

AGILE

PROJECT MANAGEMENT



SCRUM FOR BEGINNERS



UPPSALA
UNIVERSITET

TVE-MILI 18 018

Master's Thesis 30 credits

June 2018

Agile Project Management for Knowledge-Based Projects in Manufacturing Industry.

Case Study: Epiroc Drilling Tools, Fagersta,
Sweden

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Abstract

Agile Project Management for Knowledge-Based Projects in Manufacturing Industry.

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Epiroc Drilling Tools is a manufacturing company that produces tools for rock mining and excavation. The company adopted the principles and framework of Lean Product Development in their R&D department with few practices of an agile framework called Scrum. These agile practices are used in the pre-study phase or the knowledge value stream of their lean product development. Hence, this research is limited to the knowledge value stream within the R&D department.

The use of agile project management in manufacturing industry is unique and majority of the agile frameworks are specifically designed to suit the needs of software development companies. Several theories like Scrum, Lean, Kanban and DSDM were studied by the researchers to scrutinize the current framework of the department. The challenges and the similarities of the currently used framework with several other agile frameworks and the companies are discussed. Several qualitative research methods were adopted to know the viewpoints of the working employees in the department which are compared with other companies like Volvo Cars, ABB, LShift, EnergySoftware and from another division of Epiroc called Rocktec Automation who faced some similar challenges while practicing agile project management. After further research on the theories and comparison of the process, roles of the working employees and documentations within the knowledge value stream, DSDM had more similarities with the currently used framework than Scrum. This allowed to recommend ways that can fill the missing gaps using practices of DSDM without altering the existing working procedure in the knowledge value stream. This ensures that the improvement in the knowledge value stream remains continuous. On the contrary, a brief discussion is included on whether there is a need to be agile for manufacturing industries or is it just a changing trend in the field of project management.

Keywords: Agile project management, Agile, Lean, Scrum, Kanban, Dynamic System Development Method, Technical innovation, Organizational culture, Product development process.

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TVE-MILI 18 018
Printed by: Uppsala Universitet

Popular science summary

The paper was focused on exploring the product development process (PDP) of a manufacturing company in their knowledge-based projects at the research and development (R&D) department. The subject area revolves around agile project management (APM). The term Agile was outlined by an agile manifesto for agile software development in 2001, where values and principles in the manifesto evolve the need of collaboration of cross-functional and self-organizing teams, and customer collaboration. There is extensive evidence of APM being effective in the software industry and IT-projects, whilst there is lack of empirical studies for adoption of agile in other industries or non-IT projects. Companies have exposed that in new product development, it takes more than delivering high quality, low cost and differentiation to surpass the competitive market. Speed and flexibility are also what it takes which require a different approach to manage new product development to develop new products fast and to be flexible. Therefore, the agile frameworks' reputation to respond to pressure makes non-software industries tend to approach their perceived challenges in their development activities as per agile. However, lack of empirical data to perceive the actual effect of incorporating agile in non-software industry and non-IT projects leaves a gap to understand what frameworks are more suitable for the non-software industries and non-IT projects, and what challenges are perceived when transitioning to agile.

The study started with exploration of the R&D department and several organizational documents to familiarize with the work culture. The researchers were given time to act as observers in several meetings and brainstorming sessions and were given timely feedback by supervisors and employees to better identify what theories was relevant for the research. The APM frameworks Scrum, Lean, Kanban and Dynamic System Development Method (DSDM) was studied for comparison of the R&D department's established practices in the pre-study of the PDP and used as a tool to analyze the results gained from qualitative semi-structured interviews and focus group to explain findings with existing theory.

The results showed that DSDM was the suitable framework which was claimed to be suitable not only for software-based development, but also product-based development. As per the findings of the current challenges, there were certain similarities identified in the

knowledge value stream with DSDM which would prevent high amount of disruption in the current process. In addition, adoption of DSDM could not only define the current processes clearly, but also fill gaps in the ongoing activities to improve overall effectiveness in the knowledge value stream.

Acknowledgement

The degree project is the final part of the two-year master's program Industrial Engineering and Management at Uppsala University. The degree project has been conducted at Epiroc Drilling Tools' Research and Development department in the spring of 2018.

The researchers would like to acknowledge that both worked on all chapters in the degree project and participated equally in the collection of empirical data. The work delegation and participation in conducting interviews, focus groups and observations were equally distributed. All chapters in the degree project were discussed and collaboratively compiled to have a mutual understanding of the research findings with the help of supervisors.

A huge thank you to the colleagues at the Research and Development department who provided invaluable insights necessary for the study, and a special thanks to the company supervisors Göran Stenberg and Joakim Bergstrand who provided great guidance and gave the researchers an opportunity to conduct the study at the department.

A special thanks to Uppsala University, and our supervisor Ibrahim Alaff who put great amount of effort and time to guide the researchers throughout the process of the degree project. Ibrahim Alaff, you have not only provided guidance, but inspired and provided invaluable knowledge. A special thanks to the subject reader Markus Lindahl for the guidance throughout the studies of the master's program. Lastly, we thank our examiner David Sköld who provided us with continuous support and various insights to compile the final thesis.

Abbreviation

Abbreviation	Full name
AB	Aktiv bolag
APM	Agile project management
BOM	Bill of materials
IMS	Information Management System
PD	Product development
PDP	Product development process
PM	Project manager
PO	Product owner
R&D	Research and development
RDT	Rock Drilling Tools
RQ	Research question
SS	Senior sponsor
TE	Technical engineer
WiP	Work in progress

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1. Introduction

The first chapter of the research provides a background to the study and to the problem area the study is built around. Furthermore, it is scoped down to a purpose, three research questions and the delimitations of the study.

1.1 Background

Agile is recognized as the ability to change direction fast and at low cost (Schwaber & Sutherland, 2017). The term Agile was outlined by an agile manifesto for agile software development in 2001, whereas values and principles in the manifesto evolve the need of collaboration of cross-functional and self-organizing teams, and customer collaboration (Manifesto for Agile Software Development, 2001). A key factor for organizations to enhance competitive advantages and growth is innovation (Spithoven et al., 2012) and due to globalization of markets, pressure is put on organizations to continuously innovate to produce differentiated products and services (Schilling, 2017).

The software industry is pressured to release software products with high quality and forced to adapt the development processes at fast rate (Murphy et al., 2013). Thus, agile emerged from the software industry and is known for its ability to respond to pressure (Murphy et al., 2013). Agile project management (APM) have roots in software industry with extensive evidence of APM being effective in the software industry (Qumer & Henderson-Sellers, 2008; Mishra, Dangayach & Mittal, 2011). Thus, there are more available research in software industry and IT-projects related to APM and lack of empirical studies for adoption of agile in other industries or non-IT projects (Conforto et al., 2014). It results in lack of knowledge about cause and effect relationship with the use of APM techniques, practices, and tools in industries other than software (Conforto et al., 2014). Due to the agile frameworks' reputation to respond to pressure, non-software industries tend to approach their perceived challenges in their development activities as per agile. However, the lack of empirical data to perceive the actual effect of incorporating agile in non-software industry and non-IT projects leaves a gap to understand what frameworks are more suitable for the non-software industries and non-IT projects like manufacturing, and what the challenges are to transition to agile. Companies have exposed that in new product development, it takes more than delivering high quality, low cost and differentiation to surpass the

competitive market (Takeuchi & Nonaka, 1986). It is emphasized that speed and flexibility are also what it takes which require a different approach to manage new product development; an approach to develop new products fast and to be flexible (Takeuchi & Nonaka, 1986).

However, complex organizational change cannot be managed simply by replacing current technologies and tools, such changes impact management practices, structure and culture (Nerur, Mahapatra & Mangalaraj, 2005). Agile transformation is not only to adopt its process, tools, and templates (Ranganath, 2011), but it is also to adopt the mindset of employees and used practices to manage diverse activities (State of Agile Report 2018; Nerur, Mahapatra & Mangalaraj, 2005; Ranganath, 2011).

1.1.1 Overview of the company

In 2017, Atlas Copco Group, active in manufacturing industry, decided to separate into two global groups: Atlas Copco and Epiroc. Atlas Copco's focus is in industrial applications as industrial technique, compressor technique, vacuum technique, portable energy division and specialty rental division, whilst Epiroc's focus is in mining and civil engineering which is mining and rock excavation technique and construction tools division (Atlas Copco, 2018). The research was conducted at the division Epiroc Drilling Tools AB with its headquarters in Fagersta, Sweden. This division is abbreviated as RDT (Rock Drilling Tools), which provides drilling and rock excavation equipment and tools. See Appendix 1 for the diverse business sectors of Epiroc and Appendix 2 for Epiroc's divisions. Moreover, the mining and rock excavation technique business area develops and offers equipment such as underground rock drilling equipment, underground loading, haulage equipment, rock drilling tools, etc. (Epiroc, 2018). Both Atlas Copco and Epiroc are global leaders in their own respective areas. Thus, full focused and dedicated management for each company have its purpose to serve customers better and drive growth and profitability (Atlas Copco, 2018).

Epiroc Drilling tools is a manufacturing company with recent advancements in the software development due to automation. The conducted research was limited towards the R&D department located in Fagersta, Sweden with its activities based in the product development process (PDP) i.e. the process from an idea to a commercialized physical

product. The process is divided into two value streams i.e. the sequence of activities required to build the solutions planned for each stream. There are the knowledge value stream and product value stream. The knowledge value stream conducts the sequence of activities where an idea develops into a concept whereas identified knowledge gaps need to be filled with a solid ground before initiating and preparing the production of the actual physical product in the product value stream. Thus, the research focused on the knowledge value stream.

According to Epiroc Drilling Tools R&D department, it is documented that present practices in the knowledge value stream are followed by the agile frameworks Lean in the product development (PD) process and Scrum. Lean is based on the fundamental elements to drive out waste as non-value-added activities from the PDP, to improve the way projects are executed and to visualize the PDP (Morgan & Liker, 2006). Lean PD is an extension of Lean itself at PD system level to define customer requirements and follow it in the design process, minimizing deviation in designs by reusing designs, avoid immature technologies, etc. (Morgan & Liker, 2008). Moreover, Scrum is a framework used to develop, deliver and sustain complex adaptive problems; a framework to apply various processes and techniques to continuously improve the product, the team and work environment; an iterative and incremental approach to optimize presumptions and control risks (Schwaber & Sutherland, 2017).

The department incorporated Lean PD and Scrum framework approximately five years ago when a preceded global Lean coordinator had its main task to coordinate and train staff in Lean and Scrum on different sites. The aim was to align the mindset of the staff and facilitate collaboration among team members due to cross-functional departments and increase the efficiency of diverse operations. The implementation resulted in desired improvements as aligned departments and efficient work procedures. However, the Lean coordinator was removed with no successor to proceed the work, therefore, no major refinements were made in the used Lean PD and Scrum. Thus, diverse activities and individuals involved in the process face several challenges and fail to keep teams engaged with the Lean and Scrum framework. In addition, diverse set of rules and documentation are

set within the R&D, but not followed as planned which effect involved individuals in the different activities and the process.

1.2 Problem

The transition to Lean and Scrum was not managed for few years in the R&D department. Due to insufficient management and coordination to follow-up agile practices, the mindset of employees and used practices to manage diverse activities in the knowledge value stream impacted management practices, organization structure in the R&D department and the culture. The theoretical motivation of the study is that the subject area of APM in manufacturing industry and knowledge-based projects lack empirical data about the use of APM techniques, practices, and tools in industries other than software and IT projects which leaves a gap in research. Therefore, the practical problem of the case study in the company Epiroc Drilling Tools becomes theoretically relevant to fill that gap of APM by using the organizational studies. Thus, the theoretical contribution is within the field of APM in knowledge-based projects at manufacturing industries.

1.3 Purpose

The purpose of the research is to investigate existing agile practices that can be implemented in the knowledge value stream and to identify what challenges the R&D department are facing that need to be improved. Therefore, the research will investigate which agile framework is suitable for the department and its ongoing operations to recommend few possible alternatives or additions to the existing process in the knowledge value stream.

1.4 Research questions

Based on the background, problem statement and purpose, three research questions was elaborated and are presented in table 1.

No.	Research question	Explanation
1	What are the existing agile frameworks available for the PDP?	It is the researchers' responsibility to do a literature study to understand the theory, challenges in implementing such frameworks and identify which frameworks are suitable for Epiroc Drilling Tools, R&D department in Fagersta.
2	What are the challenges to integrate the PDP within the agile framework?	This is where the researchers' data collection has a key role. By conducted interviews with all interviewees within the company, it has been possible to acquire the status of how the current situation was and hence identified gaps in comparison of other companies practicing agile.
3	How can the existing practices in the PDP by using agile frameworks improve?	Data at this point has been collected and analyzed, which supported the researchers to identify gaps in the used frameworks in the knowledge value stream of the PDP and thereafter adopt the suitable framework to improve perceived challenges.

Table 1: Research questions and explanations

1.5 Delimitations

The research had its delimitations in the division Epiroc Drilling Tools R&D department. Moreover, focus was on the knowledge value stream of the PDP, and literature review of companies practicing agile was only studied in the software and manufacturing industry within IT-projects.

1.6 Outline

The *first* chapter of the essay presents the background information needed to create an understanding of the research. This leads to a defined purpose, which is then broken down into three research questions to be answered in the study. To convey a clarity about the scope of the study, delimitations have been set.

In the *second* chapter, the theoretical framework is presented and provides a basis of reviewed literature linked to the research papers subject area i.e. agile and PDP.

In the *third* chapter, the methodological framework is presented and describes how our research is a case study with a qualitative approach.

In the *fourth* chapter, the data collection as per the used means are presented.

In the *fifth* chapter, the data collection i.e. the findings of the study are analyzed and processed based on the theoretical framework for discussions. In addition, the research questions are answered based on analyzed data.

In the *sixth* chapter, final conclusions are made to discuss relevant theories and the outcome of the research. Few recommendations for the department are also shared here.

2. Theoretical framework

The second chapter provides required knowledge which the research paper revolves around i.e. the field of agile project management and project development process.

2.1 What is Agile?

To build a foundation in the study for agile frameworks, it will start with presenting the fundamental values and principles of APM. Agility is identified and recognized as the ability to change direction fast and at low cost (Schwaber & Sutherland, 2017). Moreover, the agile frameworks share common characteristics even though implementations are made differently, whereas the characteristics are that it creates transparency, mandate throughout the organization, increases ability all through the organization, and contribute to some vulnerability within the organization (Schwaber & Sutherland, 2017). In addition, agile practices are characterized and outlined by an agile manifesto (Manifesto for Agile Software Development, 2001) which values:

- Individuals and interactions over processes and tools.
- Working software over comprehensive documentation.
- Customer collaboration over contract negotiation.

However, mentioned values to the left are more valued than the ones to the right, thus, both are of importance but the ones to the left are of higher value. Furthermore, agile practices lie behind the agile manifesto which consist of twelve fundamental principles (Manifesto for Agile Software Development, 2001):

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Business people and developers must work together daily throughout the project.

5. Build projects around motivated individuals. Give them the environment and support they need and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. the sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity- the art of maximizing the amount of work not done-is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

2.1.1 Agile entering manufacturing

Agile emerged from the software industry and is known for its ability to respond to pressure (Murphy et al., 2013). The software industry is pressured to release software products with high quality and forced to adapt the development processes at fast rate (Murphy et al., 2013). Companies have exposed that in new product development, it takes more than delivering high quality, low cost and differentiation to surpass the competitive market (Takeuchi & Nonaka, 1986). Speed and flexibility are also what it takes, which require a different approach to manage new product development; an approach to develop new products fast and to be flexible (Takeuchi & Nonaka, 1986). In Japan and United States, companies took a new approach to manage their PDP (Takeuchi & Nonaka, 1986). Takeuchi and Nonaka (1986) examined manufacturers releasing successful innovations faster than their competitors. Companies as Fuji-Xerox, Canon, Honda, NEC, Epson, Brother, 3M, Xerox and Hewlett-Packard were studied, specifically, the PDP for specific products were chosen based on its novelty at the time it was developed (Takeuchi & Nonaka, 1986). Empirical findings identified that a team-oriented approach affected the design and development process which was that the teams tried to complete each phase as a unit by iteratively working on the developed product rather than working as per function in separate groups (Rigby, Sutherland & Takeuchi, 2016).

2.2 Doing Agile and Being Agile

There are crucial differences in “doing” agile and “being” agile. Doing agile is to subscribe to the framework and its activities used by management and teams to engage in agile practices (Ranganath, 2011). It is the set of activities used to focus on executing the principles of the framework, whilst being agile is related to the agile mindset that every practitioner must adopt; the consciousness and the way of being in a business (Ranganath, 2011; Ewel, 2017). Ranganath (2011) conducted research of an agile transformation and conducted three pilots before he could conclude important aspects of the differences between “doing” agile and “being” agile. He wrote that agile transformation is not only about adopting the methodology and its process, tools, and templates, but is also about the people, culture, and communication. Teams should set the goal to solve the problem, be committed, share a common purpose and create value (Ranganath, 2011; Ewel, 2017). To incorporate the agile mindset drives individuals to cultivate a sense of being part of the agile transformation and take responsibility (Ranganath, 2011). Ewel (2017) wrote that incorporating the agile mindset is a part of the organizational culture. Transformational efforts arise, and the mindset is a consistent, predictive, rapid response in the period of change, delighting customers and achievements through excellence of engaged employees working for mutual goals (Ewel, 2017).

2.3 Traditional and Agile Approach

Companies which practice traditional plan-driven methodologies, and in the pace of adopting agile methodologies are likely to face several challenges difficult to ignore (Nerur, Mahapatra & Mangalaraj, 2005). Research have shown that complex organizational change is represented by software development changes that cannot be managed simply by replacing current technologies and tools since such changes impact management practices, structure and culture (Nerur, Mahapatra & Mangalaraj, 2005).

2.3.1 Working in traditional approach

Nerur, Mahapatra and Mangalaraj (2005) contributes to the area of challenges that occur when moving from traditional to agile methodologies in organizations. Traditional plan-

driven methodologies are guided by a life cycle model such as the Waterfall model and spiral models (Nerur, Mahapatra & Mangalaraj, 2005; Conforto et.al. 2014). Such traditional methodologies have a desired mechanistic organizational structure whereas the structure is bureaucratic with high formalization (Nerur, Mahapatra & Mangalaraj, 2005). It has its fundamental assumptions that problems are specific and that an optimal solution exists for every problem and are built through extensive planning (Nerur, Mahapatra & Mangalaraj, 2005). Extensive planning acts as a base to predict, measure and control uprising problems in the development life cycle; it is process centric meaning that identified variations can be eliminated by continuous measurements and refinements of the process (Nerur, Mahapatra & Mangalaraj, 2005). The management style is in the form of command and control, whilst system development guided by a life cycle model as the Waterfall model specifies what tasks to be done, what the outcomes are desired to be for each phase and assigned roles are set for the specific task that need to be done (Nerur, Mahapatra & Mangalaraj, 2005). In addition, the project team and its team members are assigned individual roles favoring their specialization and numerous documentation is produced where knowledge of the product and codified processes are stored. Thus, knowledge management becomes explicit, and communication throughout the team are formalized through the stored documents (Nerur, Mahapatra & Mangalaraj, 2005). Moreover, the customers' role is important in the specifications development, but participation in other activities are not accurate (Nerur, Mahapatra & Mangalaraj, 2005).

2.3.2 Working in Agile approach

In contrast, the agile methodologies deal with unpredictability and have confidence on involved individuals rather than the processes (Nerur, Mahapatra & Mangalaraj, 2005; Ranganath, 2011). The desired organizational structure is an organic one which is characterized by horizontal communication and interaction, low specialization whereas knowledge is located wherever it is most useful, and decentralization with informal and formal decision-making (Nerur, Mahapatra & Mangalaraj, 2005). Furthermore, its fundamental assumptions are in continuous design improvement which is an initiated process from given feedback which requires change, thus, the project cycle is led by product features and its continuous improvements to increase customer satisfaction (Nerur,

Mahapatra & Mangalaraj, 2005). The management style is in the form of leadership and collaboration, and the project team are self-organizing and encouraged to role exchangeability, and informal communication is enhanced throughout the team, which contributes to tacit knowledge (Nerur, Mahapatra & Mangalaraj, 2005; State of Agile Report, 2018; Ranganath, 2011). It is important for team members to gain trust for each other and collaborate to be tied to the shared objectives and work as a team (Ranganath, 2011). The project is broken down to sub-projects and developers works in small teams close to the customer for collaborative decision making, fast feedback, and continuous integration of changes into the system under the development process (Nerur, Mahapatra & Mangalaraj, 2005; State of Agile Report, 2018). In addition, documentations should be stored and not comprehensive and important to reduce the amount of documentation and instead encourage tacit knowledge (Nerur, Mahapatra & Mangalaraj, 2005).

2.3.3 Challenges in adopting Agile

Research has raised key issues in challenges that occur when adopting agile, which are discussed to occur in management, organizational level, people, processes and technology (Nerur, Mahapatra & Mangalaraj, 2005; Ranganath, 2011; Ewel, 2017). The organizational policies demonstrated in the organizations routines have its basis from stabilized values, norms and assumptions that are reinforced by time (Nerur, Mahapatra & Mangalaraj, 2005; Ranganath, 2011). The organizational culture has major influence on managerial and organizational practices such as the decision-making processes, planning and control mechanisms, problem-solving practices, relationships, etc. (Nerur, Mahapatra & Mangalaraj, 2005; Ranganath, 2011). Furthermore, a considerable challenge is the change from a management style of demanding and controlling its project team to instead lead and collaborate in close relationships; it is a great challenge for the project manager to let go of the authority he/she had and rely on a self-organizing project team (Nerur, Mahapatra & Mangalaraj, 2005). It is also a challenge to coach, support and encourage team achievements or individual accomplishments since traditional view of celebrating success as per project execution (Ranganath, 2011). In addition, Ulrich and Eppinger (2016) raise the challenges of product development teams and that the issue of a risen dysfunctional PD team is due to four characteristics organizations display as lack of empowerment of the

team, functional allegiances transcending project goals, inadequate resources, and lack of cross-functional representation on the project team. The typical raise of functional allegiances and lack of cross-functional teams are due to functional organizations whereas the weaknesses rely in the coordination across different functional groups which can be bureaucratic and slow as per Ulrich and Eppinger (2016). Major issues are to integrate different functions and align team members as per their function to achieve business goals (Ulrich and Eppinger, 2016). Moreover, Nerur, Mahapatra and Mangalaraj (2005) mentioned that agile frameworks encourage Lean thinking and Lean practices as cutting down documentation, and knowledge management is tacit which can be difficult to accept for many organizations since the organization itself need to be dependent on the development team, which also leads to a shift of the power from the management to the development team. Furthermore, rejection of acceptance for such practices is also heavily dependent on the potential of knowledge loss due to employee turnover (Nerur, Mahapatra & Mangalaraj, 2005). However, such losses can be prevented by management of software development knowledge and decide what to be codified as stored knowledge and what to remain as tacit knowledge (Nerur, Mahapatra & Mangalaraj, 2005). Challenges also occur in the situation of including the customer during the PDP since decision-making now includes more stakeholders rather than the traditional approach where the project manager had the authority (Nerur, Mahapatra & Mangalaraj, 2005; Ulrich & Eppinger, 2016). The organization may need to put a lot of time to build good relationships among their employees to gain trust and respect to facilitate collaborative decision-making (Nerur, Mahapatra & Mangalaraj, 2005; Ranganath, 2011). In addition, a high barrier is the change of present process model from a life cycle model where traditional processes are activity and measurement based due to the shift of a development model being guided by adaptive and flexible systems to deal with uncertainties in the PDP, and its project cycle instead of being feature-driven, which requires major changes in work practices and the tools and technology being used (Nerur, Mahapatra & Mangalaraj, 2005).

2.4 Agile Umbrella

There are several agile practices and frameworks that come under an agile umbrella and they have been categorized as per lightweight approaches and fuller approaches, see figure 1. Lightweight approaches are usually designed specifically for software development

processes and works well for a single project team. Fuller approaches work well not only for the software development processes, but also for non-IT or PDP, especially, the one that consists of more than one project team. In addition, most of the presented agile frameworks in the upcoming sections have a glossary found in the chapter “Glossary” in this paper.

