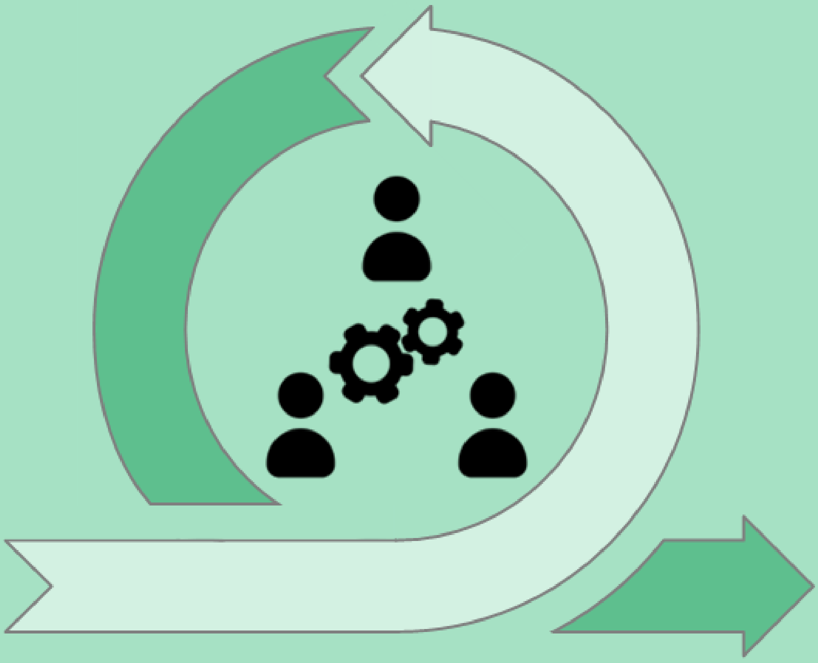
Building agile teams

Enhancing project team performance by applying agile project management aspects in the engineering industry



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Graduation Thesis | Construction Management & Engineering

Delft University of Technology

Final version | 09/02/18

Colophon

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PREFACE

As a part of the master Construction Management this thesis report finalises my studies at the TU Delft. After several months of research at Allseas Engineering, this thesis presents the opportunities that agile project management offers to improve teamwork in engineering projects.

I have worked with many people who have helped me throughout the course of this project. I want to thank everyone I have been in contact with for this project, however, a few of you deserve a personal thank you note.

Firstly, I want to thank my graduation committee. Hans Bakker, chair of my supervising committee, thank you for all your well-defined remarks and clear questions during all meetings, you made sure that I myself knew exactly what the purpose of my research was. Afshin Jalali Sohi, thank you for your support, week in, week out. You were always willing to help out and give tips on how best to approach the problems I faced. Martijn Leijten, you were always able to very clearly pinpoint the issues of my analysis and stimulate me on how these issues could be overcome. Therefore, thank you for all your wise council. Wouter Duijnstee, in every meeting we had at Allseas you were incredibly supportive which kept me motivated during the research. Thank you for all your guidance throughout the past year at Allseas. Vivian Roode, thank you for being critical on how the application of agile project management in the pilot project team. Your advice helped shape the guidelines into a practical method.

Secondly, I want to thank all the members of the pilot project team at Allseas. With your effort, cooperation and trust, you made this research possible. Precisely the aspects that make the team agile. Special thanks to Kirill and Bram for giving me the opportunity to introduce agile project management in their team and for being very constructive on the adaptation of the method.

Finally, I want to thank everyone who supported me during my entire studies. Especially my parents, who have always been there for me, thank you for your infinite support. Also, a special thanks to the rest of my family, Roelof and Esther, who have inspired me during the demanding periods of my studies. And lastly, Vera, thank you for all your help and for being there to encourage me every day.

Jasper Sonneveld
February 2018, Delft

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EXECUTIVE SUMMARY

"Successful project teams lead to more successful projects" (B. N. Baker, Murphy, & Fisher, 2008) and better collaboration within project teams lead to more successful projects (Hoegl & Gemuenden, 2001). Hence, proper collaboration within project teams is of high importance to the successful outcome of a project. However, in a considerable number of projects in the engineering industry, collaboration is not optimal. Communication and knowledge sharing are both aspects of collaboration that often lack in teams in the engineering industry (Humpfrey, Ma, Qi, & Wang, 2008). This leads to unbalanced team dynamics and demotivated project team members.

Moreover, in complicated and innovative projects, project complexity often makes it challenging to precisely determine the outcome of a project. Clients assume to know upfront what they require, however, along with growth and innovation within the design, the clients often adapt their expectations and thereby requirements with it. Adapting these requirements during later stages of traditionally managed projects often leads to budget overruns, time delays and reduced productivity of the employees (Ibbs, 2012). These problems can be partially attributed to the characteristic of traditional project management of freezing the requirements at the start of the project. This management methodology is not designed to unfreeze and adapt the requirements at later stages.

Abovementioned problems of collaboration and requirements management have led to the introduction of agile project management (APM) in the software development industry (AgileAlliance, 2001). APM aims at value creation rather than freezing project design at early stages and by means of better communication, collaboration is improved as well.

However, APM is still a young methodology in the software development industry and has rarely been implemented in the engineering industry. Partly because fully adapting APM in its current form is not eligible as characteristics and requirements of projects greatly differ (Jalali, Hertogh, & Bosch-Rekveldt, 2016). Whether APM could really improve projects remained uncertain, especially because team performance measurement of APM has not been performed in the engineering industry. Therefore, the question arises how to apply APM in the engineering industry and how to measure team performance in this environment, leading to the main research question of this graduation thesis:

How to enhance teamwork quality within a project team in innovative engineering projects by building agile teams in the front-end development?

This research question is divided into several sub questions and scoped on the front-end development phase of engineering projects. The following techniques have been applied in order to derive an answer to this research question:

1. A literature review
2. Development of agile guidelines
3. Development of measurement framework
4. A pilot project
5. Statistical analysis of the pilot project
6. Validation interviews

Literature review
A comparison between APM and traditional project management (TPM) showed that there are significant differences between the two approaches. This also means that the shift from TPM towards APM will require a considerable culture change within conventional engineering companies. Multiple researchers have suggested a cocktail approach of APM and TPM, which keeps the best of both worlds. Given that both share the same goal and building blocks, it is well conceivable that the combination of an agile approach and a conventional approach could benefit teamwork, and thereby projects, in the engineering industry.

The literature review also focusses on how a change in teamwork quality has to be measured. Multiple models have been studied to analyse the pilot project that has been executed in this research.

Research findings
In the literature study, the workings of agile tools have been investigated, leading to a set-up for the so-called cocktail project management approach with a central focus on Scrum in Chapter 4. This project management style is a hybrid version of the agile project management as it is applied in the IT industry. Certain aspects of agile don't function properly in an engineering setting and these have been adapted by introducing more traditional aspects to the project management method. This has resulted in the cocktail approach that consists of twelve adapted agile principles and four Prince2 principles. Principles for TPM methods have been derived from Prince2 as there are no overarching principles for TPM itself.

To be able to measure the teamwork quality of the guidelines, a conceptual framework has been developed that presents how teamwork quality is affected by agile methodology and which underlying aspects are important when measuring the teamwork quality.

