* showing that there is a positive view of Agile methods within the teams. Another benefit of their way of working is that low-performers cannot get away with doing less work than the rest of the team as it is now much more transparent regarding who has done each individual task. Since the employees now report more to the team and each other than to the manager or Project Manager, it

becomes very clear within the team how everybody is performing. As they have daily morning stand-up meetings, employee X now tells the whole team beforehand what they will be working on that day, which plays a part in this increased transparency. B2 has noticed that the culture has changed from one where employees sat back and waited on directions from the Project Manager to one where these same employees now lean in and actually ask for responsibility for certain tasks. This is a good development, according to B2, since the Project Managers may not always know exactly who is best suited for each task.

Respondent B3

By letting engineers divide themselves in flexible teams, smaller issues and problems are possible to solve, hence having people in robust and rigid locked team often kills that opportunity.
Having visual planning and letting the team more or less divide their own time, both gives a chance of learning for the team members, makes it easier to plan the future by having more precise judgements and creating better involvement by everyone.

B3 thinks that the new position as a Platform Owner has enhanced the organization but also Company B´s finalized products. The risk of misinterpreting the market division is obvious, but by having a skilled Platform Owner communicating with a new interface mitigate this risk. Now the Platform Owner have a constant dialog with the Product Manager, better end customer knowledge and at the same time closer connection to the team-members.

4.1.2.6 Challenges of the product development

Respondent B1

Having the organization positioned as it is today, B1 discusses some drawbacks. Within the project there is a lack of managing and leading the delivery, something a Product Leader would be responsible for. Today our Project Managers need to develop and realize that the time when they owned their resources has passed and instead they need to be able to cooperate and delegate with the core team member representing an individual competence team. Another problem identified, is the lack of cooperation and management between the Platform Owners. Without a clear vision and portfolio management Company B loses the overall picture and the Platform Owners tend to prioritize “their” projects even if it might not be the most vital for the company. One way of mitigating this problem according to B1 would be to fill the gap of a Platform Management Office (PMO) role, a manager for the Platform Owners helping them to prioritize and controlling the Portfolio windows.

Respondent B2

One of the main challenges to the model used today, according to B2, is that it is a bit difficult to regulate resources which sometimes ends in an overload of work for the teams. This problem arises mainly due to Platform Owners who do not agree upon the priorities of the various projects. To solve these issues, B2 says the company is in need of someone who looks at the big picture and can prioritize among projects and tasks based on what benefits the company most at the time. Another aspect that B2 feels has been a challenge is that there is a risk of over-planning. Every other monday, at the beginning of a new Sprint, the teams have a planning meeting. In the beginning, these meetings took a full day which was not very time efficient. While they have now improved this

process and shortened the planning time, it is still quite time consuming. Instead of having a Project Manager help the employees plan their work, the functional teams now help each other with this planning process. According to B2, this creates more of a dialogue which is good, but it also requires that there are people on the teams willing to manage these discussions.

The process for product development at Company B is, according to B2, a bit ambiguous between different parts of the organization at the moment. Since the R&D department communicates with many different stakeholders such as the production, buyer, and market divisions, who do not work with Agile methods.

Respondent B3

There is a risk of letting the engineers have the responsibility of both the technical solutions and planning of the work. B3 believes it is hard for them to have the whole picture and to mitigate the risk between cost, quality and delivery time.

4.1.3 Company C

Company C offers an extensive product range with everything from professional machines to tools for home users. Their business areas are concentrated within building and stone industry and offers machines, diamond tools and all products needed for cutting, drilling and polishing. Today the R&D-center for tools is centralized in Jonsered, Sweden, and it is also at this location the Headquarters are placed while they have sales in more than 70 countries.

4.1.3.1 Respondents

C1: Respondent C1 has an official role at Company C as Research and Development Director and has been there for four years. C1 has the overall responsibility of the R&D unit.

C2: Respondent C2 has an official role at Company C as PMO Manager. Currently in charge of thirteen Project Managers working explicitly with delivering projects. The main responsibilities involve coordinating resources between projects and always comparing the three criterias: cost, quality and time to market.

C3: Respondent C3 has an official role at Company C as Software Engineering Manager. He has been at Company C since 2012 and started at a Software Engineer. Currently his responsibility is managing Software Engineers and to optimize their internal methods and development creating their own development-DNA, further C3 control and staff software competences different projects.

4.1.3.2 Product development today and its characteristics

Respondent C1

C1 explains that Company C uses a Stage-Gate where the stages are as follows; Specification Stage lead by an Investment Gate. After this decision funding is added to move into the Development Stage

I later followed by Development Stage II. After final development work are done, the procedure moves on into an Industrialization Gate, Production gate and finally sale start begins.
C1 continues and explains that the project culture remains although software and electronic teams have adopted Agile methods compared to hardware competence team that remains with a Stage-Gate based work method.

C1 argues that tighter customer integration as early as possible will guide and improve the quality of the end result in the specification phase used in the Stage-Gate. This is a crucial step in order to form the "right" concept that lasts the whole process, and be able to set the scope directly. At the same time this is hard due to the fact that development sometimes goes in direction towards new business areas which have not been exploited before hence it is not possible to know for sure what to do.

Respondent C2

C2 explains that they use an overall Stage-Gate model divided into several stages and aims to handle their project portfolio. C2 explain that their particular Stage-Gate is a bit different because when they go from one stage to another, they talk about "opening a new gate" instead of "closing the current gate". Suggestions for which projects to go for are proposed by the Product Manager and then approved by top management. The product development process at Company C is driven in large part by the focus on quality. Time and cost are also important factors, but quality is always the main pressure point. They set tough goals and plan aggressively to a point where it is also accepted to be a bit late to market compared to the first estimate at the beginning of the project, something that C2 feels makes them Agile in their way of executing projects. C2 explains that The Product Manager decides what needs to be done to meet the needs of the market. They have Core Teams for each project that meet regularly and from these Core Teams the work is coordinated down to each Core Team member's respective competence team. The competence teams are then left to decide upon their activities based on the set requirements and features. The Project Managers do not control the work in detail for the teams but rather works as a facilitator to help the team deliver. C2 emphasizes the importance of not overloading the teams with work, as an exaggerated input can lead to no output at all.

Respondent C3

A product's life usually begins with a Product Owner identifying a demand from the market. The second source of origin for Product Development at Company C is categorized as Product Improvement, and is often found by a person with a technical experience working in Product Care. To start up a Project, a Product Owner provides a business case in cooperation with technical expertise to a executive management that gives approval to continue. At this point a Project Manager is assigned with a specification of what to be made, at what time and with which quality.

The operational work carried out by the teams is done differently within the organization. The Mechanical team sets their scope quite early and follows a sequential flow completing the tasks, but do not work in Sprints. The Electrical team team works in Sprints where the scope may change during the course of the project. C3 explains that the Software team also works in Sprints, slightly shorter than those within Electrical, using a Backlog with tasks that are labeled as "nice to have" and "must have". There is no formal Definition of "Done", each team has their own variant but all teams try to finish the planned tasks for each Sprint.

C3 further expresses that each assigned project has a group of lead engineers that work as a “core team”, people put together representing different function groups. These members communicate the development of the specific project but not necessarily is doing all the job themselves. The project decide what should be done and when, each separate competence team, how to do it and whom. C3 says that the Project Manager is in charge of the communication for the different departments, such as Production, Market etcetera.

4.1.3.3 Recent changes to the product development

Respondent C1

C1 argues that the company has not made any major changes but that development constantly is moving. Small Incremental changes have been implemented, many which have aimed to develop a good interface between the Project Manager and the different competence teams.

Respondent C2

According to C2, Company C normally works with small Incremental changes with a “learn as you go” mindset. They start by trying something in one area and if it works they integrate it further. These are the types of changes that have been made recently, hence no radical changes have been made.

Respondent C3

In the past, software engineers have been a working under a loose form, sometimes perceived as straggly and incoherent. Now, the software group has a much tighter relationship, and have now together formed a DNA for how the whole group works. By having the same work philosophy stretching over different projects, with documents having the same criterias, several positive outcomes are reached. It is easier to share the tasks required from the function, other functions group feel it is easier to communicate and co-work with software as they know what type och documents and layout it will consist of.

4.1.3.4 Factors that influence the product development

Respondent C1

Product development is surrounded by some problems and C1 argues that different departments are measured on different objectives and criterias. The R&D unit wants to put much effort in the first phases to ensure a successful product, and their upmost important value is competence and experience within the unit. This doesn't entirely match the pressure from the economy department, that solely sees R&D as a cost and wishes to accelerate through the specification phase as fast as possible.