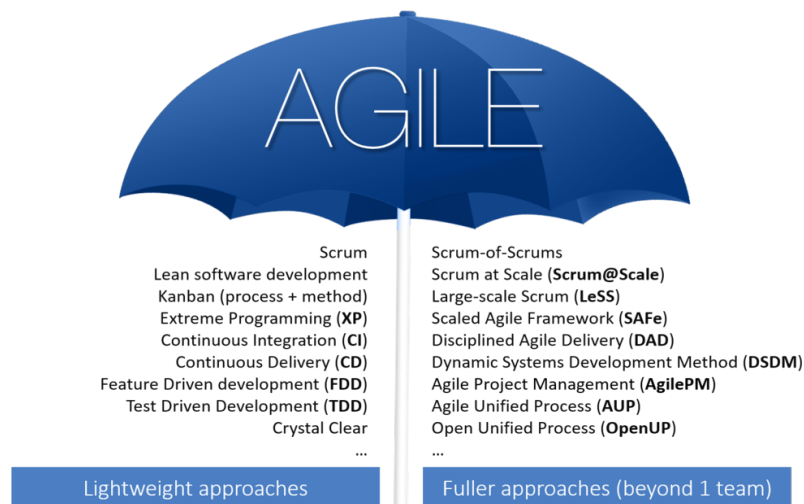


Figure 1: Agile Umbrella (nMerge, 2016)

The selected Agile frameworks for this research from the above umbrella are Scrum, Kanban and Lean from lightweight approach since the case study company Epiroc Drilling Tools is documented to follow them. The Dynamic System Development Method (DSDM) from the fuller approach was mainly selected for this research due to high relevancy. Below are the agile practices and frameworks that are suitable for a project team of not more than one i.e. lightweight approach and projects of more than one team i.e. fuller approach. It is important to mention that theory of agile frameworks do not have its purpose to be described into depth since the researchers do not want to lose focus, but rather describe the frameworks for an overall view. If further knowledge is desired, the researchers recommend full training and literature on the frameworks.

2.4.1. Lightweight approaches

Few lightweight approaches like Scrum, Lean and Kanban are briefly explained here to have theoretical knowledge in order to perceive the research more analytically.

2.4.1.1 Scrum

Ken Schwaber and Jeff Sutherland, key contributors to the Scrum framework and the updated release of The Scrum Guide 2017, includes a toolbox of interconnected agile project management methods and defined as a framework to work within which he addresses complex adaptive problems, while being productive and creative with delivery of products with the highest possible value (Schwaber & Sutherland, 2017). Sutherland and Schwaber (2017) “The Scrum Guide” is used as a key reference, therefore, the theory of how to implement Scrum is not accurate to repeat in theory section, but rather used as a tool in the discussion of the study. However, key Scrum roles and responsibilities are vital to mention for an overall understanding, see appendix 3 for a picture of the entire Scrum process. The Scrum team consist of three key roles:

- *Product owner*- The product owner manages the product backlog with the responsibility to express the product backlog items, prioritize and order the product backlog items, optimize value in existing work practices of the development team, make the product backlog transparent and clear to all team members to clarify next steps to be done, and ensure that product backlog items are understood by the development team (Schwaber & Sutherland, 2017). In addition, the product owner can influence the work of the development team and make trade-offs in the product backlog to make the backlog clearer, however, the team members who will do the work have the final decision whether they want to proceed with the suggestions of the trade-offs or not (Schwaber & Sutherland, 2017).
- *Development team*- The development team consist of professional team members, no more than between three to nine members who work with the product development process for optimal productivity (Schwaber & Sutherland, 2017). A Scrum team is self-organizing and cross-functional, which means that the team organize and manage their own work towards the sprint goal and consist of team members with

diverse competencies needed to accomplish the work and not dependent on others outside of the team (Schwaber & Sutherland, 2017). Scrum does not recognize titles to team members regardless of performed work being done by a member and recognizes no sub-teams regardless of domains that need to be addressed (Schwaber & Sutherland, 2017).

- *Scrum master*- The Scrum master serves the product owner, the development team, and the organization (Schwaber & Sutherland, 2017). It is the Scrum master's role to make sure that Scrum values, rules and practices are followed (Schwaber & Sutherland, 2017). To make sure that progress is made and goes forward pre-arranged daily stand-up meetings takes place with the development team to increase awareness of what have been completed, what is planned to be completed for the day and what obstacles are in their way (Stray, Sjøberg, & Dybå, 2016).

Scrum is a framework used to develop, deliver and sustain complex adaptive problems; a framework to apply various processes and techniques to continuously improve the product, the team and work environment (Schwaber & Sutherland, 2017). It has been used to, among other things, develop software, autonomous vehicles, managing the operation of organizations, etc. Moreover, Scrum is founded on empiricism which declare knowledge and decisions based on experience and what is known; an iterative and incremental approach to optimize presumptions and control risk (Schwaber & Sutherland, 2017). An empirical process such as Scrum consist of three pillars which upholds the implementation process: transparency, inspection, and adaptation. A natural tendency of daily turbulent work is that information gets hidden, however, transparency reveal key facts and existing practices can be adapted to the current situation and build a mutual understanding of what is seen and what needs to be done (Schwaber & Sutherland, 2017). To detect undesirable variances, it is important to inspect Scrum artifacts and the progress towards a sprint goal by Scrum users. Moreover, detection of deviation and undesirable results on product require adjustments. Adaptation requires the power to take decisions to cause change, therefore, authority is given and shifts when practicing Scrum so that those who lack mandate, but seize potential abilities to control the process, are given the opportunity to implement change (Schwaber & Sutherland, 2017). However, it is unavoidable that such framework with clear transparency

affect involved team members feelings since significant aspects of the process must be visible and reported, which can cause the state of vulnerability.

2.4.1.2 Lean

Lean production as a terminology was first introduced in a book by Womack, Jones and Roos (1990) known as “The Machine That Changed the world”. Toyota Production System (TPS) is the main basis of Lean from where the Lean practices were evolved through the effort and growth of Japanese economy (Womack & Jones, 2003) since Japanese manufacturers faced shortages of material, human resources, and financials after world war II (Abdulmalek & Rajgopal, 2007). However, the success story of Japanese car manufacturers in US is what has led to the spreading interest among several western researchers (Womack & Jones, 2003). The importance of management policy in the performance of production plant was acknowledged other than the technological and geographical differences (Womack & Jones, 2003).

Lean is based on a background of having a continuous flow in the production that differs with the help of minimum utilization of inventory, buffer levels and detecting quality issues rapidly (Womack & Jones, 2003). As per Womack and Jones, (2003) Lean can briefly be defined as “more and more with less and less”.

Fundamental elements of Lean

The Lean principles are not unique and has been defined partly by the ideas from the Henry Ford (Krafcik, 1988). Few important guidelines that are followed in Toyota are based on the following three elements in general (Morgan & Liker, 2006) which are:

1. Driving waste out of PDP.
2. Improving the way the projects are executed.
3. Visualizing the PDP.

Lean Production and Lean Product Development

The TPS is often referred interchangeably with the terms lean production and lean manufacturing (Wilson, 2015). However, it is called lean because the process itself run by using less material, less inventory, requiring less investment, and consuming less space and people (Wilson, 2015). The use of different terminology as Lean production and Lean PD is because Lean PD is an extension of Lean itself. The term lean production will be used further on in this part of theory than Lean manufacturing.

The difference between production and PD is very substantial (Morgan & Liker, 2006). Production can be defined as a recurring process of product that is created repeatedly several times and PD is to create a single set of instructions or methods for many products and product variants (Reinertsen & Shaeffer, 2005). In production, the physical output is the product itself whilst for the PD knowledge is the main output (Morgan & Liker, 2006). Moreover, the process-oriented system Lean production focuses on reducing waste as non-value-added activities by using tools as Just-In-Time (JIT), Kanban, 5S, etc. Lean PD, an extension to the PD system level, is to develop the flow in PD processes (Morgan & Liker, 2008). It is to define customer requirements and follow it in the design process, minimizing deviation in designs by reusing designs, avoid immature technologies, etc. (Morgan & Liker, 2008).

Several researchers have discussed about the effectiveness of Lean PD. It has helped companies like Harley Davidson to reduce the development time by half and has increased their production rate by four times (Oosterwal, 2010). Morgan and Liker (2006) also share simple examples in their research that shows decrease in development time. Companies as Goodyear has also discussed about the benefits of Lean PD in their book called Lean Driven Innovation by Majerus (2016).

The value stream in product development

The value stream is defined as all the activities that add value and the necessary non-value-added activities to create a product (Rother & Shook, 1998; Abdulmalek & Rajgopal, 2007). The value stream in Lean PD is divided into two streams, product value stream and knowledge value stream (Kennedy, Harmon, & Minnock, 2008), see figure 3.

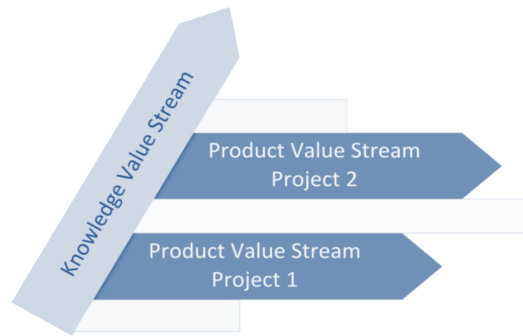


Figure 2: The product development value streams (Kennedy, Harmon & Minnock, 2008)

Product value stream

It consists of flow of several tasks or activities, human resources or labor or people and tools needed for creating elements like Bill of Materials (BOM) and the required manufacturing processes for the specific products i.e. “recipe” (Kennedy, Harmon, & Minnock, 2008). This shows that the product value stream is subjective to each project.

Knowledge value stream

The main output of this stream is to produce knowledge that is required to start with the product value stream. It shows the collections and use of existing and new knowledge about customers, market trends, technologies, products, competitors, ongoing research and new manufacturing capabilities. This stream remains common to all the projects and organizations (Kennedy, Harmon, & Minnock, 2008). It is ensured that in every PD project, knowledge is collected and re-used in the upcoming projects. Both the streams are represented in figure 2.

2.4.1.3 Kanban board

Kanban is a Japanese word defined as “large visual board”, “signal card” or “sign” and a method used to define, manage and improve services delivering knowledge work (Anderson & Carmichael, 2016). Taiichi Ohno, the vice president of Toyota Motor Company, developed Kanban and it originates from Japanese manufacturing whereas it was, specifically in car manufacturing, identified that shortage of parts needed to assemble cars could hold up the entire line (Stellman & Greene, 2015). The cost of delay was given immense importance and the manufacturing team led by the engineer Taiichi Ohno at Toyota acknowledged the

problem of predicting expected short supply for parts (Stellman & Greene, 2015). Thus, a solution for unexpected shortage in supply was the pull system whereas products and services are pulled into the production system as a response to customer demand.

Stellman and Greene (2015) writes that Kanban requires the Lean mindset, to which the Kanban method provides a solid foundation since Kanban provides means to improve the process. In addition, the means provided by the Kanban method and used by teams have its focus on eliminating waste from the process.

“Kanban is not a software development lifecycle methodology or an approach to project management. It requires that some process is already in place so that Kanban can be applied to incrementally change the underlying process”.

- David Anderson, Kanban (Stellman & Greene, 2015)

Anderson and Carmichael (2016) presents Kanban six foundational principles, whereas the first three ones are categorized under “Change management principles” and the last three under “Service delivery principles”:

1. Start with what you do know.
2. Agree to pursue improvement through evolutionary change.
3. Encourage acts of leadership at every level- from the individual contributor to senior management.
4. Understand and focus on your customers’ needs and expectations.
5. Manage the work; let people self-organize around it.
6. Evolve policies to improve customer and business outcomes.

Moreover, Anderson and Carmichael (2016) also defines six important activities:

1. Visualize.
2. Limit Work in Progress (WiP).
3. Manage flow.
4. Make policies explicit.
5. Implement feedback loops.
6. Improve collaboratively and evolve experimentally.

Kanban is used to visualize abstract knowledge work and assure that work is to be done and service are delivered (Anderson & Carmichael, 2016). The Kanban system, the flow system, limit WiP by placing either physical cards or visual signals on a Kanban board, and then move the cards rightward from one column to the next when the work item progress with a new status (Anderson & Carmichael, 2016). Moreover, the purpose to limit WiP is to prevent excessive or inadequate amount of work (Anderson & Carmichael, 2016). Furthermore, WiP limit policies, creates a pull system to schedule and deliver work when demand and capacity is accessible (Anderson & Carmichael, 2016).

On the other hand, Kanban board is a visual tool used to visualize the workflow to optimize the work. The most basic form of Kanban board consists of three columns; to do, doing and done. These columns can be made on a physical board or a digital board depending on the flexibility of the working team (LeanKit, 2018). In physical boards, the sticky notes help to absorb the power of visual input to see how the team's process works and gives and receives an overall context of the work, see figure 3 for Kanban board.

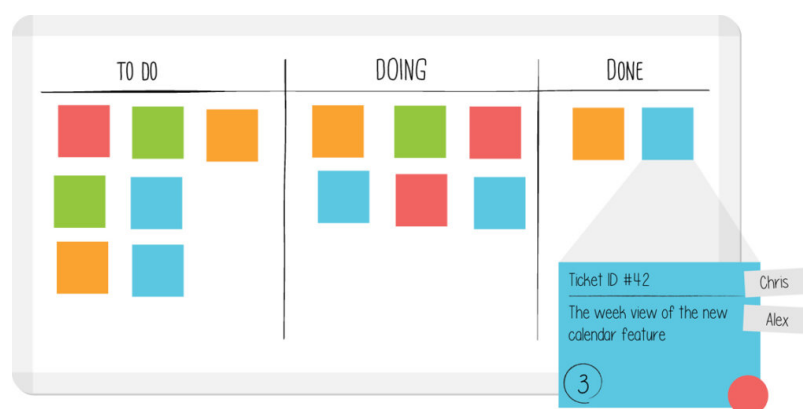


Figure 3: Physical Kanban board with a basic three-step workflow (LeanKit, 2018)

2.4.2 Fuller approaches

A fuller approach like DSDM is briefly explained here to have theoretical knowledge in order to perceive the research more analytically.

2.4.2.1 Dynamic System Development Method

It is an APM framework with an aim to deliver the correct solution at the correct time (Richard, 2013). Focus of DSDM is to have a prompt delivery of actual benefit to a business or customer whilst ensuring that the project is intact and strategically aligned. It consists of philosophies, principles, a project lifecycle with a defined set of products that has some flexibility to be altered, roles defined clearly and responsibilities, and a set of agile practices and techniques to enable product delivery (Richard, 2013).

Waterfall method has been adopted for several years with very strict rules to follow the sequence. It has been regarded as a false method by many due to the several flaws in it. Attempts were made to move away from it like Barry Boehm's development framework (Boehm, 1988) using the iteration style of spiral model. However, the adaption of it in the IT practices was not enough and needed more attention than it deserved. This emergence in recent years of Agile shows the need for a unique and different approach (Stapleton, 2003). Extreme programming gained wide acceptance when it comes to Agile frameworks, but it left few organizations confused in how to integrate it with other offered solutions. DSDM Altern was designed by Arie van Bennekum and the abstraction of which is the DSDM APM (Manifesto for agile software development, 2001). It is made to complement other Agile approaches in a scenario where a defined project approach will either add value or is expected. A brief description will help the reader understand DSDM APM better and give a quick glance of different techniques used in this framework.

DSDM was originally created in 1997 by Arie van Bennekum through the collaborative effort of several practitioners in the field of project management across many blue-chip companies (Manifesto for agile software development, 2001). The main objective was to build more quality in the existing Rapid Application Development (RAD) (Stapleton, 2003). To deliver results effectively and efficiently using agile project management, DSDM is a proven framework. It focuses on two major aspects: strategic goals and incremental delivery of real business benefits. Both the aspects accounts time, cost, risk and quality to gain control over the business.

Furthermore, the main benefits of DSDM (Fahad, 2017) are recognized as:

- Quick and in time delivery of the project with cost effectiveness.

- Self-organizing and collaborative team.
- Development of products in the form of prototypes allows more requirements to be added after regular intervals.
- Feasibility study at the start prevents the failure of the project in future.
- Continuous collaboration between all parties.

DSDM Roles and Organizations

People working collaboratively and effectively are the main foundations of any successful project. DSDM acknowledges it and assigns roles and responsibilities to every person in the project who is representing the business, technical, management and process interests. All the members of this process communicate closely to be effective (DSDM Handbook, 2014), see appendix 4 for the DSDM Team Model. Each bubble in the color scheme of the DSDM Team Model, signifies the following roles (DSDM Handbook, 2014):

- **Orange** - Business interests, roles representing the business view.
- **Green** - Solution/technical interests, roles representing the solution/technical view.
- **Blue** - Management interests, roles representing the management/leadership view.
- **Grey** - Process interests, roles representing the process view.
- **Mix of two colors**– A role that straddles two separate areas of interest, e.g. Business Analyst, has both a business and a solution/technical focus.

The project-level of the DSDM Team Model includes the business sponsor, business visionary, business analyst, technical coordinator and project manager. The project level roles can be part of a project board or steering committee for a project, and as a collective have authority to lead the project. It is the project-level roles responsibility to motivate individuals, trust the teams and give the team the support and environment needed (DSDM Handbook, 2014).

The solution development team includes the business ambassador, business analyst solution developer, solution tester, and team leader. The team build the solution and are

responsible to assure that the business purpose aligns with the solution (DSDM Handbook, 2014).

The supporting roles include the technical advisors, business advisors, DSDM coach and workshop facilitator. Guidance and support are given for a specific purpose all during the whole lifecycle (DSDM Handbook, 2014).

DSDM Process

The process in DSDM is iterative and incremental with a total of six lifecycle phases. The purpose of each phase is specific to the defined products with an intend to support the evolution of the solution and the smooth running of the project. The DSDM APM is designed to work effectively with projects of several varied sizes and complexity. By customizing the various products, DSDM ensure that the control is demonstrated to a level of formality i.e. appropriate to the organization so that the benefits of Agile are achieved without neglecting the project governance structure (DSDM Handbook, 2014). The project process mainly consists of four phases: feasibility, foundations, evolutionary development and deployment. These phases are preceded by the Pre-project phase and followed by the post project phase, giving six phases in total. Check figure 4 for an illustration of the DSDM process.

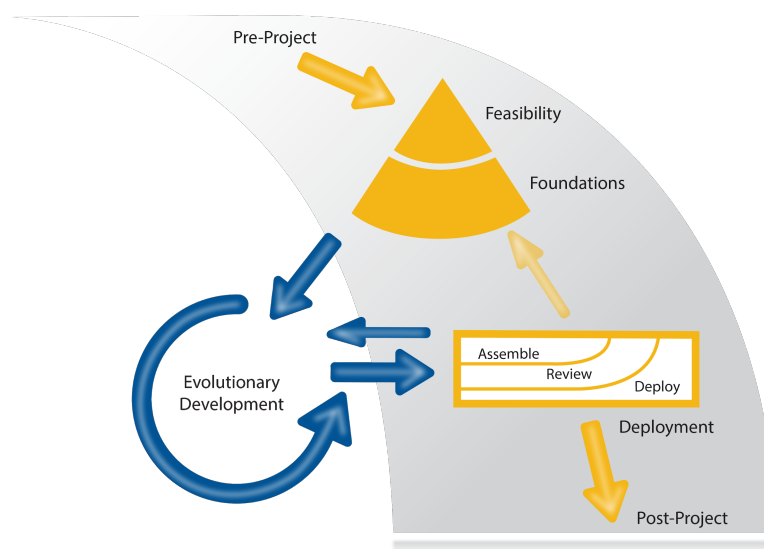


Figure 4: DSDM process (DSDM Handbook, 2014)

Pre-project Phase

This phase ensure that the correct projects are started with right set up based on a clearly defined objective that is in line with the DSDM philosophy (DSDM Handbook, 2014).

Feasibility Phase

The Feasibility phase mainly includes whether the proposed project is feasible from a technical outlook or not and whether it looks cost-effective from a business point of view or not (DSDM Handbook, 2014). The work associated with Feasibility should be enough to decide of whether further investigation is required or not, or whether the project should be put on halt or not (DSDM Handbook, 2014).

Foundation Phase

The next level of this preliminary investigation is the foundation phase. It is required to achieve a fundamental, but not very complex, understanding of the business rationale for the project, the potential solution that will be created by the project, and how development and delivery of the solution will be tackled (DSDM Handbook, 2014). By purposely neglecting low levels of detail, the foundations phase should last for less than few weeks and that goes for the complex, detailed and large projects as well (DSDM Handbook, 2014). The detail in the requirements, and the way they should be considered as part of the solution, is purposely excluded until the Evolutionary Development phase of the project (DSDM Handbook, 2014). The objective of foundations is to know the scope of work, the procedure with which it will be done, by whom, when and where (DSDM Handbook, 2014). The Foundations phase also finds out the project lifecycle by accepting the different procedure with which the DSDM process will be applied in the organization (DSDM Handbook, 2014).

Evolutionary Development Phase

The purpose of the evolutionary development phase is to evolve the solution (DSDM Handbook, 2014). It ensures that the Solution Development Team(s) uses techniques like

iterative development, timeboxing, and prioritization with modelling and workshops to combine over a span of time on a correct solution that coincides with the business need and is also built in the correct way from a technical outlook (DSDM Handbook, 2014). By using Timeboxes, the Solution Development Team generates Solution Increments, iteratively discovering the low-level detail of the requirements and testing continuously as they move ahead (DSDM Handbook, 2014).

Deployment Phase

The aim of the Deployment phase is to get a base of the evolving solution for the operational use. The deployed solution might be the final or partial solution (DSDM Handbook, 2014). The deployment phase consists of three activities i.e. assemble, review and deploy. After the assemble and review activities, approval has been made and then deploy is the action of using what has been assembled for the operational use (DSDM Handbook, 2014). It includes any technical jobs, but also the authorization of any plans for the change in business (DSDM Handbook, 2014).

Closing the project

After the deployment phase the project is then closed (DSDM Handbook, 2014). The entire team then holds a retrospective to review the overall performance of the project, both from the technical and business point of view (DSDM Handbook, 2014).

Post project phase

After closing the project, the post-project phase validates how the expected benefits are (DSDM Handbook, 2014). However, it is possible to show just the highlight of the benefits since the benefits will be matured over time (DSDM Handbook, 2014).

DSDM Product overview

DSDM has several products that are considered important only if it adds value to the project, or to the solutions it creates. It is also very important for all the stakeholders and the participants to know the need of the products, that it must be delivered on time and that

quality is assured (DSDM Handbook, 2014). DSDM mainly consist of two types of products (DSDM Handbook, 2014): products which develop over time and the products which mark a milestone (DSDM Handbook, 2014). In total, there are 14 products which are further classified into three categories dependent on the area the products are dealt with (Netmind, 2018), see figure 5 below for more details.

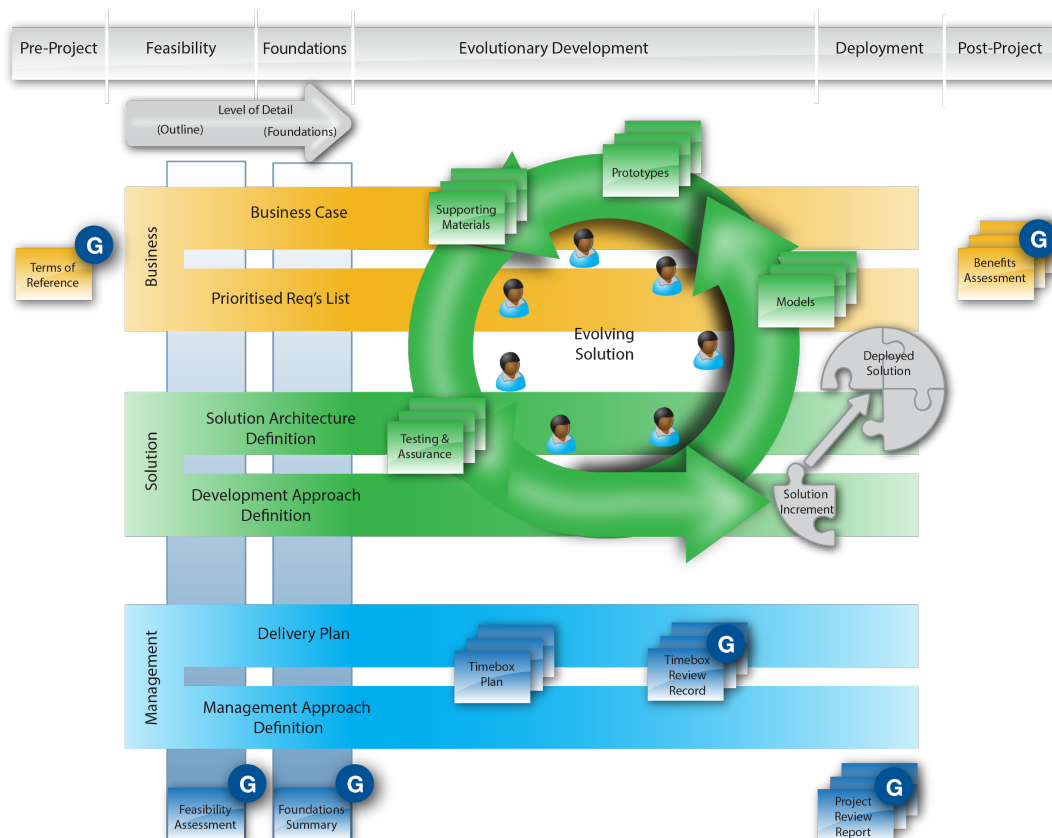


Figure 5: Product overview of DSDM (DSDM Handbook, 2014)

Business oriented products - These products highlight the expected benefits, requirements, justification for the project and are marked as yellow (DSDM Handbook, 2014).