Validation
By means of a pilot project at Allseas Engineering, the cocktail approach was tested. This pilot project has been closely monitored and has brought forward new insights into agile practices in the engineering industry (Chapter 5). Most engineers have responded positive on some aspects of Scrum such as the daily meetings and frequent checks on their work, while also some other Scrum functionalities were criticised by the project team. To figure out in what ways Scrum has improved the teamwork quality of the project team, a survey was distributed among the members of the pilot project team asking them to grade their perception of teamwork during their previous projects at Allseas and the current pilot project. This was cross-referenced against a complete department at

Allseas, to determine the change in teamwork quality, generating interesting results on all teamwork clusters of the conceptual framework.

To fully interpret the data from the survey, interviews have been executed to clarify results of the survey. These interviews have been performed with members of the pilot project team.

Conclusion

On the applicability of the agile philosophy in the engineering industry the conclusion can be drawn that apart from the principle on self-organisation, not a significant amount of changes has to be made to the APM philosophy before it can be applied in the FED of the engineering industry. However, for the engineering teams to uphold these principles, agile tools do need a significant amount of adaption before they are fit-for-purpose in the engineering industry. Hence, the developed Scrum guidelines need to accommodate this implementation in the engineering industry.

With the use of the teamwork measurement framework and four validation interviews, the team performance of the pilot project has been assessed. This assessment demonstrated an increase in the level of teamwork quality within the pilot project. Therefore, the following conclusion to this research can be given: If the complementary guidelines to the Scrum Guide are used and the adapted agile values and principles are adhered to, teamwork quality within project teams in engineering projects is enhanced.

Besides the level of teamwork quality, other factors also contribute to the project performance. It is therefore important that the effect of the cocktail method on project performance is researched as well. Although in this research limited attention was paid to the overall project performance, no indications were observed in the pilot project that the overall project performance was negatively influenced.

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Glossary

Agile	The ability to move quickly and easy. Agile project teams therefore possess this ability.
Agile Project Management	Agile project management focuses on continuous improvement, scope flexibility, team input, and delivering essential quality products.
Allseas	Allseas is a major offshore pipelay and subsea construction company with a highly innovative character. This research has been conducted at Allseas
Cocktail approach	An alternative approach to project management which combines the methodologies of agile project management and traditional project management.
Daily Stand-up	An element of Scrum. Daily meetings that generally last between ten to fifteen minutes in which every project team member shares what they have done, what they are doing and what they are going to do.
Front-end development	The front-end development phase of projects refers to the design stages that are performed before the actual fabrication and construction of the project begin.
Increment	Literally means 'an increase or addition, especially one of a series on a fixed scale.' In Scrum, this refers to the product parts that can be delivered within one sprint.
Iron triangle	Also referred to as the project management triangle. It implies the three most important features that define the quality of a project: budget, time and scope.
Lean Project Management	Being lean means being able to create more value for customers with fewer resources. A lean project management organisation focuses its key processes to continuously increase the aspects of the project that the customer values the most.
One-off projects	One-of-a-kind projects. One-off projects are custom projects that have to be specifically designed for a new project. Usually, one-off projects are highly innovative.

Product Backlog	An element of Scrum. The product backlog is a list of all things that need to be done within a project. Although in traditional project management, a backlog refers to the tasks being behind on schedule, within agile project management it refers to all tasks, both done and to be done.
Retrospective	An element of Scrum. A meeting in which the project team reflects upon their application of project management.
Scrum	A tool for applying agile project management.
Sprint	An element of Scrum. A short time frame during a project in which the team members focus on delivering an increment of the project.
Sprint Planning	An element of Scrum. A meeting which specifies the work to be done in the following sprint.
Traditional Project Management	Traditional Project Management is the collective name for all conventional forms of project management that complete projects in a sequential cycle: requirements analysis, design, implementation, testing, deployment and maintenance.

ABBREVIATIONS

APM	Agile Project Management
CFA	Confirmatory Factor Analysis
CSF	Critical Success Factors
FED	Front-end development
FPS	Flooding Prevention System
MCA	Multi-Criteria Analysis
PO	Product Owner
R&D	Research & development
TFS	Team Foundation Server
TPM	Traditional Project Management
TWQ	Teamwork Quality

1 INTRODUCTION

This master thesis is written to define and structure research into the field of agile project management that is performed for the study Construction Management & Engineering at the TU Delft. To provide context for the research objective, the research background is explained in section 1.1. After the problem statement (section 1.2), section 1.3 illustrates the research approach to the problem. The methodology and the scope in sections 1.4 and 1.5 describe how the research has been executed.

1.1 RESEARCH BACKGROUND

"Successful project teams lead to more successful projects" (B. N. Baker, Murphy & Fisher, 2008; Beleiu, Crisan & Nistor, 2015). Of course, this can be said with some side notes as the outcome of a project depends on many more factors, but with a highly motivated, knowledgeable and committed team, hurdles in projects are much easier to overcome. Especially in one-off projects, in which designs and technology have to be newly developed and the quality of the design highly depends on the performance of the project team.

It is for these projects that project complexity often makes it difficult to precisely forecast the outcome of a project. Clients assume to know upfront what they require, however, along with growth and innovation within the design, the clients often adapt their expectations and thereby the requirements with it. Leonard (1988) and Ibbs (2012) have both performed quantitative analyses on changes and concluded that the impact is extremely high on project cost, schedule and productivity. However, Mceniry (2007) states that it is important to recognize that the project teams' effectiveness in managing and administering changes and other adverse productivity factors will significantly contribute to the successful execution of the project. This is also confirmed by Suprapto, Bakker, Mooi, & Hertogh (2016), who have determined that if teamwork quality in projects improves, project performance significantly improves as well.

To enable the increase in team effectiveness, alternatives and opportunities in the collaboration of team members should be explored as raising the project team performance will benefit all parties involved. A solution may lay in project management practices according to Braun & Avital (2007). When pursuing a high team performance, project management practices create the foundation of collaborative relationships and ultimately job satisfaction. Looking at the engineering industry, most of the applied project management practices can be categorised as Traditional Project Management (TPM) practices (Walker, 2015).

An aspect that often becomes a struggle within these conventionally managed teams is the communication among engineers, which is often inadequate and therefore leads to less effective collaborative teams. To achieve a good collaborating team, Hoegl & Gemuenden (2001) have constructed six facets that together compose teamwork quality; communication, coordination, balance of member contributions, mutual support, effort and cohesion. By focussing on all these aspects, team collaboration should thrive.

In the IT industry, a new form of project management aims for a more intensive form of collaboration. This project management form also comprises long-lasting project team structures which can easily adapt to changing requirements. This new stream of project management methodology is called agile project management (APM). Even though the IT industry differs greatly from other industries, lessons can be learned from the self-managing teams that follow the principles of agile project management (Ekström & Pettersson, 2016; Streule, Miserini, Bartlomé, Klippel & de Soto, 2016).

As APM is a relatively new project management methodology, the literature on agile still holds research gaps. While most of this available literature is applied on the IT industry, the applicability of APM in other industries has had only few studies. These studies do show potential of APM in other industries, however, fully adapting APM in its current form is not eligible as characteristics and requirements of projects greatly differ (Jalali, Hertogh, & Bosch-Rekveldt, 2016). Therefore, to be able to apply APM in other industries, it is necessary to get a better understanding of APM and its applicability.