Respondent C2

C2 says that software is gaining more and more focus within Company C products. With that said, the competence teams in R&D will need to further be synchronized that will push the communication and interaction points and places even further.

Respondent C3

C3 has seen an external pull for electrified products rather than petrol driven machines, something that increases the software share for the products. This demand leads to an increased integration between the function teams, something that affect the product development.

4.1.3.5 Benefits of the product development

Respondent C1

The absolute top advantage of using a Stage-Gate model is to create a well-working guideline for the projects and be able to divide tasks that need to be done. It is possible to create checklists where order is needed to ensure the progression of the project.

C1 explains the philosophy of working with parallel concepts and the aim of keeping all possible ideas open until proven to be unsuitable, instead of choosing one idea from the beginning and killing all others. This enables the team to avoid starting from scratch in cases where a concept is tested and fails. In the long run this will both increase the accuracy of producing successful products and decrease the risk of late errors that often end up being very expensive.

Respondent C2

C2 says that one of the main advantages of the current process is that it allows them to be Agile enough to hit the gas or hit the brakes depending on the need at the time. It also creates a high level of transparency and everyone knows what is happening.

Respondent C3

C3 argues that the software division has increased their flexibility tremendously. Now they operate and control their development tasks themselves, and it is easier to adjust resources to different tasks directed from the function's Backlog. This has led to a dramatic increase in the number of tasks that are delivered successfully on time.

C3 argues that team members have become more committed to the projects by creating a sense of solidarity and inspiration instead of being just told what to do. By working in short iterations, there is a feeling that you progress all the time.

The Sprints enable the software team to focus on finding a rhythm amongst themselves in contrast to before when they had to constantly sync with all the other project members from other functions. With the current layout they still sync with other functions but less often than before, more connected to vital integration points such as gates.

4.1.3.6 Challenges of the product development

Respondent C1

C1 says that Company C´s product faces a market where customers demand that their products at different levels are connected, for example to the cloud. This creates a challenge for the company as the software integration in the products are becoming more and more vital.

Respondent C2

A challenge is that there are sometimes synchronization issues between different functions since different teams work at different paces. One integration point where synchronization is important is when software is needed in order to be able to evaluate, test and control the hardware components of a product. C2 feels that the points where hardware and software are synchronized should be further developed, perhaps by using Sprints to match the different functions better with each other with regards to the pace in which they work.

Another challenge is that there are too many requests and orders coming in to the teams from different Project Managers. This leads to team members being jerked from one project to another as the Project Managers are driven by KPIs for their own projects and sometimes all at once want more resources from the teams than they actually have.

Respondent C3

C3 says, it is important to think bigger than just the project itself, to be able to capture the knowledge and create opportunities to learn and develop the operations. C3 wished it would be possible to cooperate between products and projects in a much better way than today.
C3 further discuss that the Project Manager are supposed to have a smaller interface due to the creation of Lead team but having different competence team talking different language and operate in different rhythm it is hard to control, hence the role is under a constant pressure to adopt.

4.1.4 Company D

Company D is active in the implant industry and the main areas they operate in are: techniques for the implant surface, digital solutions and CAD/CAM solutions, Protocol for immediate installation, connections between the implant and abutment, and guided surgery. Today Company D has access to a global network of more than twenty manufacturing centers and is represented in over one hundred countries while the R&D department in located in Mölndal, Sweden.

4.1.4.1 Respondents

D1: D1 is the Director of R&D at Company D since 2002 and is responsible for the strategical planning and overall portfolio. D1 comes with a lot experience in the medical device development and has been at the company for over a decade.

D2: D2 is a Director Project Management Office at Company D. D2 is responsible for increasing the efficiency and quality for the Project Office function and driving and executing global cross functional

projects. Further, D2 coordinates the project portfolio and develops the project related processes. D2 started at the company 2004 but has been in the industry for around a decade.

D3: D3 is a Project Manager at Company D. D3 started already in 1986, with a chemical background and consequently has been working within many fields in the R&D organisation. Today the responsibilities are to bring projects from start to finish and empower team members to deliver and follow time and deadlines.

4.1.4.2 Product development today and its characteristics

Respondent D1

Product development is channeled from different actors to fulfill different needs and according to D1 especially originates from three areas. Incremental product development often originates from the Market department or the product respective Product Manager. In this case customers or the market department themselves identify a possible error or adjustment that would increase the quality of a product. Secondly the more radical innovation product development, often with a lot more risk, originates from their own R&D department but also outside entrepreneurs with start-ups that get incorporated within the firm. There is also a third channel, which is becoming more and more topical due to that the market and product is maturing, and this is the operations units who also want to change the products and develop them further to meet new cost structure and defend the margins.

D1 says that the overall mission is to build a relatively balanced portfolio and plan a pipeline that leads to at least one big release each year within some of Company D product areas. The Product development overall model is directed by a Stage-Gate that involves five stages that follows a pretty strict schedule based on the Design Control framework. Design control is, according to D1, a formal method they need to follow for their product development activities since they work in the regulated industry of medical devices.

D1 argues that much of the power what to invent lies within the R&D unit, they are responsible for deciding what potential ideas to start a study of. This study won't require big financial investments hence the executive management approval is not necessary. To take the idea and study and transform it into a project, it will ultimately demand a lot more resources and at that point the executive management gets involved. Another option could be that a Product Manager create a “mini” business case that is brought up to the executive management that possesses the big picture of the portfolio window and if successful, a project is created. D1 mentions that the same rule applies for Incremental product projects, where the executive management needs to approve a project, something that D1 thinks may be good to change in order to reach a more flexible and faster procedure.

The organization is built upon some roles with certain responsibilities, for example the PMO, which is an independent Project Management Office, Project Manager experts, and developers with different backgrounds and specific competence. Company D works with Core Teams that often are especially important for the Project and the Project Manager during the entire Project. Further, a Sponsor is elected to match the project size and importance for the firm, that together with the Project

Manager decides upon having a management board, to present progress and the development to, and who works as a mini gatekeeper version.

Respondent D2

Working with medical device, they must follow the medical regulations that almost requires a sequential flow, as clinical test and results have to be sent in at certain times. Working within these premises, a waterfall method is suitable. Further, ISO 9385 sets a rule standard, that some moments need to be done even if the organization wants to change the product development procedure. The product development process is to 99.9% divided into different phases, where they need to validate, test and document changes and development to follow current legislation, for example in Europe they need to follow the C-mark.

The typical product within the implant industry is hardware, the software is rather a support function to the hardware. The Hardware is often developed first and after this the software begin to take form. Within Company D the software team is working with Agile Methods, yet they are almost entirely isolated from the other operations carried out. At Company D, the software division have adopted Scrum artifacts by having a Backlog, monitoring the Sprint and always trying to reach an Increment each Sprint hence the only competence team within the R&D department working with Agile methods.

As D2 says, if a process is considered Agile by working in iterations, they are Agile to a certain extent in their hardware process as well, for example when setting their project charter this work is done in an Agile cycle that spins a couple times before the scope is decided.

Respondent D3

D3 explains that due to the regulations in their industry they use Design Control, a process which builds upon the way that the American FDA (Food and Drug Administration) works. It is managed through a waterfall model and a sequential flow where it is made very clear what needs to be completed before each gate. They use a Stage-Gate model with five steps. The first step of their Stage-Gate planning model is the idea generation/discovery phase in which an idea may come from an external order from a clinician or from the introduction of a new technology that the company wants to integrate into their offer. At this stage basic assessments are made regarding the units that will be affected such as technical, market, production, regulatory etcetera. The idea is then presented to an executive management team where a decision is made to start a project or not. A sponsor is decided, as is a Project Manager. The Project Manager then speaks with the line managers and explains the amount of resources needed from each function. The next phase is the proposal phase where it is decided more specifically what is wanted and needed for the project, in other words a project plan is set with deadlines, activities etc. This is then followed by the development phase, the test and validation phase and then the launch phase.

There is some flexibility so that when needed, they can start an activity from another stage before the gate in front of it has officially been passed. Those kinds of decisions are based on experience from Project Managers and often relate to activities that carry lower risk. While they seldom give economic consequences, it helps cut lead times.