Solution/technical oriented products - Technical, development, scope and quality aspects are focused on these set of products (DSDM Handbook, 2014). The products are marked in green.

Management/control-oriented products - Focuses on the project management, communication, planning of delivery and constant improvement aspects (DSDM Handbook, 2014). The products are marked in blue.

In figure 5, the products marked with G in a blue circle notifies the relation of it with the governance processes or the document that requires government standards (Netmind, 2018). All the 14 products are not at all mandatory and are mainly recommendations that are to be considered by the members of the project team which depends on project to project and from organization to organization (Stapleton, 2003).

Solutions Architecture Definition

The Solution Architecture Definition is an evolutionary product, evolutionary in the context of DSDM means iterative. It provides a high-level design framework for the solution. It is intended to cover both business and technical aspects of the solution to a level of detail that makes the scope of the solution clear but does not constrain evolutionary development (DSDM Handbook, 2014).

Development Approach Definition

The Development Approach Definition is an evolutionary product. It provides a high-level definition of the tools, techniques, customs, practices and standards that will be applied to the evolutionary development of the solution. Importantly it describes how quality of the solution will be assured. A strategy for testing and review is therefore a key part of the development approach and described in the Development Approach Definition (DSDM Handbook, 2014).

Management Approach Definition

The Management Approach Definition is an evolutionary product. It reflects the approach to the management of the project and considers, from a management perspective, how the project will be organized and planned, how stakeholders will be engaged in the project and how progress will be demonstrated and, if necessary, reported. The product is outlined in Feasibility and baselined at the end of Foundations and will only evolve beyond that when

circumstances change or if review of the approach identifies areas for improvement (DSDM Handbook, 2014).

DSDM Techniques- MoSCoW prioritization

Several practices are used to perform the DSDM and to apply the principles of DSDM, timeboxing are few of them (Stapleton, 2003). Many definitions are available for timeboxes. The most appropriate one is the time between the start and end date of the project. The end date is rigid and should not change, and a system or a product must be delivered on that date. Similar approaches in the project management frameworks can be found, like the sprints in the Scrum method (Norbjerg, 2002). In DSDM, the duration of a timebox is from one to six weeks in length. Shorter duration is preferred. This duration is not obligatory though, it can also be seven weeks long dependent on the project manager and the size of the project. Major advantage to keep the timeboxes smaller is to make it easier to grasp knowledge (Stapleton, 2003). Moreover, MoSCoW is an acronym for prioritizing the assigned requirements. The 'o's in the acronym does not hold any meaning, and the rest of the letters in capital are described in table 2 below for MoSCoW definitions (Stapleton, 2003).

M - Must have	S - Should have	C - Could have	W - Want to have, but not now
These are the requirements that are most essential and fundamental to the system. The system is considered useless without them. The 'must have's' is known to call minimum usable subset as per DSDM.	In the less time-constrained development, they are considered important requirements and mandatory. However, the system is useful with or without them.	Requirements that can be left out of the increment when under development easily.	The requirements that can wait for the next development phase or at a later stage.

Table 2: Definition of MoSCoW prioritization (Stapleton, 2003)

MoSCoW are the requirements needed for a full-fledged system and provides all the basis on which the decisions are made about what the developers will do over the whole project and during any timebox within the project. Other practices in DSDM include facilitated workshops and iterative development (Stapleton, 2003).

2.5 Managing Technological Innovation, Organizational Culture and Trends

Spithoven et al. (2012) stated that in a rapidly changing environment, a key factor for organizations to enhance competitive advantages and growth is innovation. Schilling (2017) define innovation as the practical implementation, adoption or creation of an idea into a new device, method, or material. Technological innovation is applied for commercial or practical objectives, in addition, the creation of new processes, products and procedures are vital for productivity and growth in all sectors (Schilling, 2017). Shipton et al. (2006) highlight that the economic climate, increase of global competition, rapid changing organizations, and organizations ability to innovate is vital for success. Schilling, (2017) also highlight the importance of the ability to innovation for success whereas technological innovations are an important part of firm's growth with an increasing importance due to globalization of markets. Therefore, pressure is put on organizations to continuously innovate to produce differentiated products and services (Schilling, 2017). Furthermore, Shilling (2012) discuss around strategic management of technological innovation, where resources and objectives must align with innovation projects to benefit core competencies and achieve strategic intent. Moreover, innovation by industry and the importance of strategy and developed processes are vital; firms which charge headlong into new PD without clear strategies or developed processes tend to consequently initiate more projects than it can be supported, choose projects as a poor fit for the resources and objectives, and endure long development cycles (Schilling, 2017). Brown and Eisenhardt (1997) conducted an inductive study to examine organization's engagement of constant change whereas it was supported in the study that successful firms defined innovation strategies and management processes as vital.

The innovative organization and the pace of exploration and exploitation differ dependent on the organization's characteristics- ambidextrous organizations i.e. organizations with

complex organizational form with different divisions that differ in cultures and patterns of operations (Schilling, 2017). Divisions characterized by high degree of formalization and standardization utilize mechanic structure, which increases the possibility of an effective organization mechanic structure fit for the manufacturing division (Schilling, 2017). Whilst other divisions are characterized by an organic structure with a low degree of formalization and standardization giving employees more latitude in their job responsibilities and operating procedures, and encourage an innovative environment (Schilling, 2017). Thus, it is fit for the R&D division where an innovative culture is needed (Schilling, 2017).

Bartlett and Mohammed (1995) conducted a study on the Minnesota Mining and Manufacturing Company (3M) whereas part of their collected data refers to previous CEO L.D. DeSimone who stressed that a company should find a balance between freedom and control to ensure innovation and effectiveness. Moreover, DeSimone further stressed that it is important to create a trust-relationship in the company- if someone insists that there is a potential in a blocked project there should be trust, whilst trust should also be given to the top management when activities are controlled in lower levels (Bartlett & Mohammed, 1995). The culture within the company should strive to foster trust and openness between the diverse levels within the company to be able to collaborate, build good communication, and foster an innovative culture (Bartlett & Mohammed, 1995).

Schilling (2017) discusses around locally leveraged strategy, which gives a company the advantage to take the creative resources and developments from the divisions and use them across the company. Moreover, an innovative culture is established by integrating the different divisions or subsidiary through, for instance, cross-regional meetings where staff can exchange creativity and have a chance to broaden their perspective outside of their field (Schilling, 2017).

Simmel (1957) fashion theory is discussed as a form of imitation, which affects social classes; individuals tend to follow the social contents, find satisfaction by being part of the society and not standing alone. The establishment of fashion relies on the social tendencies as the need of union and need of isolation (Simmel, 1957). Pressure to release software products in high-quality and increase of fast rate for releases, software industry is forced to

adapt the development processes (Murphy et al., 2013). Agile emerged from the software industry and is known for its ability to respond to pressure, therefore, due to the agile frameworks and its reputation of responding to pressure (Murphy et al., 2013). Non-software industries tend to approach perceived challenges in their development activities as per agile, however, research of agile in non-software industries are still emerging and there is a lack of empirical data to perceive the actual effect of other industries than software (Qumer & Henderson-Sellers, 2008; Mishra, Dangayach & Mittal, 2011; Mafakheri, Nasiri & Mousavi, 2008; Sheffield & Lemétayer, 2013).

2.6 Companies practicing Agile Project Management

The research of similar companies, or similar lines have been studied for comparison of challenges in innovation processes in software and manufacturing industry within IT-projects to find similarities in faced challenges and given effects of the incorporation of APM. The researchers have studied agile application in R&D departments in international companies, and literature have been chosen based on the transition from traditional project management to at least one agile project management framework. Research of agile in manufacturing industry within R&D is emerging, therefore, there are more available research in software industry which have its focus on agile practices (Qumer & Henderson-Sellers, 2008; Mishra, Dangayach & Mittal, 2011; Mafakheri, Nasiri & Mousavi, 2008; Sheffield & Lemétayer, 2013). The lighter approaches like Scrum and the fuller approach DSDM have been discussed around, and a comparison have been made to identify similarities in perceived challenges and improvements to get an overall view of how one or several agile frameworks tackle challenges in development processes. Thus, several shared challenges have been identified as explicit knowledge management, lack of transparency, formal communication, rigid project cycles, plan driven development model, low flexibility, individualism in teams, low customer collaboration and defined processes (Katumba & Knauss, 2014; Dagnino, 2002; Plonka et al., 2014; Paasivaara, Durasiewicz & Lassenius, 2008). Moreover, findings show that similarities in improvements are better transparency, availability, faster executions, self-organizing teams, time-commitment, end-to-end knowledge and motivation (Katumba & Knauss, 2014; Dagnino, 2002; Plonka et al., 2014; Paasivaara, Durasiewicz & Lassenius, 2008). See appendix 5 for a summary of the

companies practicing agile and their perceived challenges, incorporated agile practices and perceived improvements.

2.6.1. Volvo Car Co-operation

The research has been conducted at the automotive Swedish company Volvo Car Cooperation (VCC) and limited to the R&D department in Complete Powertrain Engineering. The focus of the paper is within the in-house software development where parts of the software are developed, and software requirements are specified for other parts, and developed by diverse suppliers. The research paper's objective is to understand to what extent agile frameworks are applicable to automotive in-house software development.

VCC faced several challenges i.e. characteristics in the automotive software development that made it hard to introduce agile. The process had the lack of structure when developing software in-house whereas tasks was given in sudden urgency and focus was upon the end-product, whilst there was heavy workload where one role were merged with another, multitasking and task switching when being part of several projects, unbalanced workload and scheduled synchronization was challenged (Katumba & Knauss, 2014). Furthermore, domain specifics and supplier network had its issues when in-house team sent requirements to supplier and managed by supplier integration; bottlenecks were created which caused process dependencies when software needed to be sent back to the supplier even though the team could work on it for shorter timescale (Katumba & Knauss, 2014). The overall context of work being done was not aligned. There was no knowledge of the functions or features developed, high complexity and lack of development structure, limited support, and individualism whereas involved individuals did not work towards the same goal (Katumba & Knauss, 2014). In addition, the culture of shared information and knowledge was rigid. There was a lack of transparency and long communication chain where information had to pass several channels to reach the person it was aimed for (Katumba & Knauss, 2014).

Studied challenges resulted in a hybrid approach with Scrum, Extreme Programming (XP) and Lean. There was a perceived view of low agile competence, in addition, a lack of software development methodology and structure (Katumba & Knauss, 2014). Thus, the process had its opportunity to improve with the implementation of a holistic PD strategy

from Scrum. The heavy and unbalanced workloads had its potential of improvements in the agile practices of Scrum and Lean as implementing the task board, sprint planning, extent commitment, and reduce the development cycles for frequent releases (Katumba & Knauss, 2014). Moreover, the process dependencies between the in-house software development team and supplier had unnecessary activities where in-house team had to send back the software to supplier even though it could be solved in-house (Katumba & Knauss, 2014). Thus, Lean had its basis to eliminate waste and shorten the time cycle (Katumba & Knauss, 2014). Lack of domain knowledge due to vague requirements from engineer's whom primarily have hardware and electronics knowledge and not software (Katumba & Knauss, 2014), the solution for such individualism relied on Scrum whereas requirements were put in a product backlog to be prioritized and have a user story (Katumba & Knauss, 2014). It was important to implement sprint planning and put confidence on a product owner (Katumba & Knauss, 2014). Furthermore, lack of sharing information and knowledge with its basis in low cross-functionality and high level of individualism (Katumba & Knauss, 2014), Scrum and Lean had an important role for such challenges. Thus, suitable agile practices were the implementation of retrospectives, self-organized cross-functional teams, team collocation, and daily stand-ups (Katumba & Knauss, 2014).

2.6.2 ABB

The research was conducted at the industrial technological company ABB in the US and limited to the R&D department towards the technology development lifecycle of industrial products. Specifically, the development of software in the technology development phase. The research paper's objective was due to several challenges with a basis in the traditional software development and the delivery of alpha systems within the technology phase. Requirements were documented in early stages, which made it difficult for developers to response to emerging requirements (Dagnino, 2002). Moreover, the number of artifacts were comprehensive and focus on the actual software developed suffered (Dagnino, 2002). The software development life cycle was slow, and there were no frequent inspections or controls to secure systems delivery (Dagnino, 2002).

Studied challenges resulted in The Agile Development in Evolutionary Prototyping Technique (ADEPT) developed by ABB and incorporated by several concepts and practices

of the agile frameworks DSDM, XP, Scrum and Feature Driven Development (FDD) (Dagnino, 2002).

The software development process was defined and rigid, therefore, Scrum-of-Scrum was implemented- teams were divided between 4-8 members and had daily Scrum, whereas one member got chosen as an ambassador to participate in daily meetings with ambassadors from other teams (Dagnino, 2002). In the end of each cycle, testing was incorporated such as an acceptance test prior development with the customer, unit tests to test implemented scripts, and functional test to test the systems final functionality (Dagnino, 2002). The test was reviewed every week with the purpose to examine risks and update completed tasks prior week and upcoming tasks (Dagnino, 2002). Requirements were prioritized and to be implemented in each cycle and documented (Dagnino, 2002). Moreover, rigid response to sudden emergent requirements set the basis of implementing adaptive and self-organizing teams and customer involvement, in addition, developers and users or/and the customer negotiated requirements were included in meetings for direct feedback (Dagnino, 2002). Furthermore, artifacts were reduced, and decision was made to maintain a project plan document and a requirements worksheet to gather features, delegate feature assignments to diverse groups, schedule date for project completion, and assign responsibilities (Dagnino, 2002). Evaluation of the progress was vital to increase quality of the final delivery; therefore, weekly risk mitigation meetings was implemented to cover progress, risks, and design information (Dagnino, 2002). Thus, the ADEPT process model incorporates three phases including above implemented practices from Scrum and DSDM as Project evaluation phase, Feature Development Phase and Project Completion Phase. For in depth knowledge about the process model and the agile practices incorporated see Dagnino (2002).

2.6.3 Lshift

The research was conducted at the high-tech software development company Lshift and limited to the R&D department in software development delivery. Difficulties in software delivery was perceived by the technical team and there was a need to integrate Integrating User Experience (UX) design into an agile project.

The challenges of Lshift arose in the feasibility-, foundation-, and engineering phase. The software engineers frequently work with external experts and additional teams such as partner agencies or client-owned teams who often are not co-located for a whole project (Plonka et al., 2014). Additional teams as UX experts were not co-located throughout the projects since it was a separate UX design company, which only had little experience of agile (Plonka et al., 2014). Issues arose in the diverse ways of working for developers and UX designers; there was no aligned perspective of the goals, upfront UX design was developed, and different skills and knowledge in diverse expertise had its separate focus on either the development of a design, or working software and technical constraints (Plonka et al., 2014). In addition, there was low awareness of lead activities both from the developers towards the designers and vice versa. Misalignment led to unawareness of a solution being developed by developers and unawareness that designers had designed the feature without the input for technical constraints (Plonka et al., 2014). Thus, issues with technical feasibility with design-led approach, whereas developers and UX designers worked mostly independent, designs were agreed with client before developers could confirm if the design is technical feasible (Plonka et al., 2014).

Studied challenges resulted in the need to integrate UX design into DSDM to cope with challenges as lack of communication and the user perspective/ user experience design (Plonka et al., 2014). It was important to align the developers and UX designer to integrate the work practices (Plonka et al., 2014). For feasibility and foundation phase, a developer was assisted to the UX team to work in a Business Analyst (BA) role to help assess the feasibility of design proposals earlier in the process (Plonka et al., 2014). In addition, the BA had a vital role to decrease the communication gap between the developer, designer and the customer and made it possible to interact directly with the customer, attend design meetings for technical input and drive business requirements (Plonka et al., 2014). Moreover, a DSDM project manager (PM) with expertise in UX design experience and technical development was incorporated to be responsible for business and technical delivery (Plonka et al., 2014). Daily communication in engineering made it possible for designers who worked on the actual design to participate in development stand-up meetings to be up-to-date and incorporate iterative and quick feedback. Upcoming challenges in design-led approach led to the decision and need to change to development-

led approach in engineering. Thus, prototype was first developed and thereafter shared with designers for feedback (Plonka et al., 2014).

2.6.4 EnergySoftware

The research was conducted at a global distributed information technology (IT) company. The organization has its projects distributed globally whereas main activities are in Europe. The study has its focus on the product development process of a product program was given the fictional name EnergySoftware, which develops software for companies within the sector of oil and energy and the project is distributed between Norway and Malaysia.

The research papers objective was due to a rigid traditional process incorporating agile practices to a global distributed project (Paasivaara, Durasiewicz & Lassenius, 2008). The software consists of five modules whereas each release is a project; the development of the software was made in increments; however, quality was not approved according to specifications until the last increment when the software worked (Paasivaara, Durasiewicz & Lassenius, 2008). In addition, requirements could be misunderstood due to the developer's perspective compared to the product owners (Paasivaara, Durasiewicz & Lassenius, 2008). It was also known that documentation was comprehensive, and it had been perceived a need of more flexibility from the customers (Paasivaara, Durasiewicz & Lassenius, 2008). Furthermore, seven teams are involved in the development whereas five are delegated around the different modules with separate product owner's, whilst the other two teams are maintenance and framework (Paasivaara, Durasiewicz & Lassenius, 2008). All product owners were in Norway and are obligated to travel often to collect requirements, whilst developers and Scrum masters are delegated both in Norway and Malaysia (Paasivaara, Durasiewicz & Lassenius, 2008). Due to the diverse geographical locations, the time differences were another challenge with the distance between the teams, whilst the work culture also differed since the Malaysian team had prolonged work time with longer breaks which affected digital communication (Paasivaara, Durasiewicz & Lassenius, 2008). Thus, challenges for the project revolves around the distance between the global distributed teams and project (Paasivaara, Durasiewicz & Lassenius, 2008). It caused challenges in communication in several fields whereas different disciplines lack communication, team alignment, update on procedures, etc. (Paasivaara, Durasiewicz & Lassenius, 2008).

Studied challenges resulted in adapting Scrum agile practices to align the teams due to the distance of both sites (Paasivaara, Durasiewicz & Lassenius, 2008). It was important to incorporate daily Scrum meetings with focus on the single roles where each member had to update about what have been done before last Scrum meeting, what obstacles was faced and what was planned to be done before next Scrum meeting (Paasivaara, Durasiewicz & Lassenius, 2008). It was important to align the time of the meetings due to time differences for both sites. Moreover, implementation of Scrum and the need of updating participants about the tasks and difficulties were challenging due to cultural aspects but improved with time when team members felt secure within the team (Paasivaara, Durasiewicz & Lassenius, 2008). Weekly Scrum-of-Scrums was incorporated, and each team rotated to whom would be given the role to participate and represent the team tasks that have been done, what obstacles have been faced and what are to be done until upcoming meeting (Paasivaara, Durasiewicz & Lassenius, 2008). Furthermore, to align and synchronize work for each module, the developers were given four weeks sprints, whilst maintenance had two weeks sprints since addressed issues in software was released every two weeks (Paasivaara, Durasiewicz & Lassenius, 2008). Due to the global distributed sites, it was not only important to align the teams globally, but also locally i.e. sprint planning meetings separate in Norway and Malaysia to discuss given drafts from the other site (Paasivaara, Durasiewicz & Lassenius, 2008). Demos and retrospective meetings were also important for involved stakeholders to participate as the team, product owner and Scrum master to go through work done and reflect over iterations done (Paasivaara, Durasiewicz & Lassenius, 2008). In addition, each team had a separate backlog and a common software was used for transparency (Paasivaara, Durasiewicz & Lassenius, 2008).

3. Methodological framework

The third chapter provides a review of used means to collect data, and the discussion of ethical considerations, issues of trustworthiness and research bias.

3.1. Research strategy and design

The research strategy was a descriptive-qualitative approach that emphasized point of views of participants within the R&D department of the company and who had a close relationship to the researchers, it was theory emergent and had a contextual understanding etc. (Bryman & Bell, 2015). The principal orientation was an abductive approach because the product development process system was analyzed in the R&D department and possible variances were identified from literature review and theories, and suggested recommendations of new ways to implement agile practices for the company. The research design was a case study and Bryman and Bell (2015) refer it to be restricted by time and activity. It entailed a detailed and intensive descriptive-qualitative analysis of the real operations, processes and system conditions of a single organization.

A case study was chosen to identify a suitable agile framework to follow in the knowledge value stream in the PDP, which required an in-depth investigation to understand fundamental principles and the problems involved. A descriptive-qualitative research design with the main type case study was conducted during a period of six months, five days a week, based on real life experiences at Epiroc Drilling Tools R&D department. It was unclear whether the company was agile and if such frameworks could be applicable; therefore, the research had its purpose to bring out clarity. In addition, research of other companies within software and manufacturing industry within IT-projects, and the implementation of agile practices and the effect of transitions was studied to support final conclusions.

3.2. Description of research methods

Following steps were followed to perform the case study research.



Figure 6: Steps for research method

Step 1 - Familiarization

Due to the complexity of the company, functioning of the R&D department and several organizational/internal documents, it was important to familiarize as researchers with the way of working of the company. An induction tour was also given to understand the production and manufacturing processes of Epiroc Rock Drilling Tools. The researchers' participated as observers in several meetings and brainstorming sessions which helped to familiarize with the way of working and gave an enormous amount of opportunities to interact with several project managers, engineers and others in the R&D department. Social interactions like "fika", a Swedish term for short breaks or snacks, twice a day also helped to know the department better. Such interactions made the interviews more effective due to the increase in comfort of sharing information by interviewees to the researchers. The main purpose of this step was to know the way of working in the company, to understand the work culture, to gain access to the organizational documents in the internal system and to have continuous interaction with all employees in the R&D department to gain the valuable insights for the research. This helped to proceed with the next step of problem identification with more clarity.

Step 1 - Problematization

The research proposal topic was identified by the company and the position for master thesis was shared on their website portal, to which the researchers applied with a descriptive research proposal and a possible approach towards the case study. After the first step of familiarization and several interactions with the supervisors from the company and university, problems and possible challenges were identified. However, the background of the problem statement was updated after every new piece of information and reviews from the supervisors. This step helped to focus on an area in the PDP of the R&D department i.e.

the knowledge value stream using the practices from APM. It further helped to select which set of theories was relevant for the research.

Step 3 - Theorization

Literature review and several theories related to APM and practices from other companies through available literature in different industrial sectors was identified after thorough understanding and narrowed down research. The relevant theories were used to conduct the data collection and analysis.

Step 4 - Data collection and analysis

Many types of data collection methods were used to perform the analysis. Data triangulation is used due to several sources of data. Through several sources the selected theories were utilized and correlated with the collected data to perform the analysis. This step provided answers to the three-research questions of the study.

Step 5 - Recommendations

Recommendations briefly shows the appropriate and recommended actions needed to fulfill the main purpose of the thesis after thorough discussion with the supervisors in the company and the university.

3.3. Methods of data collection

In this section different methods are explained that are used for the purpose of data collection. All the data has been collected using qualitative methods.