The industries in which essentials of APM could be of added value are diverse. Some industries or phases of project cycles might not be as suitable for APM as others. For example, the iterative behaviour of APM relates more to the design phase than to the actual execution in the construction industry (Owen, Koskela, Henrich & Codinhoto, 2006). These design phases are primarily referred to as the front-end development (FED). The same applies for one-off projects in the manufacturing industry. The focus of this research will therefore be on the FED in the engineering industry. However, if a form of APM is applied in the FED only, this would mean a full change in project management methodology during a project when the execution phase is initiated. This drastic change could negatively impact the functioning of the agile team and therefore is an important aspect to consider.

1.2 PROBLEM STATEMENT

Firstly, it is important that the knowledge gap concerning APM is reduced. The existing literature states that APM shows potential within the FED of the engineering industry. This implies the effects of APM on several aspects of project management should be studied because before this is proven or refuted, the applicability of APM in the engineering industry remains debatable.

Secondly, collaboration in project design teams in the engineering industry is not optimal. Communication and knowledge sharing are both aspects that often lack in teams in the engineering industry (Humpfrey et al., 2008). This leads to unbalanced team dynamics and demotivated project team members. Therefore, teams tend to improvise to solve these sorts of problems, often leading to a short-term solution instead of a long-lasting one.

These problems stipulate the need for research into project team performance by means of alternative project management methodologies of which APM shows potential to engage these problems.

1.3 RESEARCH APPROACH

In this research approach, the research strategy is discussed and elaborated. Starting with the research objective in section 1.3.1, the main goal of this research is presented. In order to achieve this objective, several research questions have been worked out which will jointly contribute to this task (section 1.3.2).

1.3.1 Research objective

Due to the limited amount of knowledge available on APM in the engineering industry and given its potential, it is important to contribute to knowledge on agile project management. To achieve this, this research investigates how the implementation of APM in the engineering industry affects the teamwork quality of project teams, thereby adapting APM to the needs of the engineering industry.

1.3.2 Research questions

This research therefore focusses on how the structure of agile teams has to be adapted in order for it to function in the FED of the engineering industry. In order to accomplish an objective scientifically, the objective will be translated into a main research question and several sub-questions (Verschuren & Doorewaard, 2010). For this research, the objective can be translated into the following main research question:

> *How to enhance **teamwork quality** within **project teams** in **engineering** projects by building **agile teams** in the front-end development**?***

As this question comprises of several aspects, it is decomposed into four sub-questions. The answers to these sub-questions combined deliver the answer to the main research question.

1 *What are the differences between the **agile way of organising teams** and the organisation of teams with a **Traditional project management methodology**?*

This question is raised to create an understanding of how teams function differently when applying two different project management methodology. In this question attention is given to advantages and disadvantages of both methodologies and the differences between the IT and engineering industries.

2 *What is the best **measure** of **performance** of project teams in both traditional and agile environments?*

In order to verify the 'enhancement of project team performance', it is important to research the best fitting measurement methodology for agile environments. Based on this methodology a framework is constructed with which the proposal of agile teams in the engineering industry is examined.

3 *How does the **application of agile project management aspects** in the engineering industry relate to the **reviewed literature** on sub-question 1 and 2?*

This question can be answered by studying a project team that implements APM aspects in practice. Implementation of APM in the engineering industry requires adaptation to certain aspects of the methodology. However, how these changes are manifested needs to be researched. Therefore, close observation of APM in practice provides valuable data for sub-question 3.

4 *What changes have to be made to the agile project management philosophy concerning teams before it can be applied in the front-end development of the engineering industry?*

To answer this question a model is constructed, containing the expected valuable aspects of agile project management in an engineering environment. Empirical research will verify its applicability in the engineering industry.

1.4 Research methodology

To achieve the research objective, the research is divided into stages in which the sub-questions will be answered in order to give a substantiated answer to the main question. As the main phase of the proposed research will entail empirical research, this graduation thesis can be defined as an empirical research (Creswell, 2009).

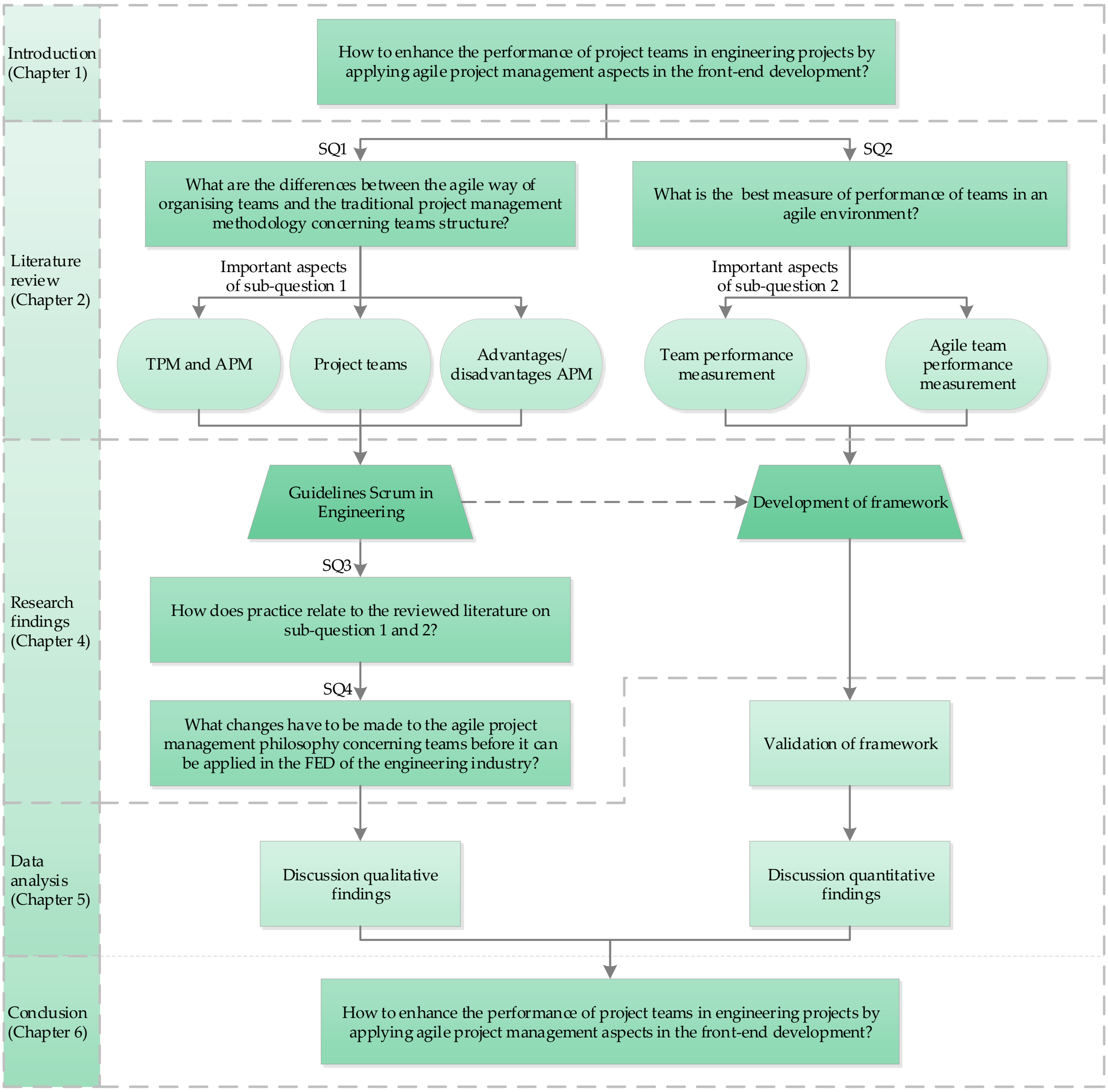

Figure 1.1 Research design (Own illustration)

In this section on research methodology, outline of this report has been combined with the methodology. Figure 1.1 displays both the outline and the research steps. In the following paragraphs, this figure is explicated.