D3 explains that they have line managers for different functions within R&D. They have roles such as sponsors and gatekeepers who make decisions of when to invest more money in a project and when to move on to the next stage. D3's role as Project Manager is very clear as they work in project format with dedicated teams with a common goal and plan for the work. There is a business unit within Company D that works with digital systems and software but the organization in Gothenburg is not specifically involved with those processes. Most of D3's projects are not directly connected to the software unit that develops digital solutions and planning systems but when the hardware projects eventually need to function together with software products there is a collaboration. In general, the digital solutions team needs documentation and information from the Project Manager to be able to add this hardware to their system library. D3 needs to assure that what is provided from the projects is in a format that is usable in their systems. There is a communication between them to make sure that when a launch date is set for an implant product, the machine that supports the product is also ready to go.

Regarding D3's view of Agile influences, it is stated that in some periods it may be possible to work in a more Agile way, for example the development phase where the requirements are set and they work mostly with technical development, design and testing prototypes which is an iterative process.

4.1.4.3 Recent changes to the product development

Respondent D1

D1 says that the importance of shortening the time to market is increasing, and the organisation tries to adopt to meet this demand. By allowing Project Managers to start smaller tasks before passing gates that does not infringe the legislation is one way of mitigating this issue. Further a change towards getting more flexible is an ongoing procedure and is done by Incremental steps.

Respondent D2

D2 says that they are in a process of trying to integrate the commercial aspects more into the product development, in other words making sure to bring in the Market department early on and make sure the commercial and technical time plans are in synch. D2 says they have also started realizing the benefits of doing some things parallel to each other, those that are not required to be done sequentially, in order to decrease the time to market.

Respondent D3

A change that D3 feels has been made is that they work more in a project format than they have before, and hence D3's role has become clearer. The work is managed in a project format with a team that works together with a common goal and plan and they often sit together in the teams in a type of project office. They have worked in teams before as well but not as focused as they do today.

4.1.4.4 Factors that influence the product development

Respondent D1

D1 explains that the organization is controlled by a Design Control philosophy which emphasizes a strict and tightly controlled development process. D1 also argues for an internal factor that Company D is a traditional company with a legacy. When it comes to these types of development models and processes and they have actively chosen a Stage-Gate based, decision based model.

Respondent D2

D2 explains that different geographical locations have different local legislation, ex in Japan it takes almost three years after the product is done until it reached the market. Due to this global market but having different legislation, the development is done in waves, where development and launch could happen simultaneously. Additionally, certain countries require unique tests that further slow down the product development cycle.

Respondent D3

The industry of medical technology is characterized by firm regulations. D3 explains that the regulations set requirements for the flow of activities which makes it difficult to work iteratively. D3 says that regarding the regulatory parts of their R&D, Design Control has always been used and also needs to be used. However, the end goal is a final delivery and sometimes they can adapt the progress in a sensible way so that if an activity needs to be started before a gate has been formally passed, this is okay as long as it has been well thought through and checked for economic risk.
Due to the nature of the products one of the requirements on Company D´s products is that they should change as little as possible and a new product should certainly not generate a need for the existing products to change. Since the implants are placed in the jaws of the patients, Company D needs to be able to provide all their implant systems to the clinicians in case somebody needs a replacement component. Due to this characteristic, the requirements from the customer, the clinicians, do not change very dramatically and it is normally not a problem to set the scope early. Either they have an implant system that they maintain or they start a brand new system but that kind of project is not as common as it implies zero compatibility with anything on the market. For any new system, it takes years for the applications, documentation etcetera. to go through.

4.1.4.5 Benefits of the product development

Respondent D1

D1 argues that several benefits are reached especially by using a Stage-Gate model. It creates a transparency within the organisation and it is easy to know where the project is positioned and what activities that are currently ongoing. Additionally, the clear project form creates specific project teams that together share the same mission hence are committed to the project.

Respondent D2

According to D2 the system they use today is well-adapted to the industry environment that they are in and to the regulations they need to follow. D2 further explains that due to the isolated activities between hard- and software, the software team are able to work with Agile methods without having

a conflict with the rest of the organisation. This enables the competence team to use the best method that is suitable for themselves.

Respondent D3

The model they work with is according to D3 a good fit to the requirements set in their industry environment. One of the main advantages to their way of working is that is gives the Project Managers a good tool to control the teams and creates clarity. The gate model makes it clear what needs to be done at a certain time. Without this gating system D3 feels it would be hard to keep the work together without something like this to base it upon. When assigned to a project the members from R&D working on the same project often physically sit together with other members of the project team in a type of project office. Then they during certain periods bring in people from marketing, operations etcetera when integration to those units are needed. This layout creates the benefit of a dynamic project team and it is easy to communicate quickly when needed.

4.1.4.6 Challenges of the product development

Respondent D1

D1 says that the Stage-Gate used today creates some challenges by using checklists and keeping tight control of the organization, it also diminishes the motivation and active responsibility of the personnel. Sometimes they just work like a robots, crossing of tasks from a list without using their intelligence and creating the best innovation for the company. Further, all projects are not the same, hence a rigid Stage-Gate model could very well be perfect in some cases but rather be an obstruction in others. Often they develop several products at the same time for the same assortment, and those products can be at different stages at different times, ultimately creating some chaos within the organization.

D1 also talks about the difference between product improvement projects versus radical product innovation, and the different demand the market requires. Incremental product innovation stresses the importance of time to market in a totally different aspect than new products. This emphasizes a need of shortening the time to market for Incremental products, consequently increasing the need of flexibility.

According to D1, a Gate model is not necessarily the best method to conduct development within the implant industry. D1 thinks that there is a faster and more efficient way. Design Control, does not require a gate model per se, but rather a logical order completing the tasks. That being said, they ought to work more iteratively during the whole procedure. Today, working with a robust Stage-Gate with checklists, it is fairly convenient to just complete the required tasks without being dedicated and alert.

"I would like to have a more iterative process. The iterative process cannot have gates in a traditional way, as the process get very slow and heavy. It will be especially difficult if you have to iterate through a gate, then it doesn´t work."

Respondent D2

D2 says that a challenge is integrating commercial aspects and the Market and Sales department earlier in the process, as they are now often connected just a few weeks before launch.
Another challenge is knowing when to let activities run in parallel and overlap the stages. They know this can lead to faster time-to-market but it is sometimes difficult to implement due to the strict regulations surrounding their product development process.

Respondent D3

D3 does not see any particular challenges with their current product development process.

5. Analysis and discussion

In this chapter the authors will compare the theoretical framework with the empirical findings in order to explain and answer the research questions. The chapter begins with an analysis of where the defined key characteristics of the Stage-Gate (Figure 3) and Agile methods (Figure 5) are found within the case companies. After this, the authors identified two hybrids that the companies can be divided into based on similarities found. The analysis then proceeds with the companies divided into these two hybrids and looks at the factors that have influenced them to choose these ways of managing their product development. This part of the analysis is strictly based on the empirical findings as the main information needed to answer this question is of a contextual nature. Next, the benefits and challenges that the companies experience are analyzed.

5.1 Characteristics of the Stage-Gate model found within the case companies

5.1.1 A tool to control Product Development from idea to launch

As Cooper (1990) argues, the Stage-Gate model facilitates coordination and control over product development from idea to launch and aims to create a culture of product innovation quality. Phillips et al (1999) agrees and state that the Stage-Gate model is a tool to bring an idea to launch. Cooper (1990) further says that the model is a comprehensive generic idea-to- launch roadmap which different kind of projects can use. All the respondents agree that each company's Stage-Gate work as a tool to exploit these traits and areas of use. At Company B, their company specific Stage-Gate model controls and assists the overall plan according to B1 and as B2 further describes, the Stage-Gate model is used as a tool to maintain the Product Development. At Company A, as explained by A1, they have a Stage-Gate that has been developed to fit Company A, in other words a company specific Stage-Gate. A1 emphasises that they use the Stage-Gate to maintain control over the development as it follows the overall timeplan for the specific project. The Project Manager is responsible for the project to meet these gate criterias that later are presented at the executive management level. A2 describes that they use the Stage-Gate to facilitate an overview and to create a manageable Product Development process. A3 further argues that the Stage-Gate provides clear expectations of a delivery from the team in regards to quality and time. In similarity to the aforementioned case companies, C2 explains that Company C also uses a company specific Stage-Gate to handle their project portfolio and to steer the development process and C1 adds that the Stage-Gate aims to facilitate a guideline for all projects. D1 explains that at Company D their product development is directed by a Stage-Gate model with five stages that follows a strict schedule based on their Design Control framework. D3 argues that since the company is directed by Design Control, the activities must be performed in a sequential flow hence the Stage-Gate provides a great tool to manage the Product Development process.