3.3.1 Literature review

Existing literature was reviewed to engage with what other researchers had studied in agile frameworks. It was a method to demonstrate the engagement in scholarly review in studied field, but also used to develop stable arguments about the study's significance (Bryman & Bell, 2015). Furthermore, literature study affirmed credibility by identifying several issues within the studied field such as what was already known about the area, what concepts and theories were relevant, what research methods and research strategies were employed,

significant controversies, inconsistencies in findings, and if there were unanswered research questions to the studied area within agile (Bryman & Bell, 2015). Thus, literature study was made using the databases Digitala Vetenskapliga Arkivet (DiVA) and Google Scholar to access journals for research within the studied area. In addition, lighter and fuller agile framework theories and case studies of four organizations in the software and manufacturing industry within IT-projects was studied for comparison and similarities throughout the faced challenges and chosen approaches to incorporate agile practices.

3.3.2 Feedback

A pre-interview form was e-mailed to interviewees to receive background information like their designation and work experience prior to the interview. This was done by sharing a form in a word document, see appendix 6 for the pre-interview form. The purpose was to receive feedback from employees in the company for the sake of knowing their feedback and not necessarily making an alteration in the organization.

3.3.3 Organizational documents

Organizational documents as sources of data act as a heterogeneous set of data sources with emphasis that documents have not been produced at the request of the researcher, but already exist independent of the researcher (Bryman & Bell, 2015). Organizational documents were used to build up a description of the organization whereas insights were given on the studied object. An information management system (IMS) used internally within the company had stored organizational documents which provided knowledge of the used Lean PD, roles and responsibilities, portfolio management, organization structure and project governance matrix. It was important to access the IMS to build a good basis of knowledge about the company.

3.3.4 Ethnographic Observations

The observer involved herself or himself in a group for an extended period to observe behavior, and conversations. Moreover, an ethnographic observation gave the participant the possibility to take a complete participant ethnography role acting as a functioning member of the social setting (Bryman & Bell, 2015). The ethnography observation was

viewed as the process of watching what is going on, taking notes on observations and sum all up (Bryman & Bell, 2015). To easily access observed individuals in their natural settings, the observer conducted the study in a covert role (Bryman & Bell, 2015). It was important to participate in the weekly meetings at the R&D department to understand and gain small insights on work culture and sharing of information within diverse groups and teams. The process of what was going on and how it was conducted set its focus on the agenda of the meeting, and overall critical review on the discussion skills. Moreover, Scrum meetings was attended, with the participation of seven to eight members, by scrutinizing the start of a new pre-study in the R&D department.

3.3.5 Interviews

Interview was a technique used to collect information about a case. The interview methodology was used in the form of qualitative research to give the investigator the ability to acquire more in-depth answers, and a better understanding of the subject (Eriksson & Wiedersheim, 2014). An interview took place between two parties where the interviewer asked questions and the respondent answered the questions (Eriksson & Wiedersheim, 2014). Semi-structured interviews were conducted which referred to a series of questions that was formed in an interview schedule but could vary in sequence of questions (Bryman & Bell, 2015). In addition, the semi-structured interview was open, and further questions could be asked than those included in the interview schedule dependent on what significant replies was given by the interviewer (Bryman & Bell, 2015). Prior to the data collection via semi-structured interviews, the interview questions were screened, and pilot tested by the university supervisor at the department of engineering sciences in Industrial engineering and management, and the company supervisors at the R&D department.

Moreover, 14 interviews were conducted whereas most of the interviewees were set in the R&D department of Epiroc Drilling Tools, Fagersta and the rest in Epiroc Rock Drills, Örebro. Input from interviewees was recorded to not miss out any details and input was transcribed the same day to decrease the possibility of memory failure. Different themes were highlighted in terms of similarities or differences in given input and decoded to label findings. Also, all interviews were compared to identify shared challenges. The focus of the semi-structured interview was on identified areas that was important to the researchers,

and the employees. The aim of the interviews was to reach insights and increased understanding of the current PDP to later identify gaps and potential for improvements with APM. The interview questions focused around the area of roles, current used framework i.e. Lean PD and Scrum, transparency, documentation, etc. See appendix 7 for interview questions to employees in Epiroc Drilling Tools in Fagersta, and appendix 8 for interview questions to employees in Epiroc Rock Drills, Örebro. The 14 interviewees in total were codenamed from A01 to A15. The designations of the interviewees were vice president of the R&D, R&D managers, project leaders and design/material/concept engineers. Majority of the interviewees were from R&D department in Fagersta although A15 and A13 were from Rocktec in Örebro. Moreover, interviewee A05 was unreachable. All the interviewees were codenamed to keep their identity and designation anonymous.

3.3.6 Focus group

The focus group was a form of group interview where several participants interacted dependent on the emphasis in the questions on a defined topic articulated by the moderator or facilitator (Bryman & Bell, 2015). Agile literature have several agile sustainability filter tools to help assess under what circumstances an agile approach is most accurate to use for an organization. Many agile frameworks build their own filters to assess the organizations and know about the potential problem areas, and to see whether their framework will fit the organization or not. A model is proposed by the PMBOK 6th edition, which represents a synthesis of several sustainability filters; attributes to help organizations assess and discuss whether projects should be undertaken using plan-driven, hybrid or agile approaches (PMBOK Guide, 2017). The agile suitability filter was a crucial tool to identify the agility of the department by scoring a set of 9 questions (PMBOK Guide, 2017). Thus, a focus group was conducted to let participants interact and discuss the content in the agile suitability filter to receive a common conclusion collectively and map out how agile the organization was.

3.4. Ethical Considerations

The proposition of the thesis was given by Epiroc Drilling Tools and it was considered that approval of participation was given to conduct the study. In the field of case studies, it was included to deal with confidential information which required certain ethical considerations

(Runeson & Höst, 2008) and the researchers of this paper participated on site at Epiroc Drilling Tools. Moreover, to collect data it was important to conduct observations, focus group, interviews, receive feedback and access internal organizational documents.

The role as an ethnographer consist of a constant threatening feeling of having one's cover blown, which could cause some issues between the observer and the observed individual who feel uncomfortable (Bryman & Bell, 2015). Moreover, observed people in their natural manner and suspicion by the observing behavior, the situation was characterized in a universalist ethical stance or else it could damage the research and the practice of research since the social researchers could be identified as snoopers (Bryman & Bell, 2015). In addition, it was possible that risen suspicions could bias data whereas individuals who was aware of being observed would not act accordingly to their natural manner. Ethical dilemmas were dealt by acting in an overt manner when observation was conducted (Bryman & Bell, 2015). The observed individuals were informed that they were observed, however, it could affect the study since interactions would not appear in their natural setting (Bryman & Bell, 2015). Nevertheless, participating in separate team meetings was in an overt role which was voluntary and often suggested by the supervisors at the company or the team members themselves to freely join for research purpose. If observations were conducted in a covert role it would have transgress ethical problems; participants would have not been informed the consent about being observed, which would not give the observed individual the opportunity to agree or disagree to participation, which is unethical (Bryman & Bell, 2015). Moreover, interviewees voluntarily approved to participate, and the purpose of the study was communicated beforehand. Furthermore, interview names were anonymous in the study and feedback was collected anonymously. Internal organizational documents of Epiroc Drilling Tools are sensitive information which included information about the R&D processes not shared for the public when the thesis is uploaded through Uppsala University. However, necessary details to create a context and understand the processes was reported in research to the public.

3.5. Issues of Trustworthiness

As previously discussed, the research design for the thesis was a case study where two of the most important aspects was the validity and the reliability of the research methods chosen. The ability of the research method to measure what was supposed to or meant to was of concern to validity and the ability of the research method to give the same result on multiple repetitions to show reliability (Golafshani, 2003).

Case study with a qualitative approach was a viable research design choice to tackle the research questions and investigate the effect of agile practices in a large-scale manufacturing company's R&D department. Out of several ways to improve the validity of the case study, one of the ways was to use a data triangulation method, which was adopted for this research. Below is figure 7 of what is seen as a data triangulation (Golafshani, 2003) from the researchers' point of view.

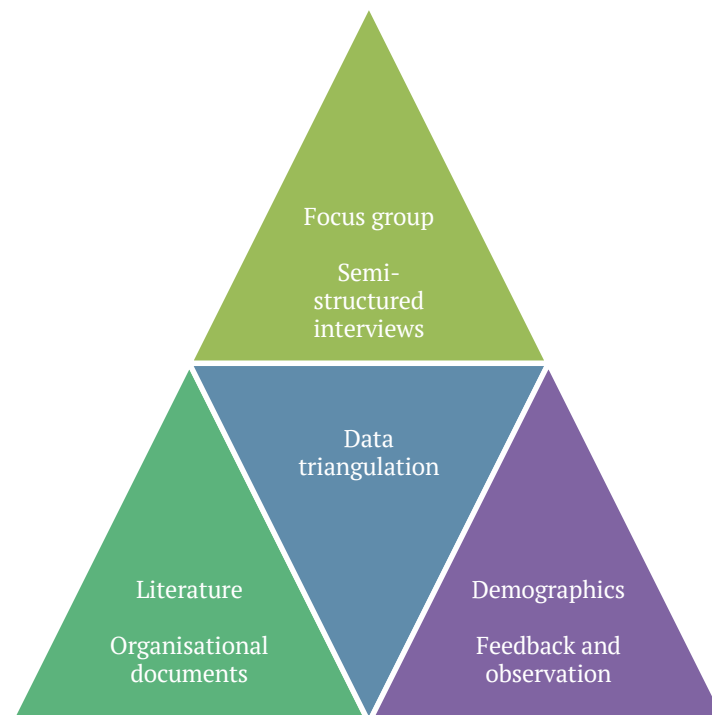


Figure 7: Data triangulation (Golafshani, 2003)

Apart from the data triangulation to improve the validity of the research, an attempt to follow a case study protocol was also made. The case study protocol was not very similar or according to the authors Runeson & Höst (2008) but was satisfactory to approach this research. A project plan using the Gantt chart and a thesis project report. Basically, this

research report was made and continuously updated after feedback and more insights in the research and data collection. Moreover, for improved validity, the research was consistently reviewed by the supervisors, both in the company and university (Runeson & Höst, 2008). Interviewees and their feedbacks also helped to validate and update the research over time.

3.6. Research bias

Bias was inevitable in qualitative research, whereas the researcher and the research situation never were neutral (Bryman & Bell, 2015). The intrusion of bias and values could occur in numerous points which could have its basis in a developed affection for the studied person (Bryman & Bell, 2015). It made it difficult to disentangle stance as a social scientist from the subjective perspective (Bryman & Bell, 2015). The researchers obtained knowledge in the field of industrial engineering and management due to present designation as master's student within that field. In the role as an interviewer and researcher who analyses collected data, difficulties were risen in terms of personal subjective experiences, feelings, and opinions to the transcribed data. Moreover, the researchers faced interrelated issues whereas there could be a pre-understanding of the setting, which referred to that the researcher had lived experiences of what creates a complete understanding of the subject (Bryman & Bell, 2015). Interference with bias could mislead analyzed data and misinterpret the output. Bias was dealt with reflexivity, whereas the social researchers reflected over the implications for the knowledge of the social world they generated their methods, biases, values, decisions in the situation they investigated (Bryman & Bell, 2015). However, the research was conducted on site and sources of data collection was diverse i.e. literature review, feedback, organizational documents, ethnographic observations, interviews and focus group. In addition, the several methods of data collection decreased the possibility of subjective perspective whereas diverse sources supplemented and strengthened the analyzed data due to identified patterns. Moreover, continuous acquired knowledge in the field of industrial engineering and management and the case study company Epiroc Drilling Tools internal processes within R&D, the view of bias as a manipulative approach was challenged. Acquired knowledge throughout the research period was resulted in challenged interview sessions where identified relevant input from interviewee was followed up due to academic knowledge and practical knowledge acknowledged from internal sources at place on the site in Fagersta.

4. Data collection

The fourth chapter will present the data collection that have been obtained throughout the research and contribute to the fruitful discussions of the upcoming chapter data analysis.

4.1 The R&D department

Secondary data sources were used i.e. the IMS which consisted of organizational documents that was studied to gather information about the organization. The R&D department's organization chart is shown below in figure 8. The organization structure of the R&D department of Epiroc Drilling Tools AB consisted of varied roles in their own respective fields. Due to no recent update on the organization chart after the split of the company, the below organization chart was applicable to Atlas Copco Secoroc AB. However, similar organization structure was still followed due to the split to Epiroc Drilling Tools AB.

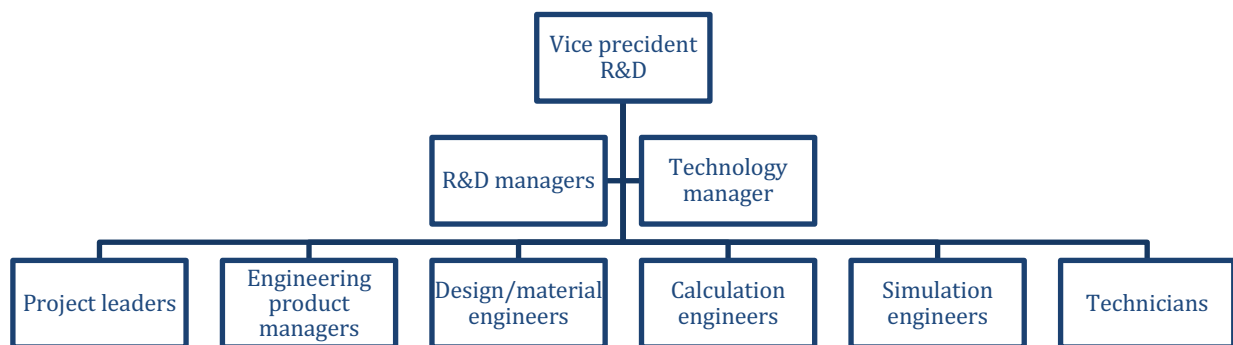


Figure 8: Organization structure of Epiroc Drilling Tools AB, R&D department (Atlas Copco Secoroc AB, 2017)

The department was as per the classical functional organization where each expertise was in an area of responsibility. The functional organization included a group of e.g. material engineer professionals who shared the similar training and expertise, and all of them report to the same manager i.e. the R&D manager.

4.1.1 The knowledge and product value stream

The R&D department had its activities based in the PDP from an idea to a commercialized physical product. Thus, the study had its focus in the knowledge value stream, see appendix 9 for a visualized figure. The knowledge value stream was where an idea develops into a concept. It was in this stream, knowledge gaps needed to be supplemented with more knowledge and be given a solid ground before deciding to initiate and prepare the

production of the actual physical product in the product value stream. In the knowledge value stream, a pre-study was decided to start if the concept was in line with the product line strategy, objectives were identified, resources were allocated, knowledge gaps were identified i.e. what the R&D need to know more about and gain that knowledge in the pre-study, etc. (Epiroc Drilling Tools, 2017). In addition, the pre-study was approved to start by top management and a three-year program plan was set for each product line to know what products to develop the upcoming three years (Epiroc Drilling Tools, 2017). The work method was to first fill in the knowledge backlog to document identified knowledge gaps expressed as questions, and the most important ones was chosen to be risen as objectives for the pre-study (Atlas Copco Secoroc, 2017; Epiroc Drilling Tools, 2017). The pre-study team used the workshop technique to identify knowledge gaps, and to solve the knowledge gaps throughout the pre-study. Each knowledge gap was associated to an activity and therefrom to a sub-team who could solve the question dependent on its expertise (Epiroc Drilling Tools, 2017). The project leaders had access and managed the knowledge backlog to follow-up. Furthermore, sprint planning had its basis from the knowledge backlog. Dependent on knowledge gaps and linked activities to solve the gaps, the sprint was built around the chosen knowledge gaps and was set in a period between 3-4 weeks for each sprint (Epiroc Drilling Tools, 2014; Epiroc Drilling Tools, 2017). After each sprint, it was proceeded with a lessons learned-meeting which had its purpose to include internal stakeholders in the completed sprint and discuss about what was done, what could have been done and what should be avoided in the future (Epiroc Drilling Tools, 2017). Moreover, after each sprint a demo took place where stakeholders from diverse departments were invited to gain information from the R&D department about results and to receive input from stakeholders (Epiroc Drilling Tools, 2017). Thus, a pre-study was decided to be closed and move forward to the product value stream when objectives and knowledge gaps were filled, gained knowledge was documented and stored, final report about the pre-study was available, etc. (Atlas Copco Secoroc, 2017; Epiroc Drilling Tools, 2017).

On the other hand, product value stream was initiated by prepared and planned R&D project that was undertaken to produce a new product. Preparing and planning stage occurred before the start of the product value stream. At this stage the project objectives, steering committee for the project and the project leader was set (Epiroc Drilling Tools,

2017). Success assured meant that there was a very high certainty for the new product to be made. Moving on to the product values stream, once the success was assured, a handover took place from the knowledge value stream to the R&D project which was anchored by the product generation plan. The main aim here was to expect a complete design and at least one competitive product in the end (Epiroc Drilling Tools, 2017). Lastly, Phase in stage ensured a smooth and structured introduction of a new product which required some planning and cross-functional interaction (Epiroc Drilling Tools, 2017).

4.2 Interviews

Information collected from interviews had its purpose to gain knowledge about how work in the pre-study was perceived by employees. Documentation in the IMS was used as a basis to formulate the pre-interview form and semi-structured interview questions. See appendix 6 for pre-interview form and appendix 7 and 8 for interview questions. In addition, the IMS was used to facilitate the organizations storage of information and included all documentations for guidelines, roles and responsibilities, technology planning, innovation handling and patent management. Thus, the department of R&D and the individuals who worked within the PDP in the knowledge value stream perceived dissimilar roles and collected data reflected different opinions in the same fields discussed. Collected data highlighted both similarities in the opinions of diverse field, whilst different opinions were reflected due to the interviewees hierarchical stand and authority in the department.

4.2.1 Demographics

In the R&D department at Fagersta, 12 employees were interviewed due to the supervisor's recommendation and as per their working experience. A pre-interview form was created to collect data about the employee's role and work experience. Since the designations of the interviewees as per the pre-interview form did not align with the IMS system, they are referred as per the roles in table 3 for ease in indexing and coding of the interviews that later helps in the qualitative analysis for research purposes.

Role	Responsibility
Senior Sponsor (SS)	A person who provides resources and support for all projects, program, or portfolio and is accountable for enabling success for the R&D department.
Product owner (PO)	A person who provides resources and support for the local projects and program and is accountable for enabling success for the local R&D department or as per function in the local R&D department.
Project Manager (PM)	A person who plans the project, ensures deliverables result according to objectives, arrange steering committee meetings, weekly pulse meetings, support the team in faced challenges in the product development process, compile crucial documentation as costs, stakeholders, final report for finalized projects.
Technical Engineer (TE)	A design or materials engineer who work with computer aided design and in charge of drawings, or handling of material related issues to tackle process engineering to materials selection for physical products.

Table 3: Role categories for indexing and data analysis

Data collection through the pre-interview form indicate that the interviewed employees had many years of total experience as engineers which was between 7-24 years. Moreover, collected data from the pre-interview form indicated that the SS had 11 years of work experience within his present designation. The PO's forms showed a total work experience as 6- 20 years, whilst the PM's differed between 1-13 years. The TE's had 0.5 - 12 years of work experience in their present designation. Thus, all interviewees had a minimum of 7 years' work experience as engineers, however, two interviewees had recently changed roles within the R&D department and therefore stated a total work experience between 0,5-1 years in their respective role.

4.2.2 Epiroc Drilling Tools AB, R&D Department, Fagersta

As previously described about the R&D department, data was collected through 12 interviews to better understand how work in the pre-study was perceived by the employees.

The 12 interviews were the primary source for findings and was analyzed under the chapter "Data analysis" where a research question was answered as per the findings of the collected and analyzed data. However, it was important to present collected data in brief to have an insight of the discussed fields related to the R&D department.

The R&D department shared staff in different projects, and certain projects was jointly worked upon with other divisions. The interviewees were at start asked questions in the field of their professional background at the department to receive insight in what they did which was documented. The workload in terms of number of projects, differed between the interviewees and was highlighted to be a constrain for their time delivery and prioritization of work to be done. Further on, the interview questions moved onwards to the field of Lean PD to understand their experiences due to the applied framework and how it facilitated or caused disturbances in their work. It was also important to identify their experiences of Scrum and the use of the interconnected tools of the framework. Many of the interviewees had received training several years ago when a Lean coordinator was on site to train staff in both Lean and Scrum, whilst others who started after the Lean coordinators left, had not received any training and was not sure what the frameworks were about. Moreover, common highlights were that higher management had low awareness of the frameworks as some of the team members did. It was commonly pinpointed that it was unclear how work could be coordinated, how to prioritize work items and that the mindset was not aligned among colleagues. The low awareness of the frameworks and absence of a lean coordinator and/or management of leading the team as per agile directly reflected on the transparency to receive and understand updates from other teams and to store obtained knowledge of executed projects in documents. Thus, even though many of the interviewees did not have a clear idea of what it meant to work as per Lean PD or Scrum, it was commonly said that if it would improve the work procedures they would agree to adapt as per agile.

4.2.3 Epiroc Rock Drill AB, Rocktec Automation, Örebro

Apart from the 12 interviews in the R&D department of the Epiroc's division in Fagersta, two separate interviews were conducted in the division Epiroc Rock Drill in Örebro within the department Rocktec Automation. The Rocktec Automation department did not share any of their staff with Fagersta. However, there was certain projects which was jointly

worked upon with other divisions. The interviewees were from the same department and had the same roles of project leader in their respective teams. The department worked closely with software and hardware development to remotely control the mining or drilling site. The department was regarded as a support headquarter for automation. The contact of the interviewees was gained through the supervisors in Epiroc Drilling Tools and with the help of Epiroc's internal contact online database. Due to scarce availability and limited time, only two interviewees were identified and agreed upon to receive some qualitative input for the research. The interview questions asked were relatively different from the ones asked to the R&D department of Epiroc Drilling Tools AB. Moreover, both the interviewees had similar years of experience in their respective field and worked mainly with the software development part of the Rocktec Automation. The team consisted of 5-10 members in their group and as a team leader their role was to support the team and have communication with the customers who was basically the other divisions of Epiroc. Moreover, each team worked for a specific project that belonged to a different division. Interviewee A13 stated *"Sometimes the division forms 1-4 groups that work with them and each of them have a separate team leader"*. The team leader usually participated in the reporting meetings, discussion on new requirements, exploration of new features, etc. The team however was responsible for supporting, planning and evaluation of the software. The team mainly consisted of developers who worked with embedded firmware and was responsible for control systems, whilst the team leader also acted like a coach. Interviewee A13 shared the following:

"I do a lot of coaching. So, I usually walk around and talk to everyone in the team and try to see if they are stuck with something, then two to three days later, if they work with large tasks, I book a meeting and we have a discussion on what the status is and what is being achieved and what is the problem, and how we can move forward. And then later figure out on how to proceed in a good way".

They had common arguments when it came to criticize the PDP of their department and had very similar arguments to most of the interviewees. A13 believes that the PDP was very unstructured and very different from other divisions in Epiroc. It was shared the fact that they were looking for a restart to their agile mindset on slightly broader scale. This was done by applying a basic setup of JIRA- a software tool used to follow Scrum framework. It

included tools such as Kanban board or a Scrum board. Interviewee A15 shared the fact that since they mainly dealt with software development, Scrum was the most suitable agile framework. Another reason was that the new developers who joined the department were already familiar on how to use the Scrum framework and were quite comfortable with it. Moreover, the Scrum was used in the department for the entire process and not partially as per the R&D department of Fagersta. The tools used were not standardized. For example, JIRA was recently used, and previously used software consisted of several content and had no good integration between them to transfer the content. So, the team usually built scripts or did manual work to synchronize the content in the two tools.