1.4.1 Literature review (chapter 2)

The literature review is performed to answer the first sub-questions of this thesis and form the basis of this research. To answer these sub-questions, the literature review is divided into four sections. These sub-questions focus on subjects which can be investigated separately. Therefore, the literature review first evaluates and categorises the differences between traditional and agile project management. Thereafter, an in-depth research has been performed on team performance measurement, both in a traditional as in an agile context.

1.4.2 Research methodology (chapter 3)

The chapter Research methodology elaborates on the methodology of this research and is thereby an extension to the current section. With the knowledge presented in the literature review, a more detailed research methodology can be presented in which the exact steps to gather and validate the data are explained.

1.4.3 Research findings (chapter 4)

By combining the findings of this literature study, guidelines for the use of APM in engineering projects have been drafted. These guidelines are tested by implementing them in an ongoing project at Allseas Engineering b.v. (hereafter to be referred to as Allseas). To be able to measure the impact on teamwork of changing the project management methodology, a conceptual framework has been developed to determine how team performance is affected.

1.4.4 Data analysis (chapter 5)

The framework to which the guidelines are tested, has to be validated. Supported by a department-wide survey at Allseas on teamwork, the framework is validated by means of confirmatory factor analysis. To validate this framework, Allseas was willing to use this proposed agile methodology in one pilot project that will cover only several months. During this phase a qualitative analysis as well as a quantitative study has been performed to research the relation between APM and project team performance. To implement new management methods, the full cooperation of especially the project lead is required. To achieve this, brainstorm sessions on the optimisation of the tools will be held before and during the start of the project.

1.4.5 Conclusions and recommendations (chapter 6)

Conclusions have been drawn based on trends that show in the data analysis as well as the qualitative results that are observed during the pilot project. As the data retrieved from the pilot project team cannot be statistically validated as it concerns a small sample group, it is of high importance that this data is supported by qualitative observations and interviews during the pilot project. This also means that the conclusions cannot fully validate or rule out the functioning of the proposed framework. Therefore, the documentation of all observations will be of essential value to eventual outcome of this report.

1.5 SCOPE

The field of agile project management comprises many aspects that can be researched. Given the limited amount of time and resources, the scope and limitations have to be clearly demarcated. This enhances the quality of the researched aspects and manages expectations on what the research implicates.

1.5.1 Front-end development

The scope of the research mainly focusses on the first phases of projects, the so-called FED. These phases are considered to be most compatible with an agile approach (Bahceci & Holmgren, 2014). However, for successful adaption of APM in a project, the full project must be considered and therefore the transition from FED to execution phase is investigated as well, assuming a transition from the suggested agile project management form towards the commonly used TPM.

1.5.2 One-off projects

One-off projects usually involve a higher amount of engineering, innovation and uncertainty about requirements than in bulk manufacturing processes. Throughout the process of engineering in innovative one-off projects, project teams often encounter issues with these aspects and if following TPM, they are often unequipped in resolving these issues accurately (Atkinson et al., 2006). Agile project management is described as to be better equipped to deal with these issues. As agile could contribute to these projects, this research is limited by focussing on project teams in one-off projects only.

1.5.3 Agile in engineering

Literature states that APM in the construction or manufacturing industry has potential. However, how this potential can be realised is yet unknown. By scoping this research towards the engineering industry, both the construction and manufacturing industry benefit from the outcome of this research. As APM finds its origin in the IT industry and the agile movement is still relatively young, the available literature in the engineering industry is limited. Therefore, this research can be defined as exploratory. Nonetheless, a pilot project has been executed with the conceptual framework of implementing APM in project teams, to benefit project team performance.

1.5.4 Allseas engineering

This research is commissioned by Allseas. Allseas is an offshore engineering contractor which focusses on pipe lay in deep sea and heavy lift activities. Since two years, the company owns and operates the largest construction vessel in the world of which the pipe lay processes continue to be improved at the department of Innovations. This research focusses in particular on a project team at this department.

The innovative character of the company and the habit of changing the scope of projects during any phase of the project can be interpreted as a good basis for agile project management. However, at this stage, projects are still being managed through means of TPM methodology. To introduce a completely new form of project management to a team of engineers is challenging, but it is exactly this challenge in transitioning that delivers valuable insights. Besides, as the company is positive towards APM, pilot projects with hybrid forms of project management are a good alternative.

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2 LITERATURE REVIEW

This chapter entails a summary of literature that is available on teams and agile project management in both the engineering industry and software industry, where APM originates from. This literature review focusses on providing more information on the given problem statement in order to give a grounded direction to this research. To deliver a substantiated research objective, this literature review is written to introduce all topics separate. First, TPM, APM and their differences are explained in section 2.1. After this short introduction into project management, the literature review gets to the core of this research, project teams (section 2.2) and their performance measurement (section 2.3) in both agile and traditional environments. A short review on team processes elaborates on the rhythm of teamwork (section 2.4). Thereafter, the literature review is concluded with a discussion (section 2.5).

2.1 PROJECT MANAGEMENT

Many authors have delivered a definition of project management. Ranging from Oisen (1971), being one of the first, to more recent definitions by the Project Management Institute (2013), stating "project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements." In most definitions of project management in the twentieth century, cost, time and quality are almost always included (Atkinson, 1999). By the end of the century companies started to realise that the use of project management was a necessity and not a choice (Kerzner, 2009). For this reason the definitions of project management became more diverse, specified for different industries. Atkinson (1999) also states that "perhaps project management is simply an evolving phenomenon, which will remain vague enough to be non-definable, a flexible attribute which could be a strength."

Which project management process is suitable, highly depends on the type of project. Wysocki (2014) states that the project management landscape is mostly determined by complexity and uncertainty and that the decision of project management methodology should depend on the clarity of the project's goal and the solution. Wysocki (2014) distinguishes four project management categories; TPM, APM, Extreme project management (xPM) and Emertxe project management (MPx). Projects without a clear goal are rather infrequent and therefore the theories on xPM and MPx will be disregarded in the continuation of this research.