5.1.2 Product development divided into smaller stages

As is explained in the Theoretical Framework of this thesis, the original Stage-Gate model constructed by Cooper (1990) tries to break down the Product Development process into manageable phases in order to increase the possibility to create transparency and overview where

the project lies at the moment. As stated by Adler et al. (1996), Ettlie and Stoll (1990) and Sosa et al. (2004), a disciplined product development process promotes a higher performance rate. Additionally the Booz Allen Hamilton Global 1000 agrees that a tight and strict innovation process for a product development lifecycle, characterized as Ideation, Project selection, Product development and Commercialization correlates with a higher success rate (Jaruzelski et al. 2005). All the respondents from Company B and Company A describe the Stage-Gate model used at their firm as a model to divide Product development in parts and stages. B2 explains that Company B's Stage-Gate includes the five main stages; Pre-study, Concept, Detailed Design, Trial Production, and Product Validation which is further followed by an extra stage called Review which occurs after the launch and serial production has started. This is further strengthened by B3 that explains that Company B divides their work in five stages from when a project has been started until a product is launched. At Company A they use a Stage-Gate involving six stages, as explained by A2, with different tasks within them. A3 further explains that the model follows a traditional flow that starts with a project request in the Scoping stage and if accepted it moves on to a Requirement stage. The following stages are Concept development, Product and Test development, Validation and Industrialization and finally Launch. C1 explains that Company C's Stage-Gate model involves different stages beginning with a Specification stage. This is followed by an Investment gate and if accepted Development I followed by Development II take place. After development work is completed, the Industrialisation, Validation and Testing and Launch stages occur. C2 and C3 argue that the Product development procedure follow different stages, which create transparency within the organisation. When it comes to Company D, the product development process is to 99.9 percent divided into stages. D3 further explains that their Stage-Gate model involves five steps that follow a sequential order; Idea Generation/Discovery, Proposal, Development, Test and Validation and finally Launch. In these phases it is clear what needs to be done in a certain time.

5.1.3 Risk management tool

As argued by Cooper (1990), one of the most important contributions of the Stage-Gate is that by having the process divided into smaller stages, the possibility to judge and react on how the development proceeds becomes stronger. It becomes quite evident if a project is lacking at certain points and if the budget is overstretched. Cooper (1990) argues that the gates are quality checkpoints that control the development. These checkpoints or criterias often control which tasks receive the label "must meet" and which receive the label "should meet". This further mitigates and facilitates the possibility of making decisions in contrast to risk and a positive Net Present Value. Moreover, the Stage-Gate helps mitigate the risk problems which are quite evident talking about new product development by separating activities and adjusting funding based upon certain predetermined criteria. At Company B, B1 agrees with Cooper (1990) that the Stage-Gate model is a good investment model as the executive management at each gate is served with a set of deliveries and criterias that they end up making a decision based upon. At Company A, the Stage-Gate serves a similar function and A1 describes the Stage-Gate model as a perfect tool for executive management to make decisions. The model provides a good interface for these decisions as financial input and risk are the best factors deciding a if a project should get a 'Go' or 'No go' decision. A3 agrees with A1 and explains that the model creates clarity of what needs to be done in order for executive management to make a decision based on whether the firm can generate positive cash flow from the

specific project, hence the model work as a risk management tool. At Company C the Stage-Gate plays a similar role and as C1 argues the model facilitates executive management to make decisions. C1 adds however that the model is often too rigid since it aims to judge projects the same way although all projects are not the same, limiting the advantage of using it as a Risk management tool. According to D1, heavy financial investments are not required at the beginning of a product's life but to take the idea further and transform it into a project funding must be added, and risk versus future cash flow will be judged. The Stage-Gate provides exceptional information to the executive board to make a 'Go' or 'No go' decision based on these risks.

5.2 Characteristics from Agile methods found within the case companies

5.2.1 Agile roles

According to Schwaber and Sutherland (2016) the roles of Development Team, Product Owner and Scrum Master are pillars when implementing the Agile method of Scrum. B1 describes that some of these Agile roles are identified at Company B even if there is no absolute transformation. The R&D unit removed the Project Managers and replaced these with Platform Owners, which they explained as being similar to the Scrum role of Product Owner but for several products, and carrying similar responsibilities to the previous Project Managers. The Platform Owners are the ones prioritizing the Backlog for the Development Teams. The Development Teams at Company B are positioned in competence teams, hence not in cross-functional teams as literal Scrum methodology promotes. B2 and B3 describe that the projects have a Core Team consisting of representatives from various competence teams needed in order to deliver a function. The work and tasks are then brought back by the representative to each competence team and divided amongst the team members within the time frame of the Sprint. At Company A, A1 explains that the company works with Scrum Teams but that the transition is still ongoing as the role of Project Manager and the project form still exists. This being said, A1 does not explicitly state that the Scrum roles are fully adopted yet, although many formal changes towards these roles have been made. A2 explains that each competence team has a Scrum Master to manage the Backlog, but not a Product Owner that controls the order of it, as should be the case if Scrum is literally implemented. Instead this role is divided between Project Managers and Line Managers at the moment. At Company C, C3 who is responsible for the software team says that this particular competence team has adopted many roles of Scrum. They have somebody who is responsible for planning and coordinating software related activities within the project. This role is called Software Lead but is according to C3 very similar to what it in Agile terms known as Scrum Master. They have a technical Product Owner within R&D who is responsible for the technical solution and a commercial Product Manager in the market department who maintains the product in relation to the customer and market. C3 feels that for this role they do not fully match the Scrum definition of Product Owner as in this case these roles are not connected to a certain team but rather to a certain product. The technical Product Owner and commercial Product Manager hence have some distance to the software team and have a more overall view. For the software team, C3 explains that the Software Lead is therefore important in order to close that gap. For Company C´s product development as a whole, C1 argues that the project culture still weighs heavy for the company, even if competence teams have adopted different philosophies of how to complete their

tasks, where the software and electronics teams are quite Agile and the mechanical/hardware teams work more by the Stage-Gate. C2 says that the competence team decides how their activities should be executed while the Project Manager is there to facilitate the team to deliver. The respondents explain that the Scrum Master role for each competence team is named XX Lead, but involving the same tasks. At Company D, D1 explains that the organization is characterized by traditional roles, yet the software division have totally adopted the Agile methods. D1 and D3 explain that roles such as Project Manager, Sponsor and Core Team are central roles within Company D´s projects. The project culture is strong at the company hence Agile methods such as Scrum and its respective roles take little place within the projects on the hardware side. D2 agrees with D1 and explains that even if the software team have adopted Agile roles, this competence team is isolated as they are located in another country and there is a low degree of communication with the other R&D teams.

5.2.2 Agile events

According to Schwaber and Sutherland (2016) the events of Sprint Planning, Daily Scrum, Sprint Review and Sprint Retrospective are essential for a full implementation of the Agile method, Scrum. B1 states that Company B uses Agile events with Sprints, Reviews and Retrospectives as a tool to manage short term planning with. B2 further expresses that the Sprint events are used by all competence teams but the duration of the Sprint varies. When it comes to Company A, A2 explains that all competence teams within the R&D unit work with three week Sprints but at the same time commit to the Stage-Gate and project, which ultimately creates some conflicts. Further, A3 states that the team starts the Sprint Planning for the specific Sprint with both the Project Managers and the Line Managers to match the available input and required output. At the end of a Sprint the competence team has a Retrospective meeting to examine what went well, what went wrong, and what could be done differently. At Company C, C3 describes that their internal work methods differ slightly. The mechanical team sets their scope early and follow a sequential flow when completing the tasks while the software team and electronics team use Sprints. C2 further agrees that there are different methods used by different competence teams and that this leads to synchronization issues at times, as the Sprints are fixed intervals with detailed planning for each period. All respondents argue that there are no Scrum Events within the R&D department's hardware teams although they are followed by the software team to a wide extent. C3 explains that depending on the project size the software team uses Sprint Planning and Sprint Reviews. They do not have Daily Scrums but they sit in close proximity to each other and have close contact within the team on a daily basis. At Company D, all respondents describe that the software team has adopted Agile methods and hence also work with the Agile guidelines such as Scrum events, but the rest of the R&D department have not gone this way. Instead the work is characterized by a sequential flow, regulated by ISO standards, and no aspects of Scrum or its events are implemented here. D3 says that it is very clear that the activities need to be completed in the right order and with that being said, Agile events with an iterative work process is harder to achieve.