“...but since last couple of years the focus has shifted completely. Software is the product. We are selling less machines and selling more upgrades to achieve automation. We can say that 2/3rd of our product development is on software”. - A13

This explained the transition of the division, and the department had gone from hardware oriented to more software oriented. Due to this transition, A13 shared that the staff was immature when it came to software development. Moreover, A15 discussed about the need to have more support from the IT department to have access to latest tools in the market and for better communication since there were many modern ways to collaborate across countries. This was required because most of the projects dealt with the department exist in collaboration with the division in America. Both interviewees also shared how far the company was in the aspects of digitalization. The appropriate steps were undertaken to make the divisions digitized. This adoption happened at its own pace due to several other priorities. A15 shares the fact that he was a certified Scrum master who had a detailed study on the use of Scrum. A13 also shared his interest in APM in general and curiosity of learning Scrum to the fullest. The team leaders agreed upon and tried to adopt the agile principles in work and was willing to apply it in their daily work if they received external and internal support from the company. External support included the support from the labor union in Sweden to recognize the role of a Scrum master in the organization. However, the labor union did not recognize such a role and involved a bit of a bureaucracy to make it established in the organization and not a superficial one. In the team, a person was made to work part time as a developer and rest of the time as a Scrum master and kept rotating in

the job post. This job rotation did not align well with the implementation of Scrum. Like the division in Fagersta, Örebro also faced similar issues when it came to the communication with the top management or the product owner of the department. Due to larger department it became difficult to communicate and hindered the decision-making to a considerable extent. A15 said that *“one must make smaller teams and share knowledge among each other”*. This was considered to allow the teams to stay focused on the agenda and move forward with the continuous development of their product with less documentation.

“The handling of the ideas is pretty informal, we have a box and when we were Atlas Copco we had one idea database”. - A15

Due to the keen interest in the knowledge value stream, a question regarding the handling of ideas was asked. It could be noted that, despite being a separate division, both the departments in Fagersta and Örebro had certain similarities when it came to handle the data. A physical box was used where anyone could drop in the ideas that was beneficial to the company. Management of those ideas had no formal framework but was rather very informal. However, in Örebro before the split, a digitized version of storing the ideas existed and was discontinued or forgotten due to the changes in the data storing platform and reporting system in the company.

“In manufacturing, I think they could make use of it too, it is probably harder in a way with a lot external dependency, handoffs to other companies that produce parts.... but if you at least focus on your own parts and just try to make everything a small task or a case which includes a sprint then the result of every case can be done in just a few days, but it does not have to be a full product, you can at least find parts of it that are clearly a deliverable that you can evaluate and get feedback on faster and then prioritize along the way. But then you are of course stuck with a lot of external dependencies and longer time frames also”. - A13

When asked regarding the implementation of Scrum in manufacturing, above is the statement given by the interviewee. He agrees to fact that the practices are applicable, however, there might be certain challenges and issues that he has discussed above due to external dependencies and longer timeframes.

4.3 Focus group

A focus group was conducted to assess and discuss whether projects should undertake agile, hybrid or predictive approaches (PMBOK Guide, 2017). Predictive approach will be called plan-driven from this point. The researcher's prepared presentation material for an overall view of what the focus group and the Agile Suitability Filter would be about and how it would be conducted. The Agile Suitability Filter was used to map out "How Agile" the organization was and used as a tool to help assess and discuss which agile approach was most accurate to use for projects (PMBOK Guide, 2017). The focus group included participants of the roles SS, PO, PM and TE for fruitful discussions and viewed diverse expertise. See appendix 10 for the questions of the Agile Suitability Filter and the values collectively decided by participants of the focus group. Issues were discussed openly and honestly to understand the issue and an agreement only came in the context of R&D department. Thereafter, the researchers interpreted the results to visualize the Suitability Assessment Chart presented in figure 9 below.

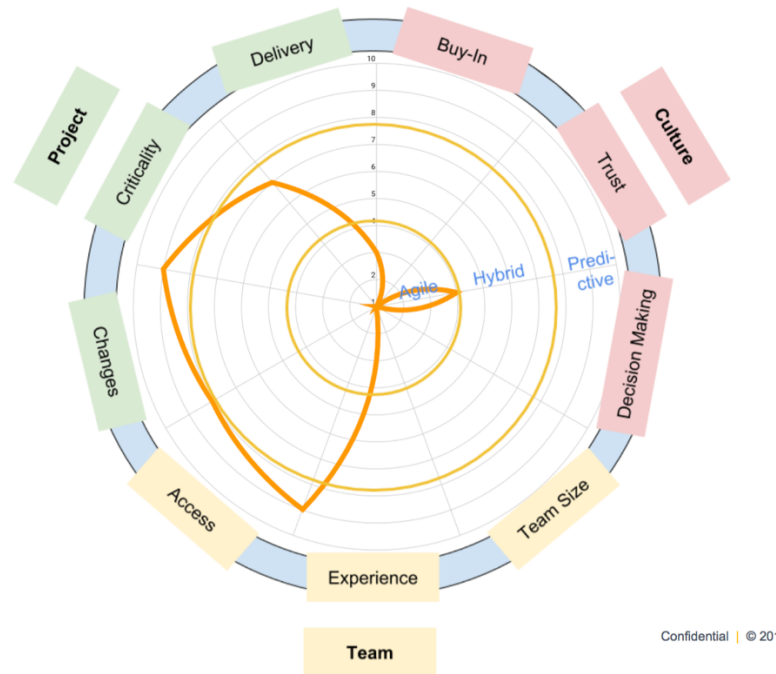


Figure 9: Agile Suitability Assessment Chart

The total 9 questions were scored in a scale of 1 to 10 indicating alignment or potential risk areas (PMBOK, 2017) which were categorized under "culture", "team" and "project". A

central cluster in the assessment chart demonstrates a good fit for agile approaches, whilst the middle-centered radar is the result of hybrid approaches i.e. a mixture of agile and plan-driven approaches as a good fit (PMBOK, 2017). The outer area demonstrates plan-driven approaches as a good fit (PMBOK, 2017). In addition, if reviewing the Suitability Assessment Chart in figure 9, the scale between 1-4 are considered as agile, the scale 5-8 is set as a hybrid and 8-10 as plan-driven.

As shown in figure 9 above, there is a high level of buy-in to approach, trust in team and decision-making power of the team under the category “Culture”, which centers the radar for an agile approach. Under the category “Team”, the team size of the core team was small and between 1-9 team members which placed the radar in agile at the chart. Moreover, it was collectively concluded that each role in a team had at least one experienced and skilled member within their field, therefore, it also ended up in agile. However, the radar chart had a drastic change when moved towards the last question under “team” and forward to the questions under the category “project”. The small teams did not have easy access to the customer or business representative to ask questions or/and receive feedback. Instead the primary contact relied on the marketing department to convey further information to R&D, and previous experiences of trying to reach out to the customer or business representatives ended up as a problematic situation between both the department. Thus, there was no regular access to the customer or business representatives and therefore the radar was placed in the plan-driven approach in the radar chart. Moving forward in the chart towards the category “Project”, the likelihood of changing requirements given by either external or internal stakeholders were fairly decided as low and therefore placed as plan-driven approach. The criticality of a product or service i.e. the consequence of a system failure was concluded that it would result in jeopardizing “many lives” on the way, which was in the case of the R&D department jeopardizing many projects. Therefore, the radar chart was placed in the plan-driven approach. Furthermore, incremental delivery where the product can be built and evaluated in portions and having customers or/and business representatives available to provide timely feedback was unlikely since the marketing department was the primary contact. The radar ended up at the hybrid approach, but at the crossroad of being plan-driven.

4.4 Ethnographic Observation

The researchers were on site and able to participate on weekly meetings at the R&D department throughout the duration of the research. Department meetings were led by the local R&D manager and thereafter the word was given to a team member of each function to update the latest news. The absence of the local R&D manager was covered by another R&D manager from a specific function. Once another R&D manager took lead and coordinated a weekly meeting, it was incorporated to reuse a digitalized board in the meeting room to view information instead of using traditional physical boards, the importance of the program plan was highlighted to ensure that planning was on time, and it was requested that teams made sure that the actual plan was as the original one. The meeting was more structured compared to previous meetings and it was later known through informal conversation that the R&D manager who had stepped in was a previous global Lean coordinator by the time the division was named Atlas Copco Secoroc, with the main task to coordinate and train staff on different sites in Lean.

Furthermore, several teams in the R&D department was dependent on deliverables from other departments to proceed. Team members perceived knowledge gaps from other departments and awaited important material to be handed over. Thus, it was time-consuming for R&D to re-work input and convey knowledge for proper reassessment of needed documents from colleagues in other departments. Moreover, it was repeatedly updated that project leaders were waiting in objectives from a steering committee and approval from top management for guidance to proceed their tasks. However, there was an absent steering committee in the department for the pre-study phase and no one who took responsibility to guide the team although team members claimed top management to have that role. Thus, individuals were classified by their function and although most team members at the R&D were linked to one function they contributed to more than one project.

Throughout the end of the weekly meeting, the local R&D manager went through a resource backlog which only concerned few team members, but all teams had to stay put throughout the updates.

5. Data analysis

The fifth chapter analyses data to compile and discuss findings. Thus, the chapter addresses and answers the three research questions.

The research questions were analyzed to solve the purpose of the thesis from where few recommendations were drawn. The theoretical framework helped to understand the selected theories to build up knowledge around the subject of agile project management. It was important to grasp the theoretical framework to perceive the data analysis section. The first research question focused on the identification of a suitable agile framework for the PDP with the focus on the knowledge value stream. The acquired theory was used to scrutinize which agile framework was more related to the current work practices in the knowledge value stream. Moreover, there was a slight difference in the knowledge value stream that was mentioned in the IMS system than in practice. Appendices 11 shows the update version of the Lean PD which was used in practice. The comparison of this updated knowledge value stream was made with the two agile frameworks, Scrum and DSDM. DSDM was then identified as a suitable framework for comparison due to higher similarity than Scrum. The analysis of second question answers what the challenges was to integrate the PDP with DSDM. These challenges were identified through all the collected data from interviews, focus group, feedbacks and from the companies that practiced APM. This concluded that the scope of improvements was in the process, roles of the team members and documentation within the knowledge value stream. Analyzed data for the third question which demanded improvements to the previous identified challenges, several practices and techniques from DSDM was recommended which seemed feasible for the knowledge value stream.

5.1 First Research Question

APM emerged in the software industry and various existing literature was published the last few years with focus on software development and practices for improvement (Mishra, Dangayach & Mittal, 2011; Qumer & Henderson-Sellers, 2008). Data was segregated and analyzed based on the three RQ's. The first RQ addressed in the study asked, *"What are the existing agile frameworks available for the PDP?"*. The chapter of theoretical framework in this research paper was iteratively worked on due to continuous findings as per the studied

company and in literature. For the first RQ, data collection showed what practices were related and suitable for Epiroc Drilling Tools R&D department which was the fuller approach DSDM. The original figure of the knowledge value stream in appendix 9 and described information in chapter 4 “Data Collection” did not visualize that the knowledge value stream had its starting point in the activities of data collection, data integration and data analysis for idea process handling. The idea process did not have full documentations that described it in the IMS. To understand the process, input was gained from the R&D department’s technology manager through an interview and feedbacks. The idea process was fed with ideas by employees through an idea database, and data collection of ideas had its starting point when an idea was submitted by an employee in the idea database (Epiroc Drilling Tools, 2016). Thereafter, the idea was screened and evaluated by the technology manager to decide whether submitted idea aligned with the product portfolio (Epiroc Drilling Tools, 2016). Furthermore, the process of data integration starts, which meant that two or several ideas were integrated and became a concept. Integrated ideas which formed a concept were at last analyzed to be decided if the concept was technologically feasible and if should be selected to continue further in the pre-study (Epiroc Drilling Tools, 2016). Appendix 11 shows an updated version of the knowledge value stream where the idea process was added.

The theoretical framework presented both lighter approaches as Scrum, Lean and Kanban and the fuller approach DSDM. Even though the researchers analyzed that DSDM was the suitable approach, it was important to review Scrum, Lean and Kanban in the theoretical framework of the research to understand the frameworks Epiroc Drilling tools and its R&D department was documented to follow. However, Lean was used throughout the whole PDP whilst Scrum and Kanban was documented to be applied in the R&D department knowledge value stream. The researchers conclude that the reason why Lean was adopted was because most of the employees were engineers who work in a manufacturing company. The Lean framework had its base in a continuous flow in the production (Womack & Jones, 2003). Hence, considering the academic profile of the employees in the R&D department which was Mechanical Engineering or Material Engineering, the most generic management tools and systems adopted was about Lean. This indicated that the mindset of the department was more towards the principles of Lean PD. Due to lack of awareness of agile principles and

more focus on Lean principles, the department was less updated on the latest and ongoing project management practices and hence seem to have more plan-driven mindset.

Findings through interviews for applied practices conclude that the department did not use the full package of the agile framework Scrum, nor were employees full aware of what it meant to work with Scrum. Findings throughout used means reflected several aspects of misalignments where used agile practices was not used as it was documented in the IMS, several Scrum practices was not applied, and Scrum terminology was not used. The Scrum framework consists of three important roles which are the Scrum team, the product owner and the Scrum master (Schwaber & Sutherland, 2017). The Scrum roles and the Scrum framework is as per the theory used for one project at a time. However, findings for the R&D department indicate that each team had its own product owner, and each team member played multiple roles for different projects. A suitable Scrum role could not be assigned to the roles of the organization and its R&D department. Hence, the roles in the organization of Scrum was inapplicable thereof the R&D department. Moreover, findings indicated that the development team consists of team members no more than between three to nine members and was self-organizing and cross-functional as per Scrum (Schwaber & Sutherland, 2017). However, the role of a product owner and its main task to manage the product backlog (Schwaber & Sutherland, 2017) was not defined properly and the role definition kept varying. There was neither an assigned product owner nor a product backlog. Furthermore, the role of the Scrum master was also absent which was identified as the previous Lean coordinator. The absence of a Scrum master had caused poor agile practices and lack of management to ensure that Scrum values, rules and practices was followed. It was documented that the time-box of each sprint was supposed to be 3-4 weeks, and a program plan was visualized on a board in the weekly meeting room with time-boxes for when projects are to be executed. Unfortunately, not only did projects pass by their time limit, but it was due to our attendance of a sprint planning session that it was to our notice that a project had overdue two years.

Thus, Scrum practices that was not adopted both in principle and practice by the R&D department was Scrum events as daily Scrum and sprint review; Scrum artifacts as product backlog, sprint backlog and increment; artifact transparency as the definition of “done”

(Schwaber & Sutherland, 2017). Nevertheless, the department worked in 3-4 weeks sprints, but projects overdue their time limit, and activities as lessons learned which was associated with Scrum sprint retrospectives was adopted. In addition, an activity window, which was associated with the Kanban board, was used by one team who visualized their progress in the weekly department meetings but not by other teams. Thus, the researchers conclude that the R&D department did not use the full package of scrum but rather some of the procedures. Even though the department documented and stated that work practices was as per the Scrum framework, empirical findings was weak to indicate that full Scrum practices was applied. Similarities was found when obtained knowledge of the content for “what is done” in each activity compared to Scrum. However, the full framework was still not adopted. There were significant differences in adopting agile practices and adopting the agile mindset (Ranganath, 2011). The set of agile practices adopted as the process, tools and templates does not make an organization agile, on the contrary, agile transformation is about the individuals involved, the organizational culture and the communication (Ranganath, 2011). It is important for the team members not only to follow the set of activities and focus on execution, but also commit to the common goal, collaborate and create value together (Ranganath, 2011; Ewel, 2017). Findings of the Epiroc Drilling Tools R&D department indicated that they had not yet adopted the agile mindset, whereas team members and the top management blamed this discrepancy on each other, or the loss of motivation resulted in team members not eager to either learn more or use available tools to facilitate the transparency of the R&D department.

Similarities with DSDM

Throughout further research, it was identified that the department worked closer to the fuller agile approach DSDM. In the idea process, collected ideas from the idea database was screened and evaluated by the technology manager to decide whether submitted idea aligned with the product portfolio and whether screened ideas could be incorporated to a concept. Thus, the researchers conclude that the pre-project phase of DSDM was like the R&D departments idea process handling where data was collected, integrated and analyzed (Epiroc Drilling Tools, 2016). If the product in DSDM was considered as knowledge or a technical report which consist of all the identified knowledge gaps, the pre-project phase in DSDM could be directly related to the idea process.

Furthermore, the final decision made in the idea process was whether the analyzed concept was technologically feasible and whether further investigation was required to decide if the concept will continue throughout the pre-study or not (Epiroc Drilling Tools, 2016; Technology manager 2018). The activity of the final decision was identified as per the feasibility phase whereas proposed projects was decided whether further investigation was required or not (DSDM Handbook, 2014). In addition, when a concept was selected, and decision was made to start a pre-study, the foundations phase had similar activities where a basic understanding was needed for what the potential solution was i.e. what was to be created, how development and delivery will be dealt with which was identified as the activities of identifying knowledge gaps to know the scope of work and by whom, when and where the procedures were done (DSDM Handbook, 2014; Epiroc Drilling Tools, 2017). This showed that feasibility and foundation phases of DSDM were closely related to the brainstorming session that was in the start of the pre-study phase of the Lean PD.

Other similarity was the included events and activities throughout the initiated pre-study that was identified as per the evolutionary development phase of the DSDM framework which evolved iterative development, time-boxing and prioritization of items (DSDM Handbook, 2014). As previously discussed, the pre-study involved the use of Scrum as a tool to produce certain amount of iterations using sprints (Epiroc Drilling Tools, 2017). Certain artifacts and events of Scrum were also adopted in the pre-study; however, there was not enough to call this iteration process a Scrum. This iteration process could perfectly be related to the evolutionary development phase of DSDM. The initiation of a pre-study lead to the iteration shown in the knowledge value stream where sprints were supposed to be executed every three to four weeks with the continuous activities of sprint planning, weekly pulse meetings, demo, lessons learned and update of the knowledge backlog. The included events and activities throughout the initiated pre-study was identified as per the evolutionary development phase of the DSDM framework which involved iterative development, time-boxing and prioritization of items (DSDM Handbook, 2014). In short, the ideas and knowledge gaps surrounding it was assembled together and went through several evolutionary development to reach the review. Later deployed product i.e. a document or a final report consisting of all the identified knowledge gaps in form of a technical report was sent to the product value stream (like the knowledge brief in the IMS). This technical report

that consisted of all the technical knowledge, financial benefits, risk analysis, etc. was needed to reach the point of success assured. Hence, it was said that the success assured at this stage, i.e. the transfer from knowledge value stream to the product value stream was regarded as the post project phase in DSDM, see appendix 11 for the updated Lean PD.

Furthermore, the roles and organization of the DSDM was identified to be similar with more advancements as compared to the one in the R&D department. Below is the table 4 that depicts the type of roles the R&D department had next to the similar role identified in DSDM.

No.	Roles in R&D Department	Similar role in DSDM
1	Vice President	Business Sponsor
2	R&D Manager	Project Manager
3	Technology Manager	Technical Coordinator
4	Project Leader	Team Leader
5	Engineering Project Manager	Business Analyst
6	Design Engineer	Solution Developer
7	Calculation Engineers	
8	Simulation Engineers	
9	Technicians	Solution Tester

Table 4: Role comparison with DSDM

After analyzing the theory of roles in DSDM and comparing them with the roles in the R&D department, above similarity in the roles were identified. Few roles that could not be found in the R&D department when compared to DSDM are DSDM coach, Workshop facilitator, Business Ambassador, Business Advisor and Business Visionary. However, it can also be said that few persons in the R&D department play more than one DSDM role. These similarities helped us identify a suitable framework i.e. DSDM for the knowledge value stream of the R&D department.

5.2 Second Research Question

The next question helped us identify the major challenges that must be solved to make the department closer to both being agile and doing agile. *“What are the challenges to integrate the PDP within the agile framework?”*. By analyzing the collected data and the available literature few challenges were identified that was closely related to the knowledge value stream of the PDP.

5.2.1 Challenges in Knowledge Value Stream

The certain common challenges were identified through the data collection. With the help of the data from interviews following are the key challenges.

Insufficient knowledge

The Lean PD was implemented several years ago when the company had a Lean coordinator who coordinated training for the introduction of Lean globally to the different sites to align and facilitate cross-functional work. However, the Lean coordinator was deserted, and no one followed up to coordinate and train the employees for many years. According to SS, PO, PM and TE's, the knowledge was poor to the Lean framework among employees due to lack of training. According to the SS and PO's, the awareness of Lean PD among different R&D managers was poor and it was a challenge to make every department understand the process and the responsibilities, which affected the ability to work cross-functional. It was said by a PO *“I do not know if everyone is updating themselves as it should be”*. - A06

Several years ago, the department identified unnecessary activities which was removed, and thereafter implemented the agile framework Scrum. There was a lack of understanding what the framework was about due to no training. Thus, the IMS with its comprehensive documentation which past Lean coordinator had set was not followed for the processes since the implementation of Lean and Scrum was documented and adapted to describe how it was to be followed. Moreover, it was also highlighted by PM's and TE's that the department was bad in updating their documents with perceived knowledge of a conducted task or project which contribute to a negative loop of redoing what was known by previous an employee.

Misaligned roles

Furthermore, it was identified that the importance of communication was high according to top management as SS and PO. However, PM's share the input that there was a clear confusion on role descriptions and lack of communication. It was clearly stated that commitment from management level was required to steer the teams and take decisions. In addition, not only was the issue of unclear role descriptions identified through interviews, but also when the pre-interview form was sent back to the researchers to receive background information due to the employee's designation. In comparison to what was said about their role description and workload in conducted interviews, what was written in pre-interview forms and what was stated in the IMS; the information from various sources did not align. The IMS had documented roles descriptions and how work should be followed. However, the workload in terms of number of projects and activities handled at the same time showed that what is supposed to be done could either be more required than documented or/and different than documented due to their role description.

Lack of guidance

There was poor management and leadership at the R&D department to steer the team towards the right direction and reach their objectives, whereas the objectives were unclear for the employees. Not only was there lack of guidance, but there was an issue with following the prioritization of projects from the program plan. Thus, the lack of guidance had its basis in the absent cross-functional steering committee whom should steer the team towards the right direction. It was concretized by SS and PO's that due to an absent steering committee there was no one to, among other things, guide the engineers who often were given open questions to solve; it relied in their nature as engineers to solve the problem and continuously refine, which in the case of the R&D department affected the time to execute a project. However, in the time of data collection three months in to the project, it was to the R&D department's notice that a cross-functional steering committee was set, but no further actions were taken whilst finalizing the research.

Lack of prioritization

The PM's faced challenges of improper prioritization in the program plan i.e. to decide and follow what projects to prioritize as identified under the challenge "lack of guidance". Both PM's and TE's highlighted the problem of prioritizing the R&D in other departments which made it, among other things, difficult to receive requested resources. The effect of misaligned priorities had so far resulted in prolonged projects and lack of resources. Furthermore, TE suffered the absence of stakeholders from the production during the concept phase, where drawings were involved, to receive direct input from their expertise. It was said that *"...departments as production are not on important meetings because of the distance between our departments, which is a problem"*. - A11

In addition, it was also identified that a challenge for many was to make crucial stakeholders attend planned demos where strategic input from top management was required to align operative work. It was stated by a PM that *"...I invite the most important people to the demo...the ones that should be interested in what is going on...I also send a presentation in advance, but never receive feedback. If you do not get any feedback, then you do not know what is good or not"*. - A10

Insufficient transparency

The R&D department of Epiroc Drilling Tools and its employees had their offices close to each other either in the same halls or with a short distance in the same location, which had made it easy to reach one or another for physical meet when needed. Furthermore, common means used to visualize work for transparency was the web-based platform SharePoint, and weekly pulse meetings with the R&D department where activity windows was used to visualize work in progress. However, due to the participation of diverse roles and knowledge in diverse field at the R&D, there was often a lack of understanding what other colleagues was updating about during the weekly pulse meetings. It was said by a TE that *"...if you sit in a group and move around post-it notes and understand, then it is good. But if I am sitting at a meeting with other teams and they show their post-it notes, I do not know which activities to focus on, and then it is important to be updated so I can understand"*. - A07

Moreover, due to lack of time it was felt that there was no time to update the activity windows to afterwards present it on the weekly pulse meetings, and the accessibility to

SharePoint was only given for the specific project one worked with. TE's highlighted the importance of the accessibility to get updated about projects, and the importance of understanding what work was in progress. Several common views of the transparency were viewed as poor according to interviewees. In addition, the migration to SharePoint was made less than a year ago and no training was given for employees to understand it; it was hard to find within the platform and time-consuming. Moreover, the PM's and TE's raised the issue of non-updated documents in the IMS, difficulties of navigating throughout the system and the lack of governance and structure. A TE said *"we do not document the knowledge that we get...the problem is time and priority... in 10 years someone else will have to do the same things all over again"*. - A02

However, acquired documented knowledge was identified to be more usual among SS, PM's and PO's due to their managing roles and the requirement to report to a higher management, whilst it was rare among team members managed by a leader to document obtained knowledge.