The four-quadrant project landscape (Figure 2.1) can be compared to the Stacey Matrix (Figure 2.2), created by Stacey (1996), which divides projects in four categories; simple, complicated, complex and anarchy. In this matrix, TPM would be the most fitting to the simple projects and a small range of the more complicated projects, as TPM works most optimal if requirements are fixed. This can be stated as the waterfall method, a traditional project management method, which was developed with the philosophy that not allowing changes to requirements simplifies the development process (Beck, 1999). However, in more complicated and complex projects, where uncertainty cannot be ruled out, change to requirements is almost inevitable (T. M. Williams, 1999). If the requirements and technology are less certain at the start of the project, a more agile approach is recommended as in these cases TPM lacks the characteristics to address this with dynamic and innovative approaches (Cockburn & Highsmith, 2001).

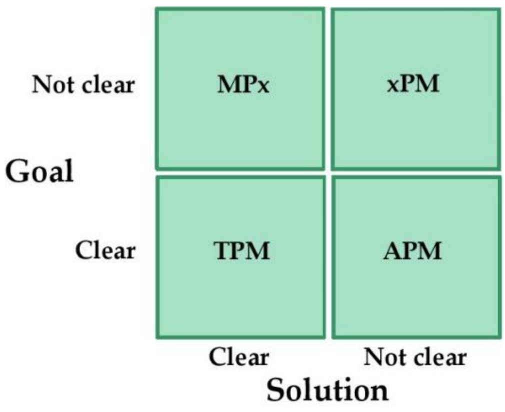

Figure 2.1 Project landscape - Adapted from Wysocki (2014)

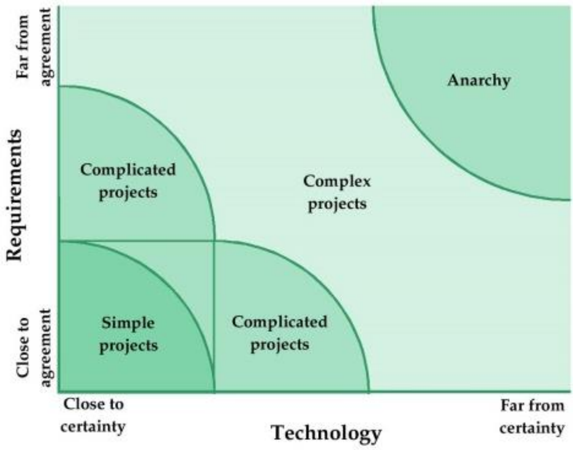

Figure 2.2 Stacey Matrix - Adapted from Stacey (1996)

These shortcomings of TPM have raised the question whether APM could replace or enhance TPM (Vinekar, Slinkman & Nerur, 2006). Therefore, in section 2.1.1 and 2.1.2 the important aspects of respectively TPM and APM will be discussed after which a comparison will be made in section 2.1.3. Section 2.1.4 compares different tools that can be used in APM and section 2.1.5 reflects how one of these tools is applied within the engineering industry.

2.1.1 Traditional project management

Most definitions drafted about project management in the twentieth century are applicable to TPM as it is considered the historical root of modern project management (Wysocki, 2014). As this project management method has evolved through common practice, the term TPM can be considered a collective name for a wide range of common project management practices. For example, in many organisations where no well-defined project management method is being applied, the method has a close resemblance to the definition of TPM (Wysocki, 2014). These practices thereby mainly represent the conventional approach to managing a project in general, but also in the engineering industry in particular as this sector remains primarily conservative.

Best recognisable in TPM is its linear approach to project stages, which resembles the waterfall model. With this linear approach one stage in the project design process has to be completed almost 100% before continuing to the next phase. Many authors have assigned different definitions to the stages of the waterfall model, but the most recurring are requirements analysis, design, implementation, testing, deployment and maintenance (Bell & Thayer, 1976; Royce, 1970), always dependent on the scope of the project. The essence of this methodology is that after each phase the design is frozen, thereby demanding a fully pre-defined scope. For simpler projects, a clear goal and solution can be pre-defined, however, for more complex projects changes due to dynamic markets, advancing technology and other uncertainties are very likely (Hester, Kuprenas & Chang, 1991; Ibbs, 2012) This has induced the call for more adaptable project-based processes (Joiner & Josephs, 2007; Kerzner, 2009).

To understand why more adaptable project-based processes have failed to be implemented in a TPM environment, the principles of TPM have to be studied. However, as the collective name of TPM does not clearly define project management principles, the principles of one of the most commonly used conventional project management tools, Prince2, will be explained. Prince2 is a broadly practised conventional project management tool, with seven main principles which define its core. These principles are put in place to ensure the proper application of this management tool (Palmquist, Lapham, Miller, Chick & Ozkaya, 2013):

1. Continued business justification
2. Learn from experience
3. Define roles and responsibilities
4. Manage by stages
5. Manage by exception
6. Focus on products
7. Tailor to environment

These principles are presented in order to clarify the essence of TPM and distribute examples of what the important factors of this project management method are. The broad description of these principles creates a wide variety of possible utilisations of the method, which results in many project teams applying TPM in comprehensively different ways (Kerzner, 2009). As long as these principles are upheld, TPM can be tailored.

2.1.2 Agile project management

A more adaptable project-based process is the aim of the agile movement, started by seventeen software developers who composed the Agile Manifesto (AgileAlliance, 2001). Agile software development can be summarised by the four main values that form the cornerstones of Agile Software Development (Schwaber, 2004). These values are listed below.

1. Individuals and interactions over processes and tools
2. Working software over comprehensive documentation
3. Customer collaboration over contract negotiation
4. Responding to change over following a plan

Highsmith (2002), one of the authors of the Agile Manifesto, explains that the ‘agile way of thinking’ is focussed on uncovering better ways of developing software by doing it and helping others do it. He states that in essence agile is not a project management approach or tool, however, over the years the ‘agile way of thinking’ has been implemented in both project management approaches and tools. The umbrella name for all different agile project management approaches is APM, thereby being more of a philosophy than an actual project management approach.

To create a context for the four values of the Agile Manifesto, the AgileAlliance (2001) also constructed twelve principles for practitioners of APM to follow. By adhering to these principles, a project can be considered agile. The principles have been gathered into four sections by Stellman & Green (2014). This division has been made as the four sections – delivery, communication, execution and improvement – are consistent themes throughout the principles and agile in general (Table 2.1). The value of these principles on agile teams can be considered high according to L. Williams (2012), who determined in her study that over 60% of agile teams state that the agile principles contribute to understanding the agile philosophy: "all agile teams choose among software development practices, but, if they want to be agile, they should choose practices that are in line with the principles." 50% of the surveyed teams also stated that the agile principles "guide teams new to agile," thereby showing the value of upholding the agile principles when introducing APM.

Table 2.1 Agile principles, divided into four sections - Adapted from AgileAlliance (2001) and Stellman & Green (2014)

Agile sections	Agile principles
Delivery	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.
Communication	4. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
	5. Business people and developers must work together daily throughout the project.
	6. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
Execution	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.
Improvement	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 behaviour accordingly.

Agile project management has been developed specifically for the software industry. As the software and engineering industry have significant differences, applying all aspects of agile in an engineering project is not advisable (Jalali et al., 2016) and few engineering projects have adopted an agile philosophy (Jalali Sohi, Hertogh, Bosch-Rekveldt & Blom, 2015). Therefore, the belief is that some of the values and principles have to be adapted before they can be applied in the engineering industry.