5.2.3 Agile artifacts

According to Schwaber and Sutherland (2016) there are several artifacts of Scrum that play an important role in an Agile organization. Such artifacts include a Backlog, a Definition of Done and the delivery of a finished product Increment at the end of each Sprint. All respondents at Company B state that a Backlog is used in order to manage all the tasks needed to be completed and this is used

for all their competence teams. B2 explains that the Definition of Done is slightly different for the Hardware team compared to the Software team as the Hardware team does not need to deliver a complete working product Increment. The Definition of Done for a hardware team could instead be characterized as the placement of an order for materials or the testing of a material or function. By allowing such Definition of ”Done”, an Increment each Sprint is feasible. A1 describes that at Company A, each competence team has their own Backlog. A3 further explain that the Definition of Done within the company exists but is governed under different rules. A3 says that the Hardware team might just complete some steps in a classic “loop” that are supposed to be done under a Sprint. Still, the definition is shared in the company. Each team are supposed to reach an Increment each Sprint, but as explained that Increment can differ. At Company C, C3 argues that the competence teams working with Sprints such as Electrical and Software carries a Backlog with tasks divided into “nice to have” and “must have”. Further C3 says that since adopting Agile methods their percentage of successfully delivered Increments each Sprint have increased. C3 continues “we don't have a formal Definition of ”Done”, each team respectively decides that, but all team tries to complete the tasks that they planned”. At Company Dthe software division is the only competence team within the R&D department working with Agile methods and that have adopted Scrum artifacts. D2 doesn’t know for sure which artifacts are used since the team is quite isolated from the rest of the R&D but based on the information that they use a full Agile method, the Scrum artifacts of a Backlog, Increment and Definition of “Done” are most likely implemented.

5.3 The emergence of hybrids when Agile methods are integrated within a Stage-Gate model

The case companies use the Stage-Gate model and Agile methods in various ways, as seen above in chapters *5.1* and *5.2*, some which are similar and some which differ. Regarding similarities, the case companies involved in this study all use a form of Stage-Gate at a strategic level. There is also a similarity in that Agile methods are proven to exist to some extent in all of the case companies at a more operational level. Consequently it becomes clear that all the case companies use both a Stage-Gate model and Agile methods and hence we can see the emergence of hybrid models. While the existence of Agile methods at the operational level means that all of the case companies fall into some sort of hybrid model, the difference comes first when looking at the separation that has been made between hardware (HW) and software (SW) in some of the companies. Company C and D use Agile methods for their software development only, while Company A and B use Agile methods in a more widespread manner as they stretch over both hardware and software development. It is due to this difference that the authors have decided to divide them into *Hybrid 1* and *Hybrid 2*. In the model below, *Figure 8,* the hybrid models are placed out on a scale. On one end is the layout where a Stage-Gate guides the product development at both a strategic and an operational level, while on the other side is the layout where the Agile methods are used at both levels.

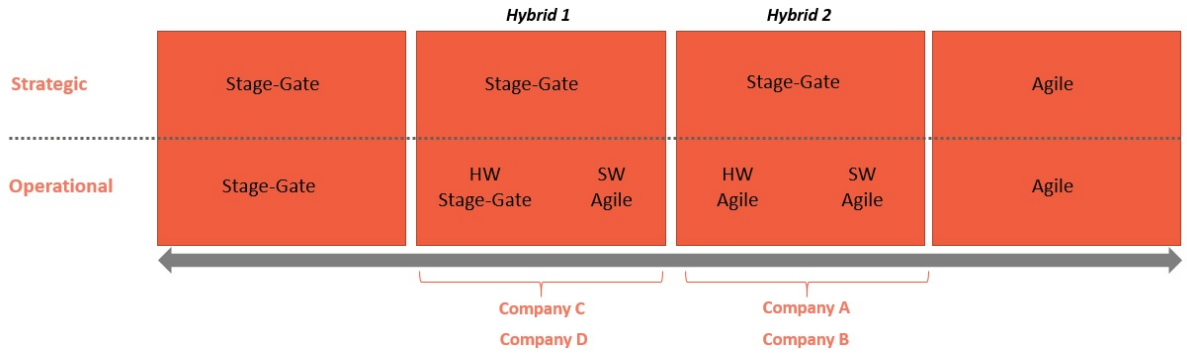

Figure 8. Hybrid models of product development.

The case companies in *Hybrid 1* representing Company C and D, both operate their product development process within the philosophies of a stage gate on a strategic level. On an operational level *Hybrid 1* manages their software development through Agile methods while the hardware remains within the realms of a Stage-Gate model and is hence characterized by a sequential flow of activities. This combination of the two approaches within their product development is the type of hybrid studied by Karlström and Runeson (2005; 2006) where they concluded that this combination of the two approaches, Stage-Gate and Agile methods, was in fact compatible.

Through the findings at the case companies of *Hybrid 1*, a tendency is shown that when hardware and software development teams work with different methods, the interaction between the two needs to either be quite limited, as in the case at Company D, or the teams should have strong and well-functioning interfaces, as seems to be the case at Company C. Company D has a low degree of interaction points between hardware and software teams and they can work quite separately with their respective parts of the product development process. This implies that the competence teams as of now are able to work independently within the R&D department hence the choice of method used for one of them does not affect the other. Since the integration needed between the Agile software team and the rest of the R&D organization in these companies is not so significant, it is relatively easy to maintain a functioning interface. At Company C the need for interaction between hardware and software is however stronger than at Company D. The need for cooperation and interaction between the competence teams is growing stronger than before. This places pressure on a well-functioning interface between the hardware and software teams and as Karlström and Runeson (2005; 2006) explain, a key success factor for this type of hybrid to be successful is that the interfaces towards the Agile subproject are functioning. At Company C these interfaces do in fact seem to work well and the teams can therefore work with their different methods but also quite easily sync when needed.

The case companies that make up *Hybrid 2* representing Company A and B are characterized by Agile methods' integration throughout the entire R&D departments, spread throughout both hardware and software development. On a more strategic level and as an idea-to launch method, *Hybrid 2* uses a Stage-Gate model. This type of hybrid model bears strong resemblance to the idea of Spiral Development explained by Cooper (2008) and that has through the years been developed into the Agile-Stage-Gate hybrid that is gaining in popularity today (Cooper, 2016; Cooper and Sommer, 2016; Sommer et al. 2015). When the R&D unit works with Agile methods throughout the hard- and

software teams at the operative level and with a Stage-Gate model at a strategic level, they benefit from a healthy tension between fixed planning and iterative problem solving (Sommer et al. 2015).

The case companies in *Hybrid 2* are both characterized by a high degree of interaction between the hard- and software which demands that the R&D department needs to facilitate for these teams to be able to work together. A way of tackling this has been to create a common rhythm and philosophy of work within the department and for this purpose the Agile methods have been implemented throughout. However, Agile definitions have been slightly adapted when it comes to the work of the hardware teams which is explained by respondents from both Company A and Company B, since the development is for hardware developers influenced by other factors than for software, such as longer lead times. The literal definitions of Agile methods such as Definition of ”Done” and the requirement of delivering an Increment of working product each Sprint needs to be adjusted when applied to hardware development but can according to them certainly be used.

5.4 Factors that influence the product development

It is clear through the empirical findings of this research that the Product Development process in the selected case companies have been, are, and will continue to be affected by certain factors, some external and some internal. The most important factors are featured below in order to provide a better understanding of how they influence the Product Development.

In *Hybrid 1*, Company C and Company D have a simular product development process, as previously explained, but the factors affecting them are not exactly the same. At Company D the respondents argue that the company is strictly regulated by legislation and the requirement to follow the Design Control regulation. Design Control emphasizes a well controlled and organized development process and while the Stage-Gate is not the only way to manage this, it makes sense for them to use it. The respondents of Company D explain that that the industry of medical technology is characterized by firm regulations that creates requirements for a sequential flow of activities, and does not allow for constant iterations. Design Control is something that has been used and will be used continuously and the process won't be able to differ that much. Different countries have different regulations and legislations which leads to a situation where a product does not simultaneously enter a new stage in every country at once, since the country-specific aspects play a large role. The complexity that arises from these specific regulations and legislations demands a strict process to be able to control and manage their products and to keep track of where they are in the development process, country by country. Furthermore, at Company D there seems to be a strong company culture and a legacy of using the Stage-Gate model which also explains why it is used. As for the software team that uses Agile methods, they have done so since it has been proven to work well for them and due to that the software team does not need to work very closely with the rest of the product development organization, they do not in their operative work need to be as guided by the Stage-Gate as the rest is. In the case of Company C, the respondents do not mention regulatory factors as a main reason for using a Stage-Gate, but they do have a similar company culture and legacy as in Company D, which is also here a strong factor for why it remains as a dominant model today. An aspect worth mentioning is that within the product development at Company C, the departments involved in the product development process are measured on different criteria and KPIs. The R&D department wants to maximize the effort in early stages by keeping many options open to ensure a successful outcome.