Inefficient human resource utilization

The department had a database consisting of several ideas where employees could send in ideas relevant for the product portfolio. The purpose was to collect the data, integrate and analyze it to decide whether to continue work with it or not in the pre-study. According to SS and PO's it feed the three-year program plan, and therefore it was vital to know whether the employees were aware of the idea process since it was not a process officially communicated to the department. It was clear that employees aware of the process had submitted ideas themselves in the database, whilst those who had not worked closely with it was not aware of it. PMs and TEs who either worked closely with the process or submitted ideas raised the issue of human resource utilization to speed up the slow process. It was highlighted that the department did not follow-up manhours which was a huge concern due to unawareness of how many hours was put to respective projects. It was stated that if man hours would be calculated and less projects were delegated among team members, the possibility to speed up the idea process would be possible since it was a vital part of the pre-study because it feeded the three-year program plan which everyone in the department followed.

5.2.2 Focus group

It was important to position how agile the department was perceived to be and therefore a focus group was conducted with the use of “The Agile Suitability Chart”, see figure 9. It was important to discuss the Agile Suitability Chart and the diverse questions it included, which the team members collectively set a scale on. Table 5 below will mark each topic of the questions dependent on whether it was agile, hybrid or plan-driven as identified in the data collection.

Category	Topic	Agile	Hybrid	Plan-driven
Culture	Buy in approach			
	Trust in team			
	Decision making powers of the team			
Team	Team Size			
	Experience Levels			
	Access to customer business			
Project	Likelihood of change			
	Criticality of product or service			
	Incremental delivery			

Table 5: Agile Suitability Filter- Results

There were three different themes for the Agile Suitability Filter such as “culture”, “team” and “project”. The buy-in approach asked whether the senior sponsor understand and support the use of an agile approach in a project, which the team agreed on a scale of 3, whereas 1 is yes and 10 is unlikely for all questions under the category culture. The buy-in approach was set as agile according to the suitability assessment chart. It was later asked whether the stakeholders as the sponsors and business representatives trusted their teams to transform their vision and needs to successful products. The collective of the focus group gave it a scale of 1, which is agile. It was then important to ask whether the teams had autonomous authority to take local decisions about how to undertake work and gave a scale of 4 which was also agile, but on the crossroad of being a hybrid. If reviewing the agile manifesto, it was stated among two of the twelve fundamental principles that business people and developers must work together daily throughout the project and that projects must be built around motivated individuals whom must be given the environment and

support they need and trust to get the job done (Manifesto for Agile Software Development, 2001). In addition, the best architectures, requirements and design emerge from the self-organizing teams (Manifesto for Agile Software Development, 2001). It is important to put trust on the team because team members are the key sources who move the company towards its vision with their diverse expertise.

The next step was to ask questions around the category “team”, which had its importance to first ask what the size of the core team was. The scale was set to 1 which represents the team size of 1-9 team members, which was set as agile according to the suitability assessment chart and supported as agile as per the scrum framework (Schwaber & Sutherland, 2017). The upcoming question was a statement “that it is easier when each role in the team have at least one experienced member”. It was concluded as a collective a scale 1 stating a “Yes” and therefore in the agile radar chart. However, the final question under the team category was a huge contrast compared to previous positionings of earlier questions which was agile. The last question under the category “team” asked whether the team had daily access to at least one customer representative to ask questions and feedback. It was given a scale of 9 as closest to a “No” which is placed on the plan-driven radar. The highest priority when adopting agile is to satisfy the customer through early and continuous delivery, and to satisfy the customer it is important to adapt to changing requirements and harness change for the customer’s competitive advantage (Manifesto for Agile Software Development, 2001). However, such excellence was not possible if there was no accessibility to the customer to receive direct and fast feedback. Throughout the focus group discussions, it was due to our knowledge that direct feedback from customers was given to the marketing department at first before handed over to the R&D.

The last category “project” started out by asking the attendants how likely it is that requirements are to change or be discovered monthly, whereas the scale 1 was 50 %, scale 5 set on 25% and scale 10 at 5%. The group concluded a scale of 8 which resulted as plan-driven. The set scale could reflect previous input about the team members accessibility to the customer to receive feedback. Furthermore, the topic of the product or service criticality asked what the consequence was of a system failure, whereas the scale was set due to different subtopics. The scale set at 1 stated that the consequence of a system failure would

be “Time”, and towards the scale 5 was given “Discretionary funds”, scale 5 “Essential funds”, towards 10 was “Single life” and scale 10 as “Many lives”. Note that “life” was perceived as projects whereas one project was built around one product to be developed. The group set the scale 9 which was closest to “Many lives”. The consequence of a system failure would cost the failure of many projects evolving products under development. Finally, the last question of the focus group asked whether business or customer representatives was available to provide timely feedback on product increments delivered. The group set a scale 7 which was a hybrid but also at the crossroad of being plan-driven. Thus, it was important to have continuous attention to technical excellence and good design to enhance agility (Manifesto for Agile Software Development, 2001). Table 5 which presented the results of the agile suitability filter, clearly visualized an agile culture within the R&D department, also supported by findings in interviews and observations. Team members were close due to their location and it was usual to pass by a team members office to have informal discussions about ongoing projects and need of updates. Also, team members were comfortable enough to state their point of view without the response of passive-aggressive behavior and conduct honest conversations to receive honest feedback due to discussed project. However, there was clear concerns about access to customer business, likelihood of change, and criticality of product or service. The department had a clear cut between either doing agile or doing plan-driven.

5.2.3 Similarities in challenges faced by other companies practicing agile

Four companies within the software and manufacturing industry was studied, specifically in their IT-projects. This to perceive familiar challenges among the different companies, and to compare their shared challenges with Epiroc Drilling Tools R&D department to highlight similarities in challenges between the conducted research of the four companies and the R&D department in their PDP. Thereafter, it was important to study the incorporation of APM of the four companies to identify what affects the incorporation of one or several agile frameworks had on the PDP. Shared challenges for the four studied companies was found in the topics of knowledge management, transparency, communication, the project cycle, the development model, flexibility, team, customer collaboration and defined processes (Katumba & Knauss, 2014; Dagnino, 2002; Plonka et al., 2014; Paasivaara, Durasiewicz & Lassenius, 2008). Moreover, challenges found for Epiroc Drilling Tools R&D was found in

topics of knowledge management, misaligned roles, guidance, prioritization, transparency, human resource management, flexibility and customer collaboration. Complex organizational change cannot be managed by simply replacing current technologies and tools, but such changes impact management practices, structure and culture (Nerur, Mahapatra & Mangalaraj, 2005; Ranganath, 2011; Ewel, 2017). It is not only to incorporate the agile practices and follow them as such, but it is also important to set time for the organizational change to engage teams to collaborate and commit towards the same goals and adopt the agile culture. The conducted brief research of other companies and the R&D department of Epiroc Drilling Tools both had faced challenges in the topics of culture, team and projects. It was important for the four studied companies to reinforce the agile mindset and both do agile and be agile (Ranganath, 2011). A key issue of the R&D department was commonly shared with the brief research that the organizational culture had not reinforced the agile mindset. Thus, given negative effects as explicit knowledge management, unclear role assignments, lack of transparency, etc. Because of lack of knowledge for the assumed incorporated agile framework Scrum. Stabilized values, norms and assumptions that was reinforced by time had major influence on managerial and organizational practices such as relationships, problem-solving practices, decision-making processes, etc. (Nerur, Mahapatra & Mangalaraj, 2005; Ranganath, 2011). Therefore, time should also be set for the people and not only for the processes (Manifesto for Agile Software Development, 2001). Moreover, the issues of the dysfunctional PD team are displayed due to the team's lack of empowerment, functional allegiances which causes individualism with no further insight to other roles and insufficient resources (Ulrich & Eppinger, 2016).

The typical raise of functional allegiances and lack of cross-functional teams are due to the functional organization whereas the weakness relies in the coordination across different functional groups which can be bureaucratic and slow Ulrich and Eppinger (2016). It was a major risen issue to integrate the distinct functions and align team members to achieve business goals. Furthermore, a critical challenge identified in the research was the importance of the customer. To incorporate agility and have its priority to respond to change in the project cycle, adapt as per changing requirements for iterative and incremental changes in the product to harness the customers competitive advantage, develop and produce what have been requested and continuously deliver value (Manifesto

for Agile Software Development, 2001); Nerur, Mahapatra & Mangalaraj, 2005). Flexibility and customer satisfaction was not fulfilled when there was lack of collaboration with the customer who set the basis for the requirements of what they want whilst the R&D team identified as per communication what they needed. Due to low flexibility and lack of collaboration with the customer, design processes could not be iterative due to no continuous communication for changing requirements to gain feedback and develop a product close to the customer's request.

Thus, it was found that similar improvements for the incorporation of agile for the four companies had given the effect of better transparency, availability, faster executions, self-organizing teams, time-commitment, end-to-end knowledge, committed teams and motivation (Katumba & Knauss, 2014; Dagnino, 2002; Plonka et al., 2014; Paasivaara, Durasiewicz & Lassenius, 2008). Due to similar challenges of the R&D department and convincing evidence from conducted literature review, to incorporate agile in PDP, specifically for the knowledge value stream, is highly recommended due to its several positive effects on both organizational and team level.

Therefore, the analysis conclude that the major challenges relies on the following sectors

- *Process* i.e. the present flow of work incorporated in the knowledge value stream of the R&D department.
- *Organizational structure* i.e. the governance structure of the organization and the roles of the employees in the R&D department.
- *Documentation* i.e. the required set of documents to store knowledge, manage work and communication between team members.

5.3 Third Research Question

After analyzing the knowledge value stream through several perspectives, three major sectors were identified which did not meet the compatibility with the agile practices. The process, organizational structure and the agile mindset in the knowledge value stream. With the help of the first RQ, it was concluded that a suitable agile framework for the knowledge value stream was DSDM, and the improvement for the issues in the three sectors could be found within it. This will help the researchers answer the third question i.e. “*How can the*

existing practices in the PDP by using agile frameworks improve?”. It consists of possible recommendations from the researchers after the analysis of the previous two research questions.

Training

As discussed earlier, Scrum was disregarded for multiple reasons. It can also be criticized that Scrum does not support multiple projects at the same time since it is considered a lighter weight approach. Hence, the induction and training of all employees must be made by teaching the principles of DSDM after defining the Agile Manifesto. Several employees in the company was unaware of such terms and it is important that everyone understands the principles of DSDM to work with it. This will ensure the credibility to the use of DSDM. In the brief explanation of the challenges faced by the four companies which was discussed earlier in this paper, the importance of training was pointed out. Due to continuous updates on the training, it was important to have employees updated. The training must be done twice a year and the participation of everyone in the department must be mandatory. An assessment test in the end of the training session will show the level of absorption of DSDM principles in the department. This training is provided by the DSDM coach.

Nomenclature

It was important to note that most of the nomenclature utilized in the IMS system did not match with the basic ones of the APM. It was mainly because management was built strictly upon the foundations and principles of engineering that used Lean. To have a transition and adopt the agile practices, it was important to use similar nomenclature for a clear view of the definitions in a more generalized context, and not just constrained to the company. Due to the large scale of the company, such rapid changes in nomenclature cannot be brought about in the whole product development. To prevent any changes from happening to the rest of the company and avoid any confusion, it can be advised to make fit changes in the knowledge value stream of the R&D department only. This will not affect the nomenclature of the product value stream which consist of several external dependencies such as suppliers and other divisions. Moreover, it is very likely that these external dependencies have not adopted agile principles in their product development yet.

Organization and Governance Structure

As previously discussed, roles are very much aligned to that of the DSDM and needs a refurbishment to make them clearer and can be done by adopting the roles of the DSDM. To avoid confusion with the current role designations and names, same names and definitions must be kept. However, the organization structure and the governance need a major update. The current structure is very hierarchical and traditional. DSDM offers more of a circular structure to have a sharp vision of how dependent the roles are to each other, see figure 10 below.



Figure 10: Organization structure of the R&D department as per DSDM

The figure above illustrates the organization structure of the R&D department adapted to the DSDM. The red border on the boxes denotes the absence of the role in the current organization structure of the department and the green border denotes their presence. Background color (orange, green, blue and mixed colors) and positioning of the boxes on and around the two circles (management level and knowledge development team) are made as per the theory of DSDM theory placing them in the correct order for ease in

understanding. The absent roles (in red border) does not mean that they must be included in the structure as a separate person by adding more resources since it violates the idea of utilizing the existing resources. The absent roles can be filled by the other present roles (in green border) making them cross-functional. However, roles as workshop facilitator and DSDM coach are hard to supplement and a separate resource (a working employee) might be needed. This role is like the role of the previous Lean coordinator in the R&D department. The advisor roles outside the two circles exists as supporters. Business advisor and technical advisor might exist today externally i.e. outside the R&D department, to provide managerial and technical advisory to the knowledge development team. It is important to have these supporting roles to not deviate from the objectives and in decision-making.

Proposed knowledge value stream based on DSDM process

The currently practiced knowledge value stream consists of two divisions, idea process and the pre-study. Idea process as defined previously is meant to collect the ideas from various sources and convert them into the working concepts which later becomes part of a pre-study and enters the knowledge value stream, and later the product value stream. After accounting several attributes, observations and feedback, it can be said that the complete adoption of the knowledge value stream with DSDM can help us understand the value stream better and can be performed in an agile way with defined roles and documentation. In the current pre-study, no proper steps are defined apart from the use of the iterative process. This can be solved by utilizing the DSDM process with slight tweaks. The pre-project and post-project phase in the DSDM shall be named as pre-study and post-study phase to adapt to the departments current terminology. This will prevent the effect of change in nomenclature and terminologies that are currently used in the department. Therefore, the pre-study phase can still be called pre-study with defined phases within it. Data analysis of RQ1 discusses more similarities that can be seen between DSDM and the Lean PD in R&D department. To visualize, see appendix 13 for the proposed Lean PD.

DSDM practices and products in knowledge value stream

To adopt DSDM not just by being agile, but also doing it, few practices and the products of DSDM must be included in the process. MoSCoW prioritization can be included as a practice to understand and fulfil the major challenge of lack of prioritization. For more transparency

and better documentation, the products of DSDM can be implemented in the knowledge value stream. Products here describe the solution itself and other things that are required for the process to evolve and supports governance and control; providing more control to the separate roles in the department. In other words, products are the guidelines that are used to promote good communication in a project. However, it is not obligatory to use them and may not be necessary to present them as documents every time. The main objective of these documents in the case of R&D department is however different from the actual documents in the DSDM. The main goal in the knowledge value stream is to produce a technical report that consist of all the found information through pre-study and then be sent to the product value stream once the success is assured.

MoSCoW Prioritization

It was observed in several documents of the IMS system that numerical approach of prioritizing, for example, in the knowledge backlog, program plan, activities, etc. are used. To have a clear definition of what is a priority, DSDM offers a fit solution to that by using MoSCoW. As described in the theory, it gives a complete overview of what “must have”, “should have”, “could have” and “won’t have now” means. Thus, it facilitates the communication of priorities and builds a requirement list.

Product Overview (empowering the human resources)

The products are distributed into three categories called Solution Architecture Definition (SAD), Management Approach Definition (MAD) and Development Approach Definition (DAD) see figure 5 for the illustration. The reason why these set of products are fit is because it fulfils the requirements of the idea process and the pre-study phase. The SAD documents will provide more control to the technology manager in the R&D department since it will support the role to be provided with more control, available modern technology and technically formulate the documents within it. This is like the current role of technology manager who handles the idea process more closely. A document called “terms of references” in the DSDM products will provide most of the information that are like the content required for the collection of idea. It includes the details as objectives, business drivers, financial benefits, value for the customer, etc. On other hand, MAD will empower the R&D managers since it provides more insights on how employees must develop the

required knowledge and provides a device on how to manage it. For the vice president of the R&D department, due to less interaction with the knowledge development team and a lot of other tasks other than the ones related to the R&D department, DAD is the most fit set of documents that will enrich the governance control by providing a basic summary of the former two documents SAD and MAD. It will help the vice president to take scientific and reliable decision for a project. Minimizing the effort and time needed for decision making while enhancing control over R&D. This is done by one-page executive summary document in the DSDM products. Due to the adoption of iterative development, it is important for the burndown chart to be used during the evolutionary development phase. It helps identify the status of the pre-study quickly. Importance of visual management in the department must be acknowledged to have clear perspective of what each category of the product overview means. Since the department deals with several projects at the same time, it is important to have a unified knowledge backlog within the pre-study. DSDM incorporates the required functions for it and is fit since the employees in the department play multiple roles in different projects. A unified knowledge backlog will help the department to centralize the acquired knowledge that can be shared between different projects easily. It also accounts the calculation of the man hour to have a proper utilization of the employees or the resources in the department.

5.4 Overall Outcome

The first two research questions i.e. what a suitable agile framework was and what were the perceived challenges, helped to provide an insight for the third question i.e. how the perceived challenges could be improved using DSDM. It can be said that the overall outcome of the research comes directly from the third question since it serves the main purpose of the research. The possible similarities and dissimilarities between the two agile frameworks i.e. Scrum and DSDM, and the altered knowledge value stream allows to know the possible solution and explanation to the factors that require improvements. The process, roles and documentation in the knowledge value stream are the factors that can be improved. For an overview of the comparison of these factors with Scrum and DSDM, see appendix 13.

Process

Scrum incorporates most of the events and steps that takes place in the pre-study of the knowledge value stream, but it does not acknowledge the idea process in the knowledge value stream. However, DSDM accounts both idea process and pre-study. This allows DSDM to give a complete solution to the knowledge value stream. The only change is addressing project as study. Therefore, pre-project is termed as pre-study and post-project is termed as post-study to keep the nomenclature same as before.

Roles

The roles are compared more elaborately in figure 10, however the comparison is made clearer in the recommendation column of the appendix 13. The terms used for existing roles are kept the same since it is not mandatory to use the same in DSDM. Also, it is not important to account all the roles mentioned in DSDM. Apart from the existing roles that are repeated in appendix 13 for recommendation; DSDM Coach, Business Visionary and Workshop Facilitator are identified as the roles which can be incorporated in the R&D. DSDM coach is like the Lean coordinator with the only difference that he or she will work local in the R&D. Workshop facilitator can be played by DSDM coach as well. Business visionary on the other hand can be played by the vice president or the R&D manager. DSDM allows more than one role to be played by a single person provided that the work load does not exceed.

Documents

Documentation will ensure better communication and transparency within R&D. The existing content for the idea process must remain, especially during the phase of data collection. For more insights on what must be asked to store an idea, terms of references in DSDM can be used as a source of information. Knowledge backlog and sprint backlog remain the same, however, the technique of MoSCoW in DSDM should be incorporated to prioritize the activities. A technical report or a knowledge brief can be regarded as a deployed solution. The definitions of SAD, DAD and MAD must be used to provide more control to the technology manager, R&D manager and vice president respectively. It will help them make more scientific and reliable decisions.

Tools

Activity window must be continued to be used as a tool to represent the activities in a concise manner. Burndown chart must be used in the evolutionary development to know the status of the pre-study. This will ensure whether the pre-study is on track or is too time consuming. As mentioned previously, MoSCoW is another tool from DSDM which is an essential for prioritization. To make sure the mindset of the participant in pre-study is inclined towards all the above DSDM practices- an assessment form is created by DSDM. This assessment must be conducted by DSDM coach quarterly.

6. Conclusion

The sixth chapter gives the overview of what was achieved in the research along with some discussions and recommendations in brief.

To deliver a sense of clarity by answering the research questions, below is the summary addressing each question with an answer in brief based on the data collection and analysis.

What are the existing agile frameworks available for the PDP?

The researchers conducted literature review and choose the agile frameworks that was used in the R&D department's knowledge value stream. Scrum, Lean and Kanban were the three identified theories which was used partially to suit the needs in the PDP. To increase the collection of theories, the researchers were supervised by the university, and awareness of which agile framework that was suitable arose for the department. The researchers themselves also did a thorough analysis between the current practices and processes in the existing knowledge values stream and DSDM to validate the similarities. Hence, DSDM was found to be the most suitable one and appropriate for this research. Moreover, with the proceeding questions the finding will be strengthened.

What are the challenges to integrate the PDP within the agile framework?

The knowledge value stream was adapted as per the use of the R&D department by customizing the use of agile framework as per their own needs. To understand and make possible improvement, it was important to understand the challenges where improvements could be triggered to integrate the PDP of the R&D department within the chosen agile framework called DSDM. The challenges were insufficient knowledge about the use of agile and also about the existing practices like Scrum in the company, misaligned roles showed that there was no proper definitions of the roles in the department, lack of a Lean coordinator who existed previously showed the lack of guidance towards the process in the company, prioritization methods used in the company still seemed to be obsolete and was in a numerical format, transparency both externally and internally in the department was insufficient and the human resource utilization was not satisfactory due to no record of manhours in the department. These challenges were further validated when a focus group

was conducted with the help of an agile suitability filter that allows one to know which factors in the department are agile and which are not. This strengthened the previous challenges found through interviews and observations. Moreover, through literature study, these similarities were also found in few companies who practiced agile. With this it became easier to provide improvements to the knowledge value stream by the use of the suitable agile framework DSDM.

How can the existing practices in the PDP by using agile frameworks improve?

With the help of the identified challenges in the previous research question, few sectors of improvements were found through data analysis. The four sectors where improvements are required are: process, roles, documents and tools. The knowledge value stream was customized by the use of few practices from Scrum, however, more relevancy could be found in DSDM rather than Scrum. See appendix 13 for a descriptive explanation and factors that are within the process. In short, rather than customizing the knowledge value stream by only using the practices of Scrum, DSDM will be more appropriate since it accounts both the idea process and pre-study phase together. It is not at all obligatory to follow DSDM, however, the elements of improvements can be found more elaborately in DSDM than in Scrum. Roles as another factor can be improved by accommodating the definitions of roles in DSDM to that of the existing roles in the department's organization. It is not important to call the name of the DSDM, but roles that lack proper definition can be improved with the help of the roles explained in DSDM. Documents are the third factor that requires improvement which can be done with the help of product overview in DSDM that empowers all the major human resources or roles in the department. Tools like MoSCoW prioritization can be used to improve the documents like knowledge backlog.

6.1 Discussion

There is a great need of a single agile framework for the knowledge value stream to avoid the misconceptions in the nomenclature used, unclear roles, lack of prioritization, improper resource utilization etc. Identified challenges helped the researchers narrow down the main aspects related to the selected framework for comparison, and as a recommendation to the R&D Department. “Process” in the knowledge value stream, “roles and organization structure” and “the agile mindset” are the three main aspects found after the data analysis, and the solution to which could be found in DSDM. The practices that can be improved are further explained in the data analysis using the theoretical framework built to assess the collected data. Epiroc Drilling Tools AB purely dealt with manufacturing where several constraints were presented due to the implementation of a framework designed for software development. Scrum is a framework which is developed particularly for the companies closely dealing with software. It is the reason why Epiroc Rock Drills AB, Örebro utilized Scrum in their project in a feasible way. Since Epiroc Drilling Tools AB, purely deals with manufacturing units, it is difficult to optimize Scrum to suit their work flow because it does not support multiple projects at the same time. DSDM claims to be fit not only for software-based development, but also product-based development (DSDM Handbook, 2014).

Moreover, as per the data analysis, there are certain similarities identified in the current PDP within the knowledge value stream. This will prevent high amount of disruption in the current process. However, the need to train the department with DSDM is required. Other discussed possibilities with the interviewees was to have a project office that steers the managerial requirements of the department. This will violate the principle of being agile since the resources are not utilized sustainably. It is important to not segregate the resources available, and instead utilize them in the most efficient way possible. However, the researchers are skeptical with the findings due to the lack of satisfactory data collection throughout the research. Many interviewees claimed that not just the R&D department, but the company lacked behind when it came to digitalization in the framework or the use of PDP. Due to the change in trend and the demand of improved data reporting system with the increase in complexity of the products, it is highly important to consider the digitalization of the framework as the top priority to identify the key issues in a product

quickly and improve the predictability of the business. However, the steps were already taken in the R&D department and the need was recognized.

Independent resources are allocated to increase the digitalization in the company, which will help spread the agile principles not just to the knowledge value stream, but also spread the principles in the product value stream. According to Womack and Jones (2003), the aim of the knowledge value stream is to expand and product value stream to shrink in terms of the length of timeline, specifically, within the R&D department. Similar approach was taken by the R&D department. However, due to the collision of other departments within the product value stream, the opposite trend was happening. More resources were used for the product value stream than for the knowledge value stream. Hence stretching the former and shrinking the latter respectively.