2.1.3 Comparison of TPM and APM

From the Agile Manifesto it follows that the agile philosophy responds to aspects of TPM that are debatable for certain projects. However, there is still a continuous debate on whether agile development is as beneficial for project organisations as is expected (Barlow et al., 2011). This debate originates from the understanding that both APM and TPM have many positive aspects but by implementing one approach, the positive aspects of the other are almost fully denied (Smith, 2005). Therefore, several authors have described how combining both philosophies in what Binder, Aillaud, & Schilli (2014) call a 'cocktail' approach could prove optimal (Batra, Xia, van der Meer & Dutta, 2010; Kahkonen, 2004).

However, to design this cocktail approach remains challenging as the philosophy of APM and TPM fundamentally differs on the three dimensions of the iron triangle (Owen et al., 2006). Where in TPM the scope will always be pre-defined and the process does not allow for many changes to occur to the scope, in APM it is exactly the opposite with a varying scope Figure 2.3. Not fully defining the scope can be derived from the belief that during the project, new requirements or priorities will arise that will add value if implemented. Figure 2.3 also displays the agile ideology of not changing resources during the project. Logically, it can be said that for any project it is not beneficial to have many changing resources. However, resources in TPM projects are often varying, with many personnel changes and cost overruns (Flyvbjerg, Bruzelius & Rothengatter, 2003).

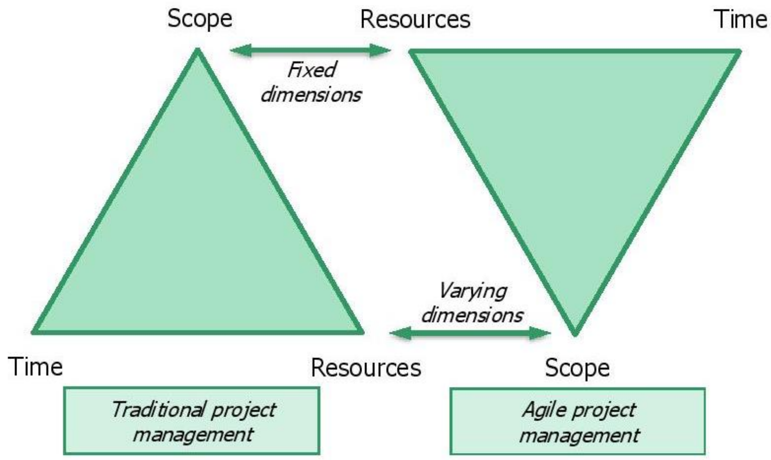

Figure 2.3 TPM versus APM iron triangle – Adapted from Owen et al. (2006)[1]

Besides the differences in the iron triangle, APM comprises of a lot of other typical aspects, which are not as simple to express in numbers as dimensions of the iron triangle. It is these aspects that are of high importance in this research. Nerur, Mahapatra, & Mangalaraj (2005) have already conducted a review of which aspects of project management show significant difference between the two approaches (Table 2.2).

Table 2.2 Traditional versus agile software development – Adapted from Sridhar Nerur et al. (2005)

Aspects	Traditional development	Agile development
Fundamental Assumptions	Systems are fully specifiable, predictable, and can be built through meticulous and extensive planning.	High-quality, adaptive software by small teams using continuous design improvement and testing
Control	Process centric	People centric
Management Style	Command-and-control	Leadership-and-collaboration
Knowledge Management	Explicit	Tacit

[1] The iron triangle is a concept in project management literature, which states that the quality of the project is restrained by a trade off in time, resources and scope. In TPM, time and resources are the varying cornerstones and in APM, only the scope should vary (Owen et al., 2006).

Role Assignment	Individual – Favours specialisation	Self-organising teams – Encourages role interchangeability
Communication	Formal	Informal
Customer's Role	Important	Critical
Project Cycle	Guided by tasks or activities	Guided by product features
Development Model	Life cycle model	The evolutionary-delivery model
Desired Organisational Form/Structure	Mechanistic	Organic
Technology	No restriction	Favours object-oriented technology

Although APM and TPM prove to be very dissimilar, their foundations and goal are identical. With both methodologies project teams explore the same stages of design; define, gather, analyse, design, code, test and release. One can argue that the iterative character of APM causes the process of development to be different, but when analysing the development of one element it shows that the stages of design remain the same. The goal of both approaches is also similar as it is "to deliver a quality product in a predictable, efficient and responsive manner" (Palmquist et al., 2013). The differences can therefore mainly be found in how activities are performed.

2.1.4 Agile tools

APM does not present a set of rules to be followed during a project. It more resembles a philosophy that is present in all daily activities. However, changing the working methods of engineers cannot be done by workshops only. Therefore, multiple agile tools have been developed for teams to adhere to, of which most well-known is Scrum. Of all teams that apply agile project management, 68% make use of Scrum, with other tools only being practised by a maximum of 5% per tool (VersionOne.com, 2017). Earlier research states that Scrum has "great potential in the design and planning departments of construction firms" (Streule et al., 2016). Of the tools with limited practice, Kanban is clearly the most promising tool for agile project management (Mahnič, 2015). Therefore, Kanban will also be investigated as this particular technique also finds its origins in the manufacturing industry (Rahman, Sharif & Esa, 2013), but can be used as an agile tool as well.

Scrum

Scrum was originally not developed as a tool to practice APM. In 1993, Jeff Sutherland started working on a tool that would enhance the effectiveness of small multidisciplinary software development teams. As in these teams collaboration and rapidly changing environments are present, the term Scrum was copied from rugby as many project characteristics are similar to the way rugby teams address a game (Schwaber, 1997). Scrum has become as popular as it is within APM due to the fact that it fits seamless to the philosophy of APM. This is mostly due to the fact that the philosophy that Schwaber and Sutherland used to develop Scrum, was later written down and named Agile Project Management.

Besides the agile philosophy, the theory of Scrum revolves around empiricism and the idea to "employ an iterative, incremental approach to optimise predictability and control risk" (Schwaber & Sutherland, 2013). By using transparent artefacts to organise all tasks and by frequent inspection of these artefacts by all team members, it is believed that these targets are realised. A third important aspect of Scrum is the controlled adaptability of the team. It is part of the agile philosophy to expect requirements to change. Yet, by limiting the adaptions to specified milestones, the project team is protected from constant changing requirements.

These requirements form the core of Scrum. In the software development industry, requirements can often be rewritten as wishes of certain stakeholders, so-called 'user stories'. The counterpart of the user story is the 'technical story', which defines the wishes and/or requirements for the system drawn up by the engineer. These user stories are then branched into tangible short tasks that have to be executed to achieve the user story. These tasks are added to the artefact called the 'task board', which creates an overview of the tasks still to be done, the tasks in progress and the tasks that have been completed. As the project team meets on a daily basis, each team member chooses a task that he or she wants to complete that day. By meeting on a daily basis, the project progress remains transparent to every member of the team and product visibility thereby remains high (Figure 2.4).