This does not match the pressure from the economy department that wants to push costs down and shorten the time to market. This phenomena pushes the organization in separate directions, but the Stage-Gate model acts as a framework for the different departments to be able to follow the progress of the development and often helps to minimize potential friction between them. Another factor that has affected how product development is managed is the growing external pull for electrified products in comparison to petrol driven machines which increases the importance of software. This makes it even more important than before that the software team can work in an effective way, which they have chosen to do through Agile methods, and that the interface between the software team and the rest of the product development functions well.

In *Hybrid 2*, the two included companies, Company A and Company B, have similar product development processes and have also recently undergone similar transformations, leading to the identification of several common traits. The factors that have influenced their product development and the way it is managed today are also quite similar. Respondents from both companies explain that there is a legacy of a Stage-Gate based development process, which partly explains why the Stage-Gate is still used today at a strategic level. One of the reasons why both Company A and Company B started a journey to adopt more Agile methods on a operative level was the employment of a new Vice President R&D (at Company A) and R&D Manager (at company B). The introduction of Agile methods in the full R&D organization is talked about by the respondents at both companies as the absolute strongest internal factor that has formed how the product development is managed today and it has brought with it many changes. At Company A the R&D organization was positive to change towards more Agile methods and the teams themselves even chose to make some of the practical changes. A1, in the role as VP of R&D, only provided the guidelines; “I only articulated a need for continuous delivery from line to the projects and transferred the ownership of the resources to the line”. Having the majority of the organization on board in the change towards more Agile methods was a huge internal factor that influenced the extent to which it was possible to implement it. At Company A, the software team were pioneers in implementing Agile methods and had been working with it since two years back when it was later implemented for the hardware teams as well. Having a positive example of Agile methods in one part of the R&D was also a factor for why they were intrigued to try it in other areas. An internal factor that was mentioned by a respondent from Company B is that there is a demand for continuous improvement that comes internally from the executive board. Agile methods are a good way to meet this requirement as the teams can show the work they have done at the end of each Sprint and display it to their “internal customer” in the board. Company B also emphasizes that “The only thing you know for sure after making a broken down project plan from the beginning is that it for sure will not turn out exactly according to that plan.” This difficulty that they feel towards planning and allocating resources beforehand is also a factor for why they have gone towards Agile methods that allow them to have a plan that is more alive and adaptable. Respondents from both companies in *Hybrid 2* explain that the integration between hardware and software is getting more and more important in their end products and consequently the teams’ interaction points are more relevant than before. They acknowledge that the organisation is much more efficient now that same methods are shared within the company’s R&D departments.

5.5 Benefits and challenges of the product development

The models and methods that the case companies use in their Product Development processes carry some clear benefits but naturally there are also some challenges that follow. After summarizing the benefits and challenges from the Stage-Gate model (Figure 3) and Agile methods (Figure 5) it is obvious that these two work methodologies accomplish different things.

At Company D the respondents explain several benefits by using the Stage-Gate: “It creates transparency and it is easy to know where the project is positioned and what activities are currently going on” and that the model makes it clear what needs to be done at a certain time. At company C the respondents explain that the top advantage of using the Stage-Gate is the well working guideline, to be able to divide tasks and know what needs to be done. Additionally, that the Stage-Gate makes it possible to have checklists and to make sure that the project progress at a certain velocity and that it creates transparency and everybody know what ongoing activities are active. As shown, the companies in *Hybrid 1* exploit and acknowledge the same benefits from using the Stage-Gate model. These benefits correlate to a very high degree with what Cooper (1990) and Phillips et al (1999) say which is that a Stage-Gate model creates transparency between departments and allows the company to keep track of the progression. At the same time, it works as a risk management tool and provides the benefit of facilitating for top management to make decisions (Cooper, 1990; Phillips et al. 1999).

Due to the industry environment Company D faces with high regulations the respondents emphasize that the Stage-Gate model is therefore a good fit although as the D1 admits, the model is too rigid to fit all projects as some need more flexibility. D1 continues to explain that the Stage-Gate model is not necessarily the best method to conduct development within the dental industry, and feels that there may be a more efficient and faster way. Design Control does not require a gate model but rather a logical order for tasks to be completed. Cooper (1990) proclaims that the model aims at being generic though Tingström et al. (2006) say that sometimes it becomes a challenge because it is too rigid which is not desirable for all projects. In environments where the work needs to follow a structured flow, such as in the case of Company D, the rigidness of the Stage-Gate is however interestingly more of a benefit than a challenge.

D1 says that creating checklists and having tight control diminishes motivation and active responsibility of the employees. The Stage-Gate meets criticism of contributing to just this problem by diminishing empowerment of independent thinking (Cooper, 1994). C3 on the other hand emphasises that the teams that have adopted Agile methods have reached an increase of motivation, spirit and solidarity, and state that the teams are much more committed to their work. Beck et al. (2001) and Schwaber and Sutherland (2016) argue that such factors are reached by delegating more responsibility to the team hence this has a strong correlation with what C3 explains as a benefit of Agile teams.

C3 argues that the Software team have increased their flexibility tremendously since implementing Agile methods, as they now control their own resources and it is also possible to adjust resources to complete high priority tasks on the Backlog. Further C3 argues that the Sprints give the competence team a rhythm that creates a feeling of progression all the time. Beck et al. (2001) and Begel and

Nagappan (2007) confirm that flexibility is a key benefit generated by adopting Agile methods and the fixed duration of the Sprints, as explained by Schwaber and Sutherland (2016), creates a continuous rhythm for the work of the development teams.

At Company C the position of the Project Managers is growing to potentially being a challenge. Today they are supposed to have a smaller and tighter interface after creating lead teams, but according to some respondents the contrary sometimes the reality. Different competence teams speak different languages and at the same time they work in different rhythms which makes it very hard to control and manage. This challenge is related to what Boehm and Turner (2003) present as a challenge which is the position descriptions that are affected when Agile methods are implemented. In contrast, at Company D the role as Project Manager has has become clearer which relates to the fact that their project culture is rather growing stronger and they often together sit in physical project offices. As Walker (1997) explains the Project Manager carries the responsibility of managing and communicating between all involved parties of a project. One can clearly see that the smaller the interface and the tighter the team is, the easier the Project Manager's responsibility becomes.

Both the case companies in *Hybrid 2* agree that the Stage-Gate is suitable for executive management to make decisions and provides them with a good interface for doing this. One respondent further says that at a company level, it is hard to replace this model, since it works very well for this purpose. The companies additionally explain that the Stage-Gate help to control and assist the overall plan. This is in line with what Cooper (1990) explains as some main benefits of using the model. The Stage-gate will create transparency between departments and allows the company to keep track of the progression and also that it facilitates decision making.

Both the case companies argue that they have obtained many benefits after implementing Agile methods. An example a respondent shed light on is that today the development teams are much more autonomous and consequently less management is needed. The engineers plan and execute their own tasks which leads to a new sense of ownership, this ownership one respondent argues creates a sense of empowerment. A motivated team that feels ownership according to the companies will positively affect and increase the quality of the product development. Further a better team spirit has evolved as the team now work tighter together. The tasks are not left to be completed by a single member but instead are considered team tasks. One respondent even says: *"If you give people responsibility they will grow, if you give them mandate to make decisions they will make good decisions".*

Beck et al. (2001) and Schwaber and Sutherland (2016) argue that a result that derives from passing over responsibility and trust to the development teams, as Company A and Company B have done, is that it creates motivated and autonomous teams. These benefits have, as explained by respondents above, been seen at both case companies of *Hybrid 2*.

However, handing over responsibility to the development team also has some consequences. Some respondents explain the risk of pushing responsibilities of technical and planning aspects to the development team as the engineers might not have a full picture to be able to make a decision based on cost, quality and time-to-market. One respondent says that there is a possibility of having "too many chefs in the kitchen". Further one respondent in Company A states that: *"If you are good at*

programming, then you should program, not manage meetings, write documents etcetera". These risks and challenges the companies face correlate with what Boehm and Turner (2003) state regarding the need of broader skills and experience in the development teams since they are more autonomous and the responsibilities are pushed down.