The adoption of agile principles by all the employees in future will ensure that the complete PDP is considered agile. However, the whole process will involve several other parameters as digitalization of the framework. On the contrary, the researchers argue that the trend of being agile is more of a hype or a buzzword that is being reflected from the software industries to the manufacturing or non-software industries. Agile practices are an ongoing trend and one of the main reason why the software industries are rapidly being more profitable than non-software industries. To adapt to this change in trend, the need to implement agile in non-software industries has been increasing. However, not many empirical studies are found regarding the topic of agile implementation in non-software industries.

Finally, the research contributes to the industrial engineering and management community as one of the few researches that discusses about agile adoption in non-software industries such as manufacturing, and what the possible challenges are associated with it. However, the research does not contribute to the entire manufacturing industry but is constrained to knowledge-based projects at the R&D department of Epiroc Drilling Tools AB, i.e. within Scandinavian boundaries.

6.2 Recommendations

The following aspects are recommended for the R&D department to work actively with after the completion of this research:

- Adaptation of the processes in the DSDM to the knowledge value stream without obstructing the current practices of idea process and the pre-study to provide a continuous development. The pre-study was defined only as the number of sprints and could instead be divided into the five stages below. In addition, see appendix 12 for better illustration. Below are definitions that can be used to define the PDP:
 - *Pre-study* – This stage ensures that only the right ideas are started and that they are setup correctly based on a clearly defined objective.
 - *Feasibility* – The feasibility stage is intended primarily to establish whether the proposed idea is likely to be feasible from a technical perspective and whether it appears cost-effective from a business perspective. This phase will decide whether further investigation is justified or whether the idea should be exterminated and is not viable. Technology Requirement Level (TRL) can also be set up to ensure that the idea or concept is mature enough to be transferred to the next phase. A brainstorming session can be setup to ensure this phase is completed.
 - *Foundations* – These are basically the objectives that are created to proceed with the idea or a concept. This will allow the preliminary investigation done in the feasibility to be taken to the next stage. It is at this stage when the knowledge development team must build a knowledge backlog to proceed with the evolutionary development stage. However, after every sprint in the next stage, it is important to come back to the foundation stage and update the knowledge backlog.
 - *Evolutionary Development* – No change is required in the current iteration process that is being used in the department. For example, having sprint planning, demo, lessons learned, weekly pulse meeting and update of

knowledge backlog. However, it is important to have a definition of "done" for each sprint which is currently missing. This multiple iteration using sprints can be termed as evolutionary development stage. The deployed solution here would be called the knowledge brief which exists already.

- *Post-Study* – At this point, the final deployment is made in form of a knowledge brief which decides that the pre-study phase must be closed now.
- Clear definition of existing roles must be defined using the similar roles identified in DSDM. However, the name of the existing roles is kept as it is to avoid any change in the designations. DSDM Coach, Workshop Facilitator, Business Visionary, Business Ambassador, Business Advisor and Technical advisor are the roles from DSDM which are missing in the organization but can be played by the existing roles in the department. This will ensure the continuous development of the knowledge value stream. The definition to these roles can be found in DSDM's glossary in chapter 7. To visualize the organization of the department, the figure 10 illustrates it appropriately instead of having a flat and three-layered hierarchical organization in figure 8. The organization structure can be divided into management level and knowledge development level where they are connected in a circular manner to showcase cross-functional interaction.
- Instead of neglecting the burn-down chart in the backlog files, it must be considered to identify the status of each sprint. It will also be useful to represent the progression within the evolutionary development. A small change can be made to have a more optimistic overview of the chart by using the burn-up chart instead of the burn-down. Since the burn-up chart shows how much work has been completed.
- MoSCoW is a DSDM technique that must be used in prioritizing activities in the knowledge backlog or for any other purpose when needed. This will ensure a more structured paradigm to prioritize the activities. This technique is briefly explained in the chapter 2 of this thesis.

- A unified knowledge backlog must be considered to have more transparency in the different activities. This will also ensure the delegation of tasks to different human resources more smoothly. The knowledge backlog can be categorized as per the project it is supposed to work for. Inter-related activities within different projects can also be presented in a unified knowledge backlog. However, this recommendation is subjective since more intuitive platform needs to be adopted for this and SharePoint is not a possible platform for it.
- By comparing the features of the SharePoint and JIRA, it was found out that SharePoint did not account Agile project management for reporting purposes, but JIRA does. In addition, JIRA was successfully used by Rocktec Automation department in Örebro. It is recommended to fulfill the aspects like unified knowledge backlog, more appropriate use of activity window and agile practices, JIRA is a complete solution for the knowledge value stream. The only drawback to this change is to transfer the existing knowledge backlog from SharePoint to JIRA which might be problematic. Moreover, with this recommendation the idea of having man hours for better human resource utilization and an improvement in reporting system can be solved to a certain extent, at least within the knowledge value stream. JIRA can be an additional platform that can be used for the knowledge value streams, but other functionalities of SharePoint can remain the same.
- To provide training and ensure the quality of understanding DSDM, it is recommended to appoint a DSDM coach that can assist the employees with the processes and techniques in DSDM tailored as per the use of R&D department. In the website of Agile Business Consortium (dsdm.org) one can gain certification to become a DSDM coach. This can be done by recruiting a new employee suitable for the role or by training an existing employee. A Level 4 - DSDM Coach certification will guarantee the successful application of the above aspects. The trained DSDM coach will ensure that the agile framework is adapted to the current functioning of the knowledge value stream instead of replacing the entire process and disturbing the nomenclature to avoid confusion. The DSDM coach will also be responsible for the templates of the documentation. Continuous improvement will be made without

altering the current practices. Once the DSDM process, roles and techniques are adapted to suit the needs of the knowledge value stream, a set of documents that are based on the three definitions of DSDM i.e. SAD, DAD and MAD must be incorporated in the documentation to provide control and power to Technology manager, R&D manager and the Vice president respectively ensuring that they will be able to take reliable and scientific decisions. The content of these definitions is explained briefly in chapter 2. Also, the DSDM Coach can spread these principles in other departments of the division as well.

6.3 Further Research

The research was conducted in a narrowed down approach where studies were conducted to find suitable agile framework for a specific department. However, not many empirical studies were available in the domain of academia of implementing agile practices in purely non-software-oriented department i.e. manufacturing. This research was one of the few attempts that was made to align APM in the manufacturing industry. To strengthen the findings, it is important to get a more holistic view of the manufacturing companies and conduct similar research in all the remaining departments like Marketing, Purchasing, Production, Communication, Distribution, etc. A multiple case-study can also be done to gather more findings. With an ongoing trend of being and doing agile; it is important to scrutinize what is appropriate for the manufacturing industry.

7. Glossary

Internal definitions	
Word	Definition
Idea	Built on a technology
Concept	Two or several integrated technologies
Objectives	The prioritized knowledge gaps that need to be answered.
Demo	A short presentation of the results of the latest sprint. Responsible managers and stakeholders attend this event.
Knowledge backlog	A list of all knowledge gaps and linked activities to solve the knowledge gaps, status and results.
Global Lean coordinator	A person who train employees in different sites in Lean framework
Activity window	A board which shows the fields "To be started", "Active" and "Completed".
Weekly pulse meeting	The whole R&D department on site in Fagersta participate on a weekly meeting to receive updated information from the diverse functions.
Lessons learned	Reflect over the sprint that just ended to enhance improvement to the upcoming sprint.
Sprint	A time-boxed event, typically 1-4 weeks
Time-boxed pre-study	A pre-study is time-boxed with a start date and a finish date.
Program plan	A three-year plan for each product line i.e. what product are to be developed during these three upcoming years and are separated per quarterly.
Success assured	The transfer of knowledge in the knowledge value stream to the product value stream.
Vice President	Have responsibility for all R&D departments for the division Epiroc Rock Drilling Tools.
Local R&D Manager	Have responsibilities in portfolio management, follow-up all R&D projects, people management,

	resource management, and general management as guiding pre-studies, projects, teams, etc.
R&D manager	Have responsibilities in follow-up its function and its projects, people management, responsibilities and general management as guiding their team in pre-studies.
Technology Manager	No description was found in the IMS.
Project Leader	Have responsibilities in planning the project, ensure deliverables result according to objectives, arrange steering committee meetings, weekly pulse meetings, support the team in faced challenges in the product development process, compile crucial documentation as costs, stakeholders, final report for finalized projects, etc.
Engineering Project Manager	Have responsibilities in portfolio management, product ownership, follows-up to verify project planning aligns with project objectives and overall guides the pre-study and projects to align with principles of Lean R&D, etc.
Design Engineer	Have responsibilities to design the product as per computer aided design.
Calculation Engineers	Works closely with the design and simulation engineer and calculates the measurements to identify possible errors in the designed product.
Simulation Engineers	The engineer provides reading for the simulations that allows to predict the possible failure in the product design with the help of engineering simulation software as ANSYS,
Technicians	Involved in field testing of the product.

Scrum	
Word	Definition
Scrum event	Prescribed events that are time-boxed i.e. a maximum time of duration.
Sprint	A time-box of one month or less. A product increment is created during this time.
Sprint planning	The entire Scrum team plans the work to be performed and is time-boxed to a maximum of eight hours for one-month sprint. The Scrum master ensures that the event takes place and attendants understand its purpose. The activity should answer the following: What can be delivered in the increment resulting from the upcoming sprint? and How will the work needed to deliver the increment be achieved?
Sprint goal	An objective set for the sprint and can be met through implementation of product backlog
Daily Scrum	A timeboxed event for 15 minutes for the development team. The event is held every day throughout the sprint and the development team plans work for the next 24 hours.
Sprint review	Held at the end of each sprint to inspect and adapt the product backlog if needed. The event is timeboxed to a maximum of four hours and attendants are the Scrum team and stakeholders.
Sprint retrospective	The Scrum team inspect themselves and create a plan for improvement to be accomplished to the next sprint. The event takes place after the sprint review and before the next sprint planning
Scrum artifacts	Produced work or value to give transparency for key information and to align everybody's understanding. E.g. documents.
Product backlog	A to-do list that is continuously reprioritized. It lists features, functions, requirements, enhancements.
Sprint backlog	The highest prioritized goals are transferred to the sprint backlog.
Increment	Sum of all product backlog items completed during a sprint.

Artifact transparency	The transparency of the produced work or value which the scrum master, product owner, development team and other involved stakeholders need to understand.
Definition of "Done"	When product backlog item or an increment is "Done", everyone must understand what "Done" means.

Lean	
Word	Definition
Just-In-Time (JIT)	It is quantity control. To supply exactly the right quantity, at the right time and at the exact location. The customer initiates demand whereas the demand is sent backwards from final assembly back to raw material. Thus, all requirements are pulled when required/demanded by customer.
Kanban	Signaling system to implement JIT production.
5S	A set of techniques to improve workplace practices/ to standardizes work procedures for effectivity to ease visual control. 5S stands for Separate, Set to order, Shine, Standardize, and Sustain.

Kanban	
Word	Definition
Cost of delay	The forecasted outcome of a work item completed in a period time compared to the actual cost if the work item were delayed in a period.
Work item	A deliverable or a component.
Pull system	Products and services pulled in to the production system as a response to customer demand.
Kanban	Large visual board, signal card or sign.
Kanban system	A system with defined commitment, delivery points and work in progress limits.
Kanban Board	A visual display with cards representing a work item and moved rightward from one column to the next to visualize progress of the work item.
Work in	A policy with a given constraints of how much work in

progress	progress is allowed in a given part of the system.
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DSDM	
Word	Definition
Agile	Working style or a way where the requirements and solutions transform through collaborative, self-organizing and cross-functional teams. It promotes adaptive planning, evolutionary development and delivery and is an iterative approach. It encourages fast and customizable response to variations.
Blue chip companies	A blue chip is a globally recognized, well-established, and financially good company. They usually sell high-quality, broadly accepted products and services.
Business advisor	The business advisor is a supporting role and an expert. The business advisor give input to the solution development or solution testing. It is normally the intended user or person who benefits the solution. Input can be given in daily project decisions, requirements, activities, etc. Advice to develop business user and support documentation, etc.
Business ambassador	The business ambassador(s) is part of the solution development team and provide important input to all requirements-, design-, and review sessions. The role provides a business perspective for daily solution development decisions, support to define and test the solution, etc.
Business analyst	The business analyst supports the project-level and is integrated in the solution development team. He/she facilitate the relationship of the business- and technical roles. He/she analyses business needs to make sure that it is correct reflected in the guidance the solution development team get to develop the solution.
Business sponsor	The business sponsor is part of the project-level and a single person. He/she is responsible for the business case and project budget.
Business visionary	The business visionary is part of the project-level and a single person. He/she define business vision which are the interpreted needs of the business sponsor, represent it in the business case and communicate it to

	impacted parties. He/she give strategic direction to the solution development team and assure that delivered solution align with the business case. He/she own the deployed solution.
Deployed solution	This is a baseline of the Evolving Solution, which is deployed into live use at the end of each Project Increment.
Done	A common term used in Scrum - an item is “Done” (completed) when it meets all the criteria that have been defined for it (“Definition of Done”.) Done is binary - an item is either Done or Not Done.
DSDM coach	DSDM coach is a supporting role and ensure that knowledge about the DSDM framework is given. The DSDM coach ensure that the DSDM process is adapted as per the project needs and the environment it operates in. The coach also ensures that the DSDM mindset influence the environment.
Feasibility	The DSDM lifecycle phase which gives the first opportunity for deciding whether the project is viable from a technical and/or business perspective.
Foundations	The DSDM phase to establish firm and enduring foundations from the three perspectives on a project of business, solution and management.
Increment	An element of the Evolving Solution, comprising a collection of one or more features which, as a group, have meaning/value for the business. One or more increments may form a release.
Iteration	A general term for working in a cyclic way, where several attempts are made to get a more accurate or beneficial result.
MoSCoW	M stands for Must Have, S stands for Should Have, C stands for Could Have and W stands for Won’t Have This Time.
Principle	A ‘natural law’ that represents an attitude and a mindset on a DSDM project.
Project manager	The project manager is a part of the project-level and assure that the expected solution and planned timescale of the project are reached by using project funds effectively.

Scope	A description of what the solution will do and what it will not do. This could be a list of features and/or a description of areas of the business that may or may not be affected.
Solution developer	The solution developer is a part of the solution development team and work with all other team roles to repetitively interpret business requirements and develop a solution increment meeting functional- and non-functional needs.
Solution tester	The solution tester is a part of the solution development team and performs tests throughout the project and work with business roles.
Team leader	The team leader is part of the solution development team and leads the team to plan and coordinate the product delivery. The team leader is chosen by his or her peers decided to be the most suitable person to lead in a specific stage of the project. Therefore, the team leader is likely to also have another solution development role as either business analyst business ambassador, solution developer or solution tester.
Technical advisor	Technical advisor is a supporting role and an expert. The technical advisor supports the solution development team with technical input and advice as per the daily decisions on the operational perspective, operational testing, etc.
Technical coordinator	The technical coordinator is a part of the project-level and the project's technical authority. The technical coordinator performs a technical perspective, the same function as the business visionary who performs from a business perspective. He/she control and agree on technical architecture, coordinate and advise technical activities of the solution development team, decide with business analyst how to turn business requirements to a technical solution, approves solution, etc.
Timebox	A fixed period, at the end of which an objective has been met. The objective would typically be a deliverable of some sort. Typically, Timeboxes operate at development level, but timeboxing can also be applied at project and increment level. A timebox is managed by adding or removing content to meet the timebox objective and the deadline.

User story	A requirement expressed from a user point of view and with associated acceptance criteria.
Workshop facilitator	The workshop facilitator is a supporting role and should be independent of the outcome. The workshop facilitator ease and organize a workshop/session to ensure that the participants achieve the workshop objective.

Agile Suitability Filter	
Word	Definition
Culture	Culture is defined as a set of values, conventions, or social practices associated with a field, activity or societal characteristic i.e. values, norms and assumptions that have been reinforced by time.
Team	A group of people that consist of three or more members which interact with each other to perform tasks to achieve the common goal(s).
Project	A set of planned and interrelated tasks which are to be executed over a fixed time-period within a certain budget by a project team.
Senior sponsor	A person or group who provides resources and support for the project, program, or portfolio and is accountable for enabling success

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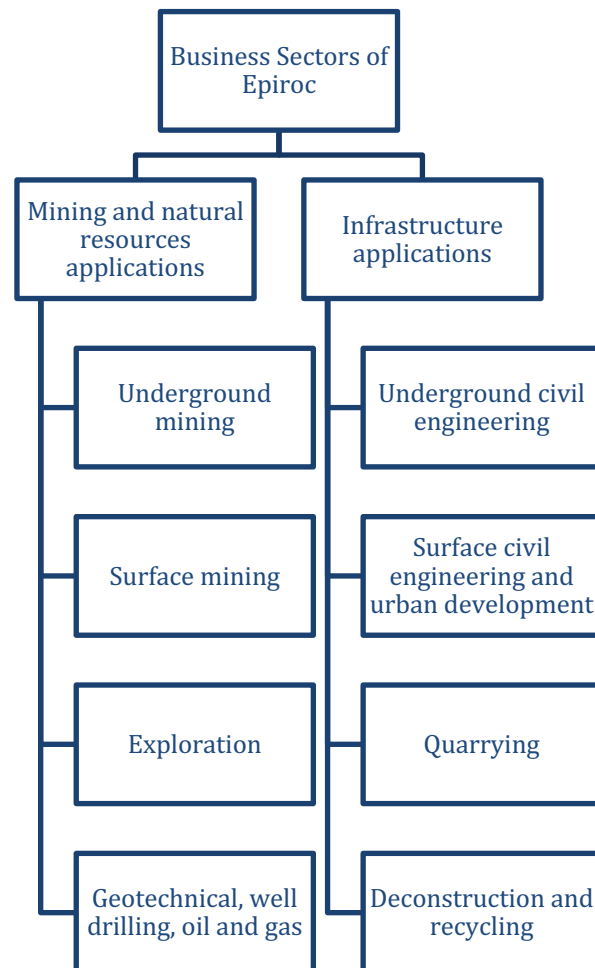
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9. Appendices

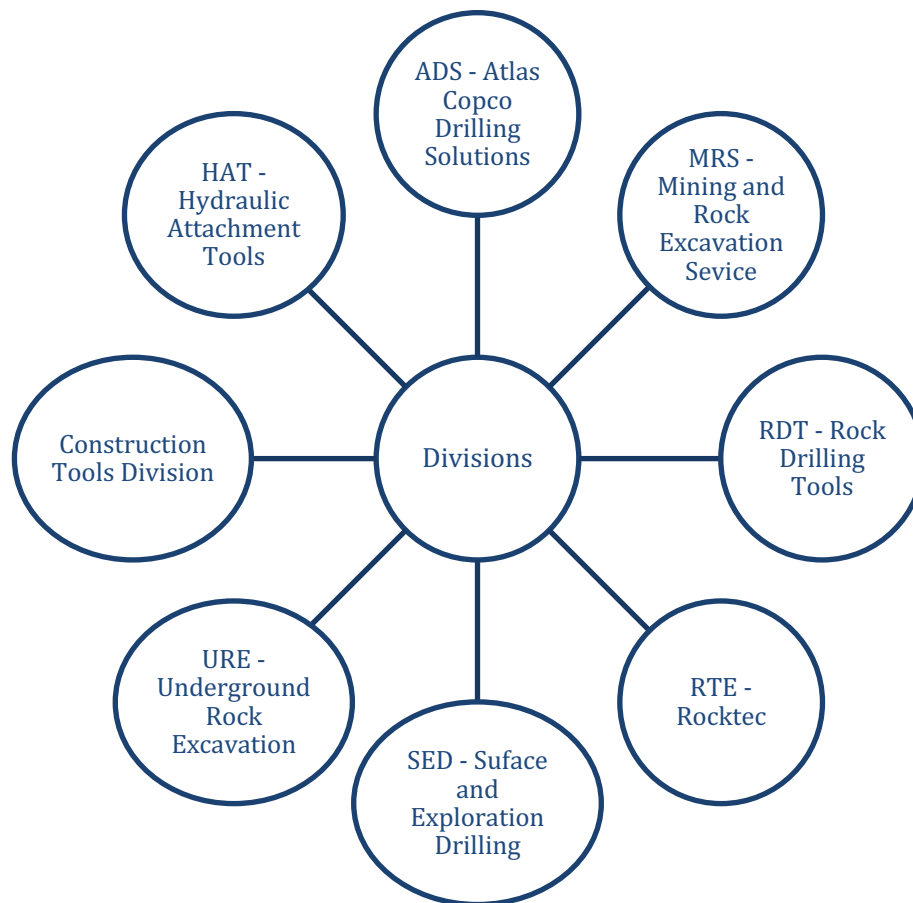
9.1 Appendix 1

Epiroc Business Sectors (Atlas Copco Secoroc, 2018)



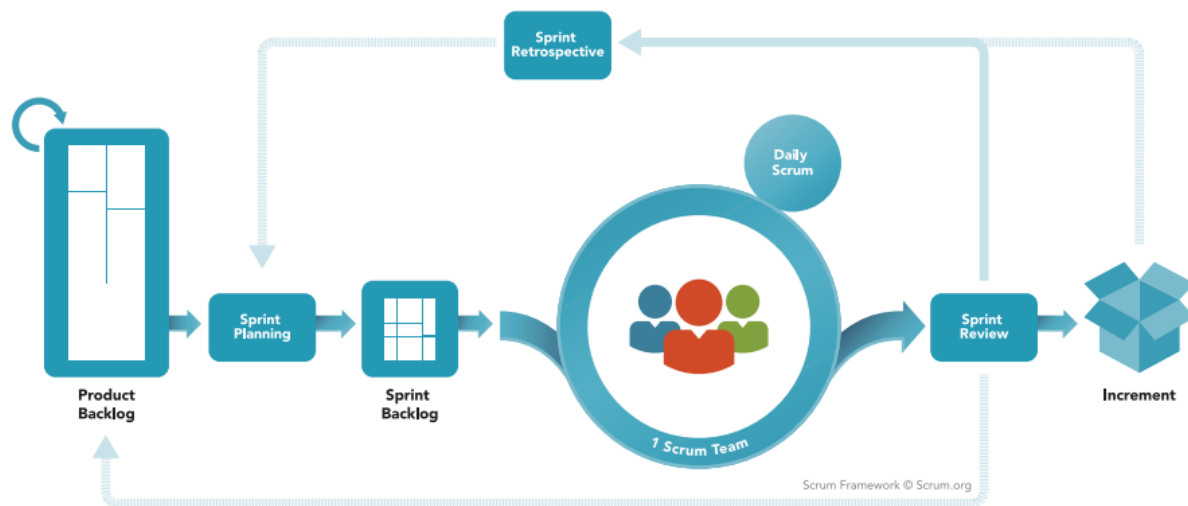
9.2 Appendix 2

Epiroc's Divisions (Atlas Copco Secoroc, 2018)