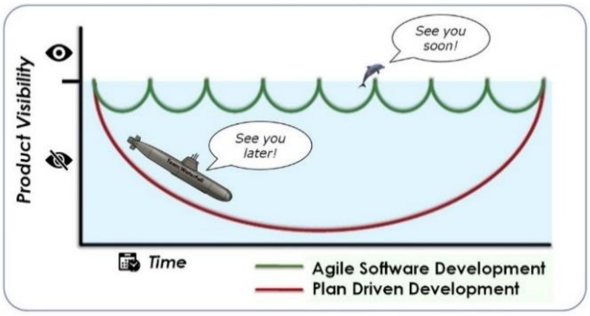

Figure 2.4 Agile vs Waterfall - Adapted from endouble.com (n.d.)

Besides the daily meetings of ten to fifteen minutes, the team meets at the start of a 'sprint' and at the end of a sprint. Sprints are periods varying from two to four weeks in which a set of user stories are grouped together to form a 'sprint goal'. During the sprint the complete set of user stories in the 'product backlog' are protected from change in order to structure the adaptability of requirements. Each sprint can be regarded as a project itself because at the end of a sprint, a deliverable is presented. The deliverables of all sprints combined form the eventual product. The complete process is illustrated in Figure 2.5 (Schwaber & Sutherland, 2013).

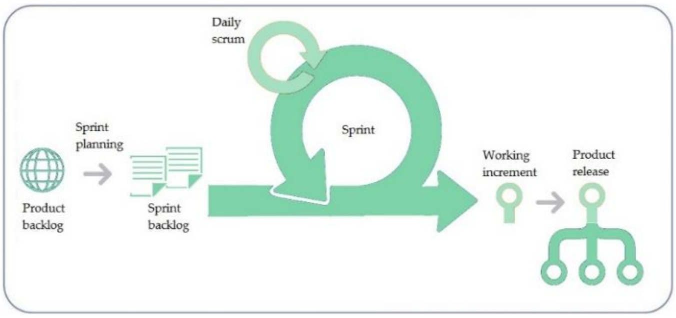

Figure 2.5 Scrum Sprint cycle - Adapted from nvt.pl (n.d.)

Within the Scrum team, the number of different roles is limited. The "Product owner" can be compared to a traditional project manager as he defines the features that the product should comprise and he ranks all user stories on priority, thereby creating a rough planning for the sequential sprints. The most important difference between a traditional project manager and an agile product owner, is that the agile project manager does not assign tasks directly to team members as the team members choose their tasks themselves from the sprint backlog at daily meetings. In this method they are thereby free to act as they seem fit within the boundaries the product owner has set. Primarily, to increase the sense of responsibility among the team members. The second role within the team is the "Scrum master", who protects the agile values and Scrum guidelines within the project organisation. Including the Product owner and the Scrum master, Scrum teams usually consist of seven to eleven people (Schwaber & Sutherland, 2013) where the remaining members of the team are not assigned any differentiating roles.

Kanban

Similar to Scrum, Kanban is also a relatively young project management tool spreading fast within its field. Derived from the Japanese word for "visible record", the main principle of Kanban is predicted by its name: Visualise the workflow. Besides this principle, four principles are directed to limit the work in progress, measure and manage flow, make process policies explicit and improve collaboration (Ahmad, Markkula & Oivo, 2013). All these principles are in line with the Lean[2] approach to project management, from which Kanban has emerged. As the Lean approach aims to deliver value to the client by eliminating waste, this philosophy can be found within Kanban as well.

Kanban revolves around one tool, the Kanban board (Figure 2.6). On this board, all tasks are divided in three categories to list the tasks by priority (Anderson, 2010). This is an ongoing process as new tasks can be added or scrapped from the board at any time during the process by anyone on the team. With the board being the only tool and the use of the board being fairly self-evident, the implementation of Kanban requires little effort. With almost no guidelines, any project team can adjust the Kanban system to how they seem fit (Klipp, 2014).

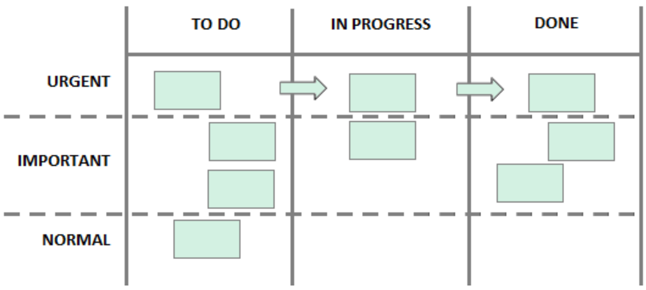

Figure 2.6 Kanban board (Own illustration)

Comparison of Scrum and Kanban

Scrum and Kanban are relatively similar tools. Both attempt to decompose complex tasks in order to create a manageable overview of work in progress. In addition, the boards that are used to display these tasks look identical and share the same objective, to visualise and keep track of the progress. However, the manner in which the boards are used is completely different. With strict guidelines on iterations and cross-functional teams, Scrum is significantly more prescriptive than Kanban (Kniberg, 2009). This makes Scrum harder to implement, however the chances of a project team

[2] Lean management involves a long-term vision of improving processes within a company. The lean methodology manages the overall work of an organization, and applies to all areas of management to get a more efficient and effective overall process (Karim & Nekoufar, 2011).

slowly abandoning agile principles are limited due to the guidelines concerning the use of the task board (Kniberg, 2009).

As a side effect, the sprints of Scrum create a sense of urgency among the team members (Schwaber & Sutherland, 2013). Towards the end of a sprint, a product owner can shift priorities to complete as much of the Sprint goal as possible. These sprints will also help to keep track of the progress of the project and provide the product owner with feedback. Moreover, the daily meetings provide a daily check for the team to ensure communication and to distribute tasks. In Kanban, the project is not divided in iterations, with the distribution of tasks being less regulated than in Scrum.

To safeguard the correct practice of the agile philosophy, for this project it is recognised that Scrum is more valuable. Considering that the project team transitions from a traditional project management approach, the expectation is that the agile philosophy will be upheld better by the guidelines provided by Scrum (Rutherford, Shannon, Judson & Kidd, 2010). Therefore, in the next paragraph, the appliance of Scrum in engineering projects will be analysed.

2.1.5 Scrum in the engineering industry

As stated before, APM has the potential to be beneficial for project teams in the engineering industry, however, not in its original form. Therefore, it is important to determine what challenges Scrum would face if it is to be used as a tool in an engineering project and moreover it is equally important to discover how these challenges could be overcome. A first characteristic of Scrum is that it has to be tailor-made for every single project team and changes to the method are tolerated as long as the principles of APM are maintained (Davis, 2012). This characteristic will ameliorate the problem of overcoming certain challenges of the Scrum. However, some principles could be reconsidered as they might not be compatible with engineering projects. This will be discussed in a later stage.

Tasks in engineering projects are hard to subdivide into small manageable tasks of less than two days, which is recommended by Scrum practices (Backblaze, 2015). It can be done, but it will require more effort of the product owner as he creates the product backlog. With tasks being longer, it is more difficult to fit multiple user stories into one sprint and succeed in delivering a working increment of the product. As delivering a working increment of the product is probably unattainable, examples of sprint endings could be design drawings and engineering decisions. Besides, designing and building an increment of a product will most definitely lead to modifications when interfacing increments are designed in later stages (Reynisdóttir, 2013). This is costly and in engineering projects also highly undesirable. A solution to this problem can be the delivering of virtual simulations of the increment instead of a physical model (Backblaze, 2015).