Another benefit the companies representing *Hybrid 2* has acknowledged is the increased flexibility the competence teams have obtained after implementing Agile methods. Letting engineers divide themselves into flexible teams, where the work is guided by a constantly adapting Backlog, resources can be allocated where they are needed the most. Just as theory explain Agile method facilitates flexibility, by having a Backlog that is alive and possible to change in relation to the current situation (Beck et al. 2001; Begel and Nagappan, 2007).

One of the main benefits of Agile methods is that it should create better customer relations and integration as explained by Beck et al. (2001) and Schwaber and Sutherland (2016). The companies in *Hybrid 2* feel that this could be difficult to achieve for the entire R&D organization, and especially for the hardware teams. The fact that hardware and software have different characteristics, they also differ in the way they define continuous deliveries. Continuous deliveries should be usable Increments that are able to be shown to a customer for close integration but this is tricky when it comes to hardware development. One respondent argues that the first stages of the product development process will produce mostly prototypes and testable products, but not products that can be tested by end customers and shown to the market. It is clear that the companies need to find new ways to mitigate this problem in order to achieve the same feeling of continuous delivery that facilitates a close customer relation across the entire R&D.

At both companies in *Hybrid 2* the Project Manager role is challenged as the R&D organisation follows Agile guidelines but have chosen to keep the project culture which is more derived from the Stage-Gate. All respondents at Company A discuss the position description of Project Manager and its responsibilities to be in a problematic situation since the introduction of Agile methods. The Project Manager's previous resources are not her own anymore but at the same time the same expectations remain. One respondent argues that nobody is fully committed to a project, rather the commitment is divided between both Sprints and projects. Another respondent talks about this problematic position for the Project Managers and says that: *"The responsibility of executing a delivery on time is still there but the power they have is swept away"*. However, while keeping a Project Manager within an Agile organization is difficult, this does not mean that removing the role altogether will solve the issue. At Company B, the removal of the Project Manager role when they first implemented Agile methods became a big challenge due to the lack of managing and leading the delivery. Insead the responsibilities were pushed down at the teams, that sometimes both lacked the competence and the willingness to take on this responsibility. This role has lately started to be brought back, yet a complete decision is not made. A challenge Agile methods brings is obviously changes in roles and responsibilities (Schwaber and Sutherland, 2016; Boehm and Turner, 2003) and as seen in Hybrid 2 the Project Manager is a very challenged position.

6. Conclusion and suggestions for further research

This final chapter contains a conclusion that is generated from the analysis and discussion section. The research question is answered by a visual figure as well as an explanation. The chapter ends with some suggestions for further research.

6.1 Conclusion

As was brought up at the beginning of this thesis, the environment that companies exist in is in constant transformation and it is important for them to be responsive to changes. Agile methods are built around the core concept of being adaptive and thus it makes sense that these methods are gaining a following amongst companies, even those where the product development has previously relied upon the Stage-Gate model at all levels. The results from this study provide support for the fact that Agile methods can be combined with a Stage-Gate model and that they work well and symbiotically together. Besides providing support for the possibility of combining Agile methods and a Stage-Gate model, this thesis has aimed to answer *how* this can be done which brings us back to the research question:

How can product development with combined hardware and software be managed in regards to a Stage-Gate and Agile methods?

There is no golden model to explain how a company should manage their product development when working with both hard- and software. However, this thesis emphasizes hybrid solutions that aim to grasp the positive aspect of both original philosophies of Agile methods and a Stage-Gate model. As explained in the analysis, there are factors that affect how the case companies manage their product development and various benefits and challenges that they experience with their respective hybrid versions.

The model displayed below in *Figure 8* was created by the authors to provide a visual overview how the case companies manage their product development. All the case companies of this study have roots from hardware which originally was managed through a Stage-Gate. At the same time the companies have software in their product where the best practice is to use Agile methods. As is presented in the analysis chapter, the case companies of this study have all chosen to address the existence of both hardware and software by creating hybrids where they do not need to choose between using a Stage-Gate or Agile methods but rather find a way to integrate them. The authors have found through the course of this study that the way these hybrids are devised varies but can be summarized into two models of hybrid versions.

To successfully manage the product development as in *Hybrid 1,* the authors have found that there is either a low degree of interaction between hardware and software teams or there is a higher degree of interaction but then also a well-functioning interface between them. The teams can then use a model or method that provides the best environment for them without creating problem for the rest of the organisation. In *Hybrid 2* the authors have found that there is a high degree of interaction between the hardware and software teams which is facilitated by the use of common methods. Using common methods does not necessarily mean using identical methods however, as the literal

translations of Agile methods might not always fit for hardware development as easily as for software development and some definitions may need to be adapted.

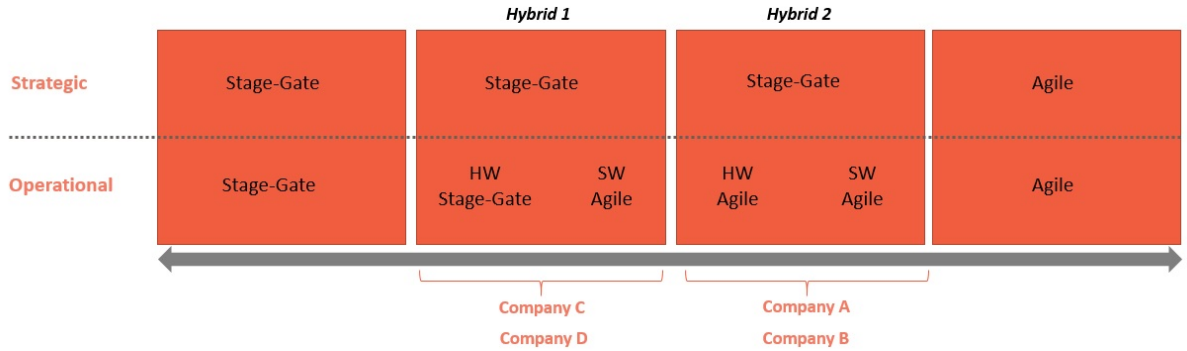

Figure 8. Hybrid models of product development.

While the results of this thesis cannot be generalized beyond the four included case companies, the findings may be able to act as a guideline for other companies that also have a combination of hardware and software in their product development. If there is a possibility to identify similar characteristics as in these case companies, these findings could provide some suggestion for how to manage their product development.

6.2 Suggestions for further research

Through the course of this research the authors have realized that the hybrid versions of product development are quite a new phenomenon and there is hence much research left to be conducted. The scope of this thesis, while contributing to this field, has left several stones unturned. One aspect that the authors believe would be interesting to dig deeper into is how roles and positions are affected when these hybrid versions are implemented. Further, it would be interesting to measure in a systematic way if the implementation of a hybrid model substantially improves the performance of companies compared to their original models, perhaps by measuring economic performance, motivational improvement etcetera. It would also be interesting to look deeper at how the Agile methods, such as Scrum, should optimally be adapted to fit a manufacturing environment and the development of hardware and perhaps create a “Scrum model for physical products”.

7. References

Adler, P., Mandelbaum, A., Nguyen, V. and Schwerer, E., 1996. Getting the most out of your product development process. *Harvard Business Review*, 74(2), pp.134.

Akhilesh, K.B., 2014. *R&D Management*, New Delhi: Springer India.

Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Cunningham, W., Fowler, M., Grenning, J., Highsmith, J., Hunt, A., Jeffries, R., Kern, J., Marick, B., Martin, R.C., Mellor, S., Schwaber, K., Sutherland, J. and Thomas, D., 2001. *Manifesto for Agile Software Development.* [Online] Available at: https://www.Agilemanifesto.org |Accessed 15-02-17].

Begel, A., and Nagappan, N. 2007. Usage and perceptions of Agile software development in an industrial context: An exploratory study. In *ESEM '07: First International Symposium on Empirical Software Engineering and Measurement*, 255–264. Washington, DC: IEEE.

Boehm B. and Turner R., 2003. Balancing agility and discipline. Boston: Addison Wesley.

Bryman, A. and Bell, E., 2015. *Business research methods* 4. ed., Oxford: Oxford Univ. Press.

Buttrick, R., 2002. Role Of The Executive Project Sponsor, Financial Times Prentice Hall.

Conforto and Amaral, 2016. Agile project management and Stage-Gate model—A hybrid framework for technology-based companies. *Journal of Engineering and Technology Management*, 40, pp.1–14.

Chesbrough, H.W., 2003. *Open innovation : the new imperative for creating and profiting from technology*, Boston.: Harvard Business School Press.

Cooper, R.G. 1990. Stage-gate systems: A new tool for managing new products. *Business Horizons*, 33(3), pp.44–54.