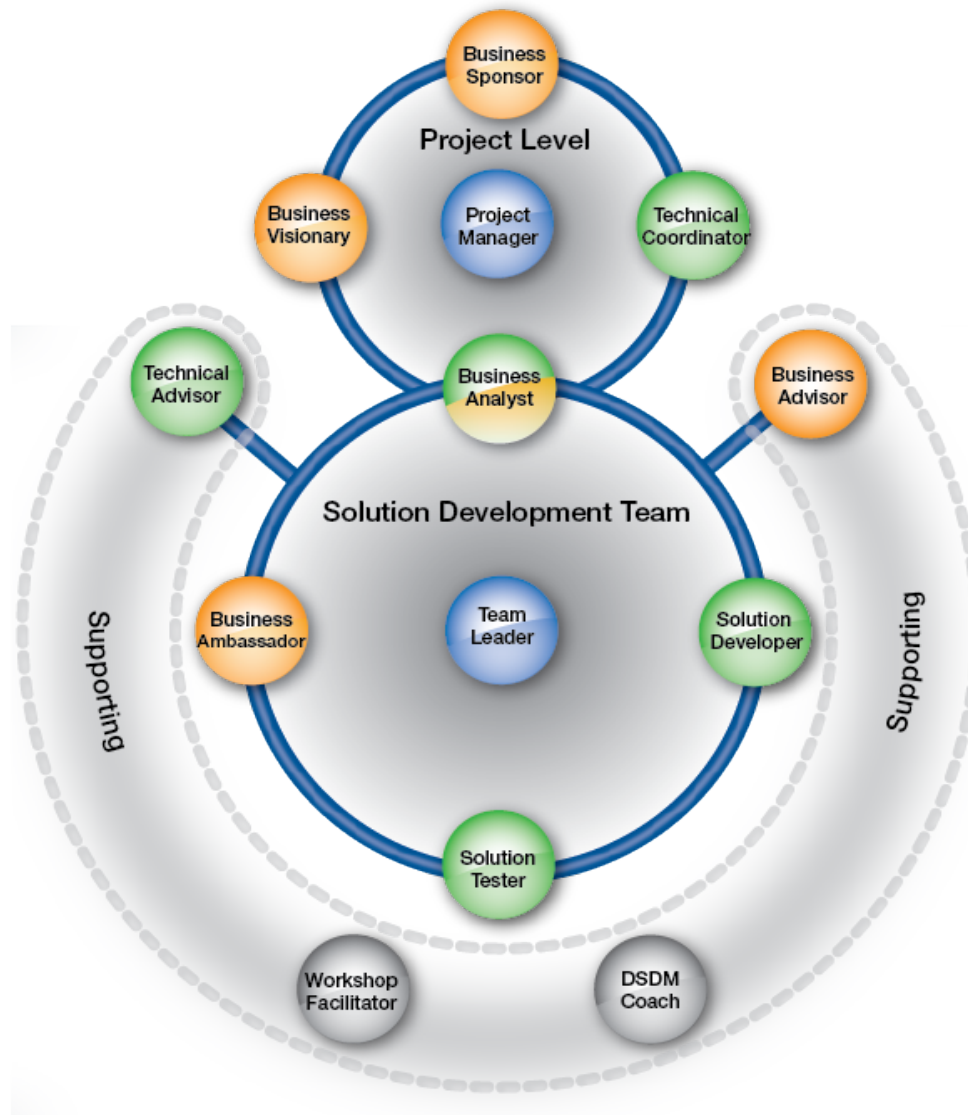
9.3 Appendix 3

Scrum



9.4 Appendix 4

DSDM Team Model (DSDM Handbook, 2014)



9.5 Appendix 5

Companies practicing Agile PM

1=Scrum, 2=Lean, 3=Kanban, 4=DSDM

Paper	Company	Challenges	Agile practices	Improvements
Katumba, B. and Knauss, E. (2014)	Volvo Car Cooperation	Process ability, Workload management, Domain specifics and supplier network, Working context and Culture of sharing information and knowledge (transparency).	1. Holistic product development strategy, task board, sprint planning, flexibility, requirement prioritization, product backlog, user story sprint planning Product owner, cross-functional teams, retrospective, self-organizing teams, daily standup. 2. Commitment eliminate waste, requirement prioritization, self-organizing teams, continuous learning	Software development methodology and structure, workload management, process dependencies, end-to-end knowledge, transparency
Dagnino, A. (2002)	ABB	Development of products under evolving requirements (flexibility), Changing technologies, Scarce human resources, Development of high quality applications.	1. Scrum-of-Scrum, product backlog, sprint planning, daily Scrum meetings, adaptation and inspection, reduce artifacts, self-organizing teams, 4. Feasibility study, Testing in iteration, customer collaboration	Faster execution, transparency, self-organizing teams, customer interaction, prioritization, motivation, time-commitment.
Plonka, L., Sharp, H., Gregory, P. and Taylor, K. (2014)	Lshift	Communication, User experience design, Misaligned teams, Vision, Developers and UX designers had misaligned perspective of goals, Precision in upfront design.	4. Business analyst role, Project manager with cross-functional knowledge, time-box, daily stand-up meeting	communication, transparency, visibility, precision in upfront design.
Paasivaara, M., Durasiewicz, S. and Lassenius, C. (2008)	EnergySoftware	Global distributed teams, Global distributed project, Cultural differences, Lack of communication, Team alignment, Lack of quality in each module.	1. Daily meetings, weekly Scrum-of-Scrums, synchronized sprints, global sprint planning meeting, local sprint planning meeting, demo, retrospective meeting, backlog	transparency, visibility, self-organized teams, management commitment, effective iteration, motivation

9.6 Appendix 6

Pre-interview form

<i>Name:</i>	
	Click here to enter text.
<i>Gender:</i>	
	Click here to enter text.
<i>Age:</i>	
	Click here to enter text.
<i>Country of Residence:</i>	
	Click here to enter text.
<i>*Name of the company:</i>	
	Click here to enter text.
<i>*Designation (Role) in the company:</i>	
	Click here to enter text.
<i>*Total work experience (in years):</i>	
	Click here to enter text.
<i>*Total work experience in your respective field (in years):</i>	
	Click here to enter text.
<i>*Scheduled time and date for the interview (date, time):</i>	
	Click here to enter text.
<i>If there is any other possible time and date for the interview, let us know below</i>	
	Click here to enter text.
<i>*Type of interview (physical meeting is preferred):</i>	
	Physical Meeting/Phone Call/Skype

9.7 Appendix 7

Interview Questions- Epiroc Drilling Tools

The questions below were asked to the respective interviewees which were selected jointly by the supervisors in the company and the researchers. The interview was timed to 45-50 minutes and was conducted as a semi structured interview. Before starting the interview, a brief description of the objectives of research was presented for 2-3 minutes.

The questions below are asked to the selected staff of Epiroc Drilling Tools AB, R&D Department, Fagersta.

Background

Give the interviewee a brief description of your project (2 to 3 minutes). At the end answer any questions he/she might have.

1. Describe your role(s) in the company? / As a (his/her position in the company), could you give us a description of your role(s)?
 - Could you identify the main tasks that you perform daily within your role?
2. Do you in a team quite often?
 - If yes, could you please describe your experience with the teams you worked with so far?
 - If no, Why? What are your expectations about teamwork?
3. Which project(s) are you currently working on?

Lean PD

4. Do you feel comfortable in currently used Lean R&D? please explain why.
5. Do you feel comfortable to accept an overall change in the Lean R&D or would you like to continue with the same process, but with minor changes or no change at all? Explain why?
6. Have you experienced any difficulties with adapting to change in Lean R&D?
7. Are there upcoming disturbances or missing tools/services/programs that affects your daily work due to this change? And do you have suggestions for what the missing tools can be?

Scrum in the pre-study phase

8. Did you receive training or coaching on Scrum or any of the other Agile PM frameworks?
 - If yes, please give details
 - If no, are you considering getting any? How long have you worked with Scrum board? How easy was it to apply any of them?
9. How comfortable do you feel in using the Scrum board during the pulse meeting? Do you feel it is an efficient technique for doing pre-studies? Explain why?
10. Describe briefly how you implemented Scrum in your pre-study?
11. Is having several sprints in the pre-study phase, by implementing Scrum, a useful way to make the pre-study phase more efficient? Why do you agree or disagree?

12. What are the common experienced obstacles/challenges/hindrances in the pre-study phase (consider your own role, collaboration/contact with other team members, collaboration/contact with other departments, etc.)?
13. How are problems handled, if any? what would be your suggestion of improvements if any?

Transparency

14. What techniques/methods are used to visualize each other's work for transparency?
15. What is your opinion on the transparency of work within the R&D department and between teams?

Idea process

16. Are you aware of the idea process?
17. How satisfied are you with the speed of idea generation and implementation in the idea process? Why?

Documentation

18. What is your opinion on the documentation in the IMS system?
19. What is your opinion on the documentation of the backlogs in Scrum?
20. How satisfied are you with the use of SharePoint?

Only to project managers

21. Have you worked with any of the traditional project management methods for example PMBOK, PRINCEII, Six-Sigma, etc.?
22. How would you define Agile project management?
23. How would you define Lean?
24. Which in your opinion is better for the R&D: traditional or agile PM? Why?

Round up

25. Can you share few thoughts on how to continue working with agile frameworks in the future?
26. Do you think it would be relevant to have a Lean coordinator who can assist the projects? Why?

9.8 Appendix 8

Interview questions- Epiroc Rock Drills

Since the questions in appendix 7 were closed framed using the terminologies only understood by the Fagersta division, it is important to keep the questions more general for the division outside Fagersta. Hence, below are the questions asked to the two interviewees in Epiroc Rock Drills AB, Rocktec Automation, Örebro. The interview method adopted was the same as previous interviews.

Background

1. Describe your role(s) in the company? / As a Team Leader/Project Manager, could you give us a description of your role(s)?
 - Could you identify the main tasks that you perform daily within your role?
2. Which department do you work in?
 - Could you explain to us briefly about the different departments in Rock Drills AB? Is Rocktec and Epiroc Rock Drills AB the same?
3. Do you work in team quite often?
 - If yes, could you please describe your experience with the teams you worked with so far?
 - If no, Why? What are your expectations about teamwork?
4. Which project(s) are you currently working on?

Product development process

5. What project development framework is currently used at RockTec/Epiroc Rock Drills
6. Are there upcoming disturbances or missing tools/services/programs that affects your daily work? And do you have suggestions for what the missing tools can be?
7. Have you received training or coaching on the currently used product development process at your department?
 - If yes, please give details
 - If no, are you considering getting any?
8. Have you experienced any difficulties with adapting to change in the product development process, what? And how were the obstacles tackled?
9. What are the common (experienced) challenges in the pre-study phase (consider your own role, contact with other team members, collaboration with other departments, etc.)?
 - How are problems handled, if any? what would be your suggestion of improvements if any?
10. The governance structure for Rocktec Automation consists of several meetings as: Which one/ones are you responsible to attend and why? Are the right stakeholders on place? Starting with management meeting, gate decision review and electronic hardware business meeting.

Transparency

11. What techniques/methods are used to visualize work made by you and others for transparency?
12. What is your opinion on the transparency of work within your department and between teams?

Idea process

13. Can you briefly describe the idea handling in your department?
 - If yes continue with Q14
 - If no, jump to “Documentation”
14. How satisfied are you with the speed of idea generation and implementation of the idea? Why?

Documentation

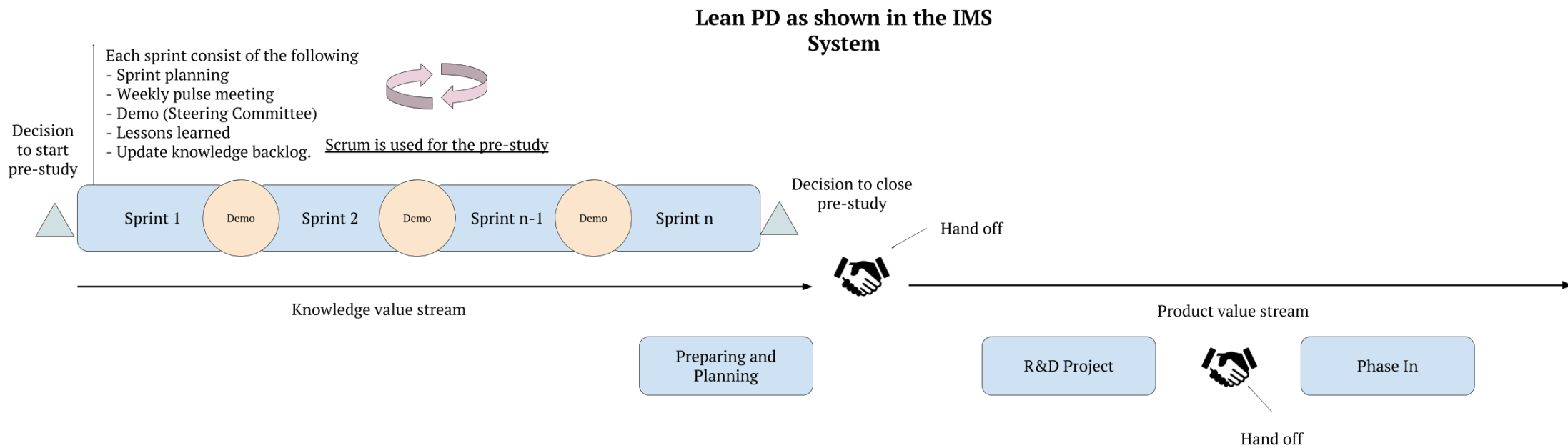
15. What is your opinion on the documentation in the RTE MS system on SharePoint?
16. Have you received training or coaching on any Agile framework or any product development process?
 - If yes, please give details
 - If no, are you considering getting any?
17. Have you worked with any of the traditional project management methods for example PMBOK, PRINCEII, Six-Sigma, Stage Gate Model etc.?
18. How would you define Agile project management?
19. How would you define Lean?
20. Have you worked with any/both (Agile PM and Lean)?
 - If yes,
 - When?
 - What is your assessment of this work experience?
 - If no,
 - How do you know about them?
 - Is there anyone you know that know about them?
21. Which in your opinion is a better way for your department, traditional or agile project management? Why?

Round up

22. Can you share few thoughts on how to continue working with agile frameworks in the future?
23. Do you have any sort of Lean coordinator who can handle projects? If yes, what is his or her role?
24. Is there anyone else we can interview in Rock Drills AB? Who can give us more insights on the product development process?

9.9 Appendix 9

Original Lean PD



9.10 Appendix 10

Agile Suitability Filter

Category	Sub-category	#	Question	Scale	Value
Culture	Buy in Approach	1	Is there senior sponsor understanding and support for using an agile approach for this project?	1-10	3
	Trust in Team	2	Considering the sponsors and the business representatives who will be working with the team. Do these stakeholders have the confidence that the team can transform their vision and needs into a successful product or service - with ongoing support and feedback going both directions?	1-10	1
	Decision Making powers of the team	3	Will the team be autonomy to make their own local decisions about how to undertake work?	1-10	4
Team	Team Size	4	What is the size of the core team?	*	1
	Experience Levels	5	Considering the experience and skill levels of the core team. While it is normal to have a mix of experienced and inexperienced people in roles, for agile projects to go smoothly; it is easier when each role has at least one experienced member.	1-10	1
	Access to the customer business	6	Will the team have daily access to at least one business/customer representative to ask questions and get feedback?	1-10	9
Project	Likelihood of change	7	What percentage of requirements are likely to change or be discovered on a monthly basis?	50% to 5%	8
	Criticality of product or service	8	To help determine likely levels of additional verification and documentation rigor that may be required, assess the criticality of the product or service being built. Using an assessment that considers loss due to possible impact of defects, determine what a failure could result in.	1-10	9
	Incremental Delivery	9	Can the product or service be built and evaluated in portions? Also, will business or customer representatives be available to provide timely feedback on increments delivered?	1-10	7

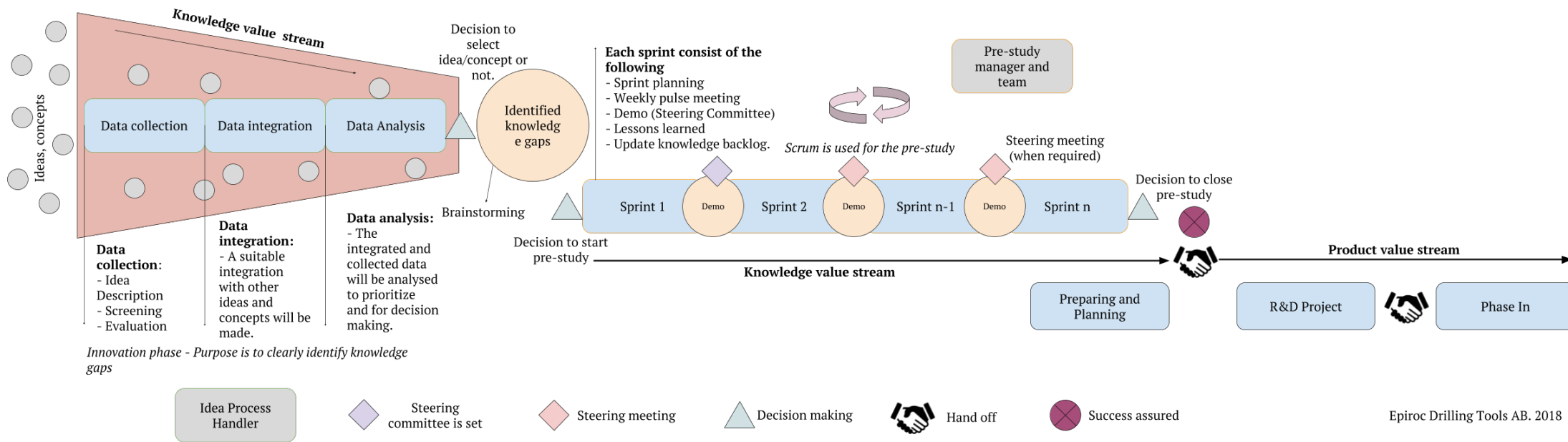
*

Scale	1	2	3	4	5	6	7	8	9	10
Team size	1-9	10-20	21-30	31-45	46-60	61-80	81-110	111-150	151-200	200+

9.11 Appendix 11

Observed PDP

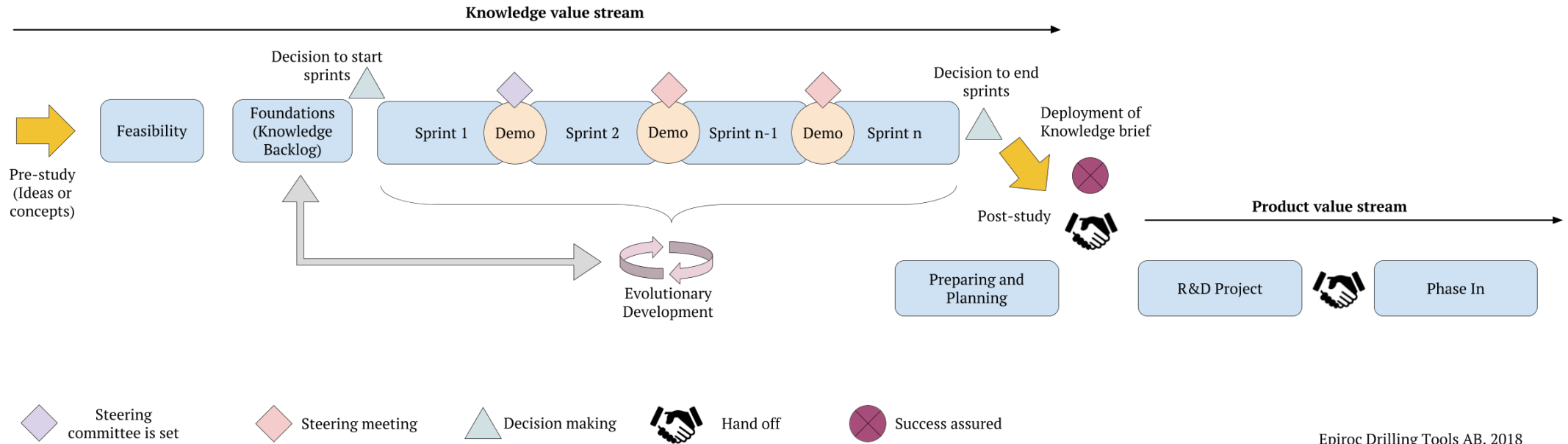
Product development process as observed.



9.12 Appendix 12

Proposed PDP

Proposed Product Development Process



9.13 Appendix 13

Comparison of Scrum and DSDM with the knowledge value stream in the R&D

Comparison of Scrum and DSDM with the knowledge value stream of the R&D (continued)

Scrum	Knowledge Value Stream (KVS) in R&D (As per appendices 11)			DSDM	Recommendation for the knowledge Value Stream	Comments for the recommendation
Scrum Roles	Existing Roles in KVS			DSDM Roles	Recommended Roles	The names of existing roles are kept as it is.
	By comparing KVS in R&D to Scrum	Currently exists in the KVS	By comparing KVS in R&D and DSDM			
Product Owner	Similar	Vice President	Similar	Business Sponsor	Vice President	Definitions of these roles are discussed briefly in the data analysis and are defined in glossary. By comparing it can be concluded that their definition and functioning are quite similar but not entirely.
		R&D Manager	Similar	Project manager	R&D Manager	
-	No similar role is identified	Engineering Product Manager	Similar	Business analyst	Engineering Product Manager	
The development team	A generic term is used in scrum, whereas in KVS, each role is well defined.	Project leaders	Similar	Team Leader	Project leaders	
		Design Engineer	Similar but the functions and tasks differ	Solution Developer	Design Manager	
		Simulation Engineer			Simulation Engineer	
		Calculation Engineer			Calculation Engineer	
		Technicians	Similar	Solution Tester	Technicians	
Scrum Master	The role definition is not the same. Lean coordinator is not present in the organization for KVS anymore.	Lean coordinator (Not present currently)	Similar but the agenda is different.	DSDM Coach	DSDM Coach	It is important to have this since it brings back the lean coordinator. Check DSDM glossary for complete definition
-	Does not exist	Technology Manager	Similar. But the role in KVS is not well defined.	Technology Coordinator	Technology Manager	The definition of this role will be well defined using DSDM's definition for Technical coordinator.
		-	Cannot be found in the KVS	Business Visionary	Business Visionary	It is not necessary to have separate resource for these two roles. Business visionary can be shared as a role with R&D Manager or Vice President. Workshop Facilitator can be played by DSDM Coach. There is no strictness towards the definitions in DSDM.
		-		Workshop facilitator	Workshop Facilitator	
		-		Business Advisor	Business Advisor	These roles can also be included and can be played by the existing roles in the department.
		-		Business Ambassador	Business Ambassador	
		-		Technical Advisor	Technical Advisor	
		-				

Comparison of Scrum and DSDM with the knowledge value stream of the R&D (continued)

Scrum	Knowledge Value Stream (KVS) in R&D (As per appendices 11)			DSDM	Recommendation for the knowledge Value Stream	Comments for the recommendation
Scrum Artifacts	Documents in IMS and Focal Point			DSDM Products	Documents in IMS	Documents currently used in the IMS system does not provide good correlation with DSDM. In order to avoid any disturbance in the current reporting style, Same documents which already exist are recommended. Here, for knowledge backlog, R&D managers are responsible and for sprint backlog, project leaders are responsible.
	By comparing KVS in R&D to Scrum	Currently exists in the KVS	By comparing KVS in R&D and DSDM			
-	No artifact	Idea and concept database	The one is KVS is more descriptive than in DSDM	Terms of References	Idea and concept database	
Product Backlog	Similar (In KVS, product is knowledge.)	Knowledge backlog	Almost similar	Prioritized requirement list	Knowledge backlog	
Sprint backlog	Similar without the use of burndown	Sprint backlog	No study was found	No study was found	Sprint backlog	
Increment	Almost similar, no definite explanation is available in Scrum that what an increment must contain.	Knowledge brief	Similar	Deployed Solution	Technical Report	
Definition of done	The definition of done is missing in KVS. The steering committee usually decides as per the demo received.	-	Some of the documents can be related to the definitions in DSDM but are not structured enough to find similarity with DSDM.	Solution Architecture Definition	Solution Architecture Definition	Provides control to Technology Manager
-		-		Development Approach Definition	Development Approach Definition	Provides control to R&D Manager
-		-		Management Approach Definition	Management Approach Definition	Provides control to Vice President

Comparison of Scrum and DSDM with the knowledge value stream of the R&D (continued)

Scrum	Knowledge Value Stream (KVS) in R&D (As per appendices 11)			DSDM	Recommendation for the knowledge Value Stream	Comments for the recommendation
Scrum Tools	Tools			DSDM Techniques	Recommended Tools	-
	By comparing KVS in R&D to Scrum	Currently exists in the KVS	By comparing KVS in R&D and DSDM			
Scrum board	Similar	Activity Window	DSDM does not describe this technique.	-	Activity Window	For better discussion in weekly meetings, Activity window is appropriate must be continued. Every pre-study team must participate by updating this regularly.
Burndown Chart	Not being practiced but is included in the KVS.	Burndown Chart		-	Burnup Chart	To have an overview of the status of the sprints at a glance, it is important to use the burnup chart more.
-		-	Cannot be found in KVS	MoSCoW	MoSCoW	Can be used in knowledge backlog and also for setting priorities between different departments.
-		-		Timeboxes	Timeboxes	A practice that provides more control to the vice president.
-		-		Tailoring DSDM	Tailoring DSDM	To ensure that the working procedure of DSDM is understood by everyone. This is done by conducting assessment test provided by the DSDM.