Cooper, R.G. 1994. Perspective third-generation new product processes. *The Journal of Product Innovation Management*, 11(1), pp.3–14.

Cooper, R.G. 2001 *Winning at new products.* 3rd ed. Cambridge: Perseus Publishing.

Cooper, R.G., 2008. Perspective: The Stage-Gate® idea to launch Process—Update, What's New, and NexGen Systems. *Journal of Product Innovation Management*, 25, pp.213–232.

Cooper, R.G., 2012. Best Practices in the idea to launch Process and Its Governance. *Research-Technology Management*, 55(2), pp.43–54.

Cooper, R.G., 2014. What's Next?: After Stage-Gate, *Research-Technology Management*, 57(1), pp. 20-31

Cooper, R.G. 2016. Agile–Stage-Gate Hybrids, *Research-Technology Management*, 59(1), pp. 21-29

Cooper, R.G. and Sommer, A.F., 2016. Agile-Stage-Gate: New idea to launch method for manufactured new products is faster, more responsive. *Industrial Marketing Management*, 59, pp.167–180.

Dybå, T. and Dingsøyr, T., 2008. Empirical studies of Agile software development: A systematic review. *Information and Software Technology*, 50(9), pp.833–859.

Ettlie, J.E. and Stoll, H.W., 1990. *Managing the Design-Manufacturing Process.* New York: McGraw-Hill Collage.

Fowler, M., 2005. *The New Methodology.* [Online] Available at: https://www.martinfowler.com/articles/newMethodology.html [Accessed 03/03/2017].

Griffin, A., 1997. PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices. *Journal of Product Innovation Management*, 14(6), pp.429–458.

Grönlund, J., Sjödin, D.R., and Frishammar, J., 2010. Open Innovation and the Stage-Gate Process: A Revised Model for New Product Development. *California Management Review*, 52(3), pp.106–131.

Guba, E. G., and Lincoln, Y. S., 1994. 'Competing Paradigms in Qualitative Research', in N. K. Denzin and Y. S. Lincoln (eds), *Handbook of Qualitative Research*. Thousand Oaks, CA: Sage.

Jaruzelski, B., Dehoff, K. and Bordia, R., 2005. The Booz Allen Hamilton Global 1000: Money isn't everything. *Strategy + Business,* 41, pp. 3–15.

Johne, A., 1999. Successful market innovation. *European Journal of Innovation Management, 2(1)*, 6-11

Karlström, D. and Runeson, P., 2006. Integrating Agile software development into Stage-Gate managed product development. *Empirical Software Engineering*, 11(2), pp.203–225.

Karlstrom, D. and Runeson, P., 2005. Combining Agile methods with Stage-Gate project management. *Software, IEEE*, 22(3), pp.43–49.

Lincoln, Y. S., and Guba, E. (1985). *Naturalistic Inquiry.* Beverly Hills, CA: Sage.

Mintzberg, H., 1970. Structured observation as a method of studying managerial work. *Journal of Management Studies*. Vol. 7, pp. 87-104.

Mintzberg, H., 1971. Managerial work: analysis from observation. *Management Science.* Vol. 18, pp. 97-110.

Mintzberg, H., 1973. *The Nature of Managerial Work.* New York: Harper & Row.

Mintzberg, H., 1975. The manager's job: folklore and fact. *Harvard Business Review*, Vol. 53, pp. 100-10

O´Connor, P., 1994. Implementing a Stage-Gate process: A multi-company perspective. *The Journal of Product Innovation Management*, 11(3), pp.183–200.

Ovesen, N., 2012. *The Challenges of Becoming Agile: Implementing and Conducting Scrum in Integrated Product Development* (Doctoral dissertation, Videnbasen for Aalborg Universitet, Aalborg Universitet, Det Teknisk-Naturvidenskabelige Fakultet, Institut for Arkitektur og Design).

Ovesen, N. and Sommer, A.F., 2015. Scrum in the Traditional Development Organization: Adapting to the Legacy. In: Schabacker M., Gericke K., Szélig N., Vajna S. (eds) *Modelling and Management of Engineering Processes.* Berlin, Heidelberg: Springer.

Oxford University Press, 2017. *Oxford English Dictionary* [Online] Available at: http://www.oed.com.ezproxy.ub.gu.se/view/Entry/3979?redirectedFrom=Agile#eid [Accessed 17/01/2017].

Phillips, R., Neailey, K. and Broughton, T., 1999. A comparative study of six Stage-Gate approaches to product development. *Integrated Manufacturing Systems*, 10(5), pp.289–297.

Schumpeter, J. A., 2013. *Capitalism, socialism and democracy*. London: Routledge.

Schwaber, K. and Sutherland, J., 2016. *The Scrum Guide. The Definitive Guide to Scrum: The Rules of the Game.* [Online] Available at: http://www.Scrumguides.org/Scrum-guide.html [Accessed 29/01/2017].

Scrum.org, *2017. The Scrum Framework.* Available at: *https://www.Scrum.org/resources/what-is-Scrum*. [Accessed 15/02/2017].

Serrador, P. & Pinto, J.K., 2015. Does Agile work? — A quantitative analysis of Agile project success. *International Journal of Project Management*, 33(5), pp.1040–1051.

Sommer, A.F., Hedegaard, C., Dukovska-Popovska, I. and Steger-Jensen, K., 2015. Improved Product Development Performance through Agile/Stage-Gate Hybrids: The Next-Generation Stage-Gate Process?, *Research-Technology Management*, 58(1), pp.34-45

Sommerville, J., Craig, N. and Hendry, J., 2010. The role of the Project Manager: all things to all people? *Structural Survey*, 28(2), pp.132–141.

Sosa, M.E., Eppinger, S.D. and Rowles, C.M., 2004. The Misalignment of Product Architecture and Organizational Structure in Complex Product Development. *Management Science*, 50(12), pp.1674–1689.

Tingström, J., Swanström, L. and Karlsson, R., 2006. Sustainability management in product development projects – the ABB experience. *Journal of Cleaner Production*, 14(15), pp.1377–1385.

Tseng, Y. H., Lin, C. T., 2011. Enhancing Enterprise Agility By Deploying Agile Drivers, Capabilities and Providers, *Information Sciences*, 181(17).

Walker, D., 1997. The Role of the Project Manager. *Construction Management and Economics*, 15(3), pp.307–309.

Yin, R.K., 2014. *Case Study Research - Designs and Methods*. 5th ed. London: Sage.

Appendix 1 *Interview guide for semi-structured interviews used in main study*

Allmänna frågor om personen

Vad är din bakgrund på företaget?
Kan du beskriva din roll på företaget?
Huvudsakliga uppgifter?
Ansvarsområden?
Tidigare erfarenheter från andra arbetsplatser med liknande uppdrag?

Allmänna frågor om produktutveckling

Beskriv hur produktutveckling bedrivs hos er?
Vilka är era kunder och vilka krav ställer de på produkten?
Vad är det viktigaste för er produktutveckling?

Förändringsarbete

Har ni ändrat ert arbetssätt nyligen och vilka huvudsakliga förändringar genomfördes?
Om ja:
Hur gick ni tillväga?
Hur togs det emot?
Varför gjorde ni förändringen?
Vad blev resultatet?
Skulle ni gjort någonting annorlunda?

Processen för produktutveckling

Beskriv flödet från ett behov som uppstår till lanseringen av en produkt.
Finns det några viktiga beslutspunkter eller steg för utvecklingen?
Vad har ni som övergripande modell för att styra och hantera projektportföljen?
Vilka interna & externa faktorer påverkar hur ni arbetar med er produktutveckling?
Vad är fördelarna med era befintliga metoder?
Vad är utmaningarna med era befintliga metoder?

Organisation och roller

Vilka roller finns inom produktutvecklingsprocessen? Vad innebär dessa roller hos er?
Hur är er organisation kring produktutveckling uppbyggd och varför?
Vilka beslutsforum finns inom organisationen?
Vem styr inflödet av pengar/resurser till projekten?

Produktarkitektur

Hur ser er produktstruktur ut? Grad av modularitet?
Varför har man valt en sådan struktur?
Hur påverkas ert erbjudande av sättet ni bygger upp produkten?
Hur matchas produkten med erbjudandet och vice versa?
Vart sker integrationen mellan HW/SW?

Framtiden

Blir mjukvara eller hårdvara viktigare för er?
Har ni sett några trender inom er bransch vad gäller produktutveckling?
Finns det något mer optimalt sätt att arbeta i teorin? Om bara i teorin, varför är det inte applicerbart?
Hur tror du era processer ser ut om 10 år?