Another characteristic of Scrum that might present problems for the project team is the cross-functionality aspect of APM. Already in software development teams, complete cross-functionality is hard to achieve and in engineering teams the multidisciplinary aspect is even less frequent (Conforto, Salum, Amaral, da Silva, & de Almeida, 2014). As engineering companies are unlikely to adapt their team consistency, alternatives have to be found to cope with this aspect of APM.

A recurring challenge will also concern not co-located team members and the likelihood of team members working on different project teams (Conforto et al., 2014). Both situations will conflict with holding daily meetings and enhancing communication within the project team. Part-time team members could be asked to attend the daily meetings on the days they work on different projects, however, this is only possible if only one team works agile. Otherwise the employee will have several Scrum sessions every day. Besides part-time team members, not co-located team members will also encumber the possibility of having daily meetings. Meeting around an analogue task board will be impossible and therefore the only remaining option is a digital task board.

To address the issue of not co-located teams, digital Scrum task boards have been developed. Next to having solved the problem of co-location, digital task boards can also analyse data of the project progress. Especially for time estimation and project planning, digital task boards are valuable as they generate burndown-charts, capacity estimates and efficiency statistics (Meier, Taylor, Mackman, Bansode & Jones, 2007). An example of digital task board software is the Team Foundation Server (TFS) of Microsoft, one of the top five most used agile tools (VersionOne.com, 2017).

2.2 Project teams

Cohen & Bailey (1997) distinguish four different types of teams:

1. Work teams
2. Parallel teams
3. Project teams
4. Management teams

The primary difference separating project teams from the other three types of teams is their characteristic of being time-limited and producing one-time outputs (Mankin, Cohen & Bikson, 1997). When a project is completed, these teams either dissolve into the other sorts of teams and return to functional units, or new projects are started with (parts of) the team.

Several studies have described the significant impact of teamwork quality on the overall project performance (Hoegl & Gemuenden, 2001; Li, Chang, Chen, & Jiang, 2010; O'Connor, Ryan, & Ivan, 2012; Suprapto et al., 2016) and thereby point out the importance of smoothly collaborating teams. However, the composition of these teams should heavily depend on the type of project or project management method that is applied. Once the decision is made which project management methodology will be used, the teams will be composed. The differences and similarities between these teams will be discussed in section 2.2.1.

2.2.1 Comparison of traditional and agile teams

Zhou, Cheung, & Hsu (2017) have categorised eighteen different types of project teams and their underlying dimensions. Among these types of project teams are the engineering project design team and the agile project team. The other categorised project teams are considered irrelevant for this research as they cover teams in execution phases, management teams and teams focussed on sustainability. As applicable to agile project management, the agile teams are reported to have a higher interdependence and sharedness than the engineering project design teams (Conforto et al., 2014; Singhaputtangkul & Zhao, 2016) which are still working with traditional project management methods. Sprauer (2016) states that within engineering project design teams, teams with a higher interdependence result in more successful projects.

This higher interdependence and sharedness can be directly attributed to the high amount of collaboration within the agile teams of which part is forced upon the team members by daily team meetings in which all tasks are discussed. While in traditional functioning teams, it frequently occurs that team members develop conflicting objectives and competition amongst each other (Zhang & Cheng, 2015), decreasing the collaboration and fragmenting the shared vision of the project even further.

Other aspects that distinguish agile teams from traditional project teams are the self-organising capability and cross-functionality[3] of the team members, small team sizes and no differences in ranking (Cockburn & Highsmith, 2001). On the other hand, traditional project teams would need strict controlling from managers and in most teams a team member is needed for a certain expertise (Wysocki, 2014). Also, no boundaries are set on team sizes and almost everyone is assigned different job titles. In the engineering industry, self-organising teams can be seen as an improvement (Binder et al., 2014), but having no experts in a team and being bound to small team sizes will be aspects of APM that can prove difficult to implement (Blindenbach-Driessen, 2015). However, the transition from a plan-driven approach with traditionally-managed professionals towards a self-managing team is a considerable challenge (Nerur & Balijepally, 2007) as both the mind-set of the people and the culture of the organisation will have to undergo changes (Moe, Dingsøyr & Dybå, 2010).

2.3 PERFORMANCE MEASUREMENT

Within projects, there are many performance measuring variables with the iron triangle as primary example. Based on the performance measuring variables, projects are often called a success or a failure. This research focusses on the performance of teams within projects and therefore the actual project outcome is subordinate. However, to understand what project team performance contributes to, this section starts with project performance (section 2.3.1), before continuing with project team performance (section 2.3.2).

2.3.1 Project performance

To start with, the distinction between project performance and project management performance has to be clear. De Wit (1988) differentiates these two phenomena by stating that project performance, also referred to as project success, measures the overall objectives of a project whereas project management success is measured by time, cost and quality. Project success transcends these three objectives as there have been many projects which are considered successful, while being late and over budget (Baker et al., 2008).

[3] In general, cross-functional teams are teams with specialists in different fields. However, in the agile philosophy, cross-functionality also means that the specialists should mix and each specialist is willing to work outside their own field of expertise (Kniberg, 2011)

Atkinson (1999) proposes four categories of success criteria to measure this project success. Next to the standard iron triangle, three new categories have been recommended:

1. The information system[4]
2. Benefits for the organisation
3. Benefits for the stakeholder

These success criteria can be assigned to so called critical success factors (CSFs) that lead to project success (Cooke-Davies, 2002). Chan, Scott, & Chan (2004) defined five CSFs that together lead directly or indirectly to project success. However, multiple studies have been performed in which CSFs have been defined and redefined, with CSF number varying from five to 33 (Bakker, Arkesteijn, Bosch-Rekveldt & Mooi, 2010), producing various sets of marginally different CSFs (Alias, Zawawi, Yusof & Abra, 2014). Further investigation must be performed in order to determine which CSFs are most applicable in the engineering industry.

For this research, it is important to keep abovementioned literature in mind in order to understand which different aspects all contribute to project performance. However, Suprapto, Bakker, Mooi, & Hertogh (2016) have determined that if teamwork quality in projects improves, project performance significantly improves as well. Therefore, the model in this research will be focussed on measuring team performance only and will disregard the actual project performance.

2.3.2 Team performance measurement

When evaluating the teamwork of a project team only, different measurement criteria apply. Instead of easily measurable results or skills like cost and time, the quality of teamwork mostly comprises soft skills which are hard to quantify. This realisation has to be clear throughout the measurement process because the results will be relative and can only be used to compare project teams and find relations between aspects of teamwork. To determine all relevant aspects, three conceptual models on teamwork have been investigated. The models of Dickinson & McIntyre (1997), Hoegl & Gemuenden (2001) and Salas, Sims & Burke (2005) will be discussed in the following paragraphs. In literature of teamwork relations, these three models are the most referred to models and are widely supported among the academic world (Boos, Kolbe, Kappeler & Ellwart, 2011; Rico, de la Hera & Tabernero, 2011).

Many researchers have studied the components that make up teamwork and how this performance can be measured. Combining all components and creating a framework in which teamwork aspects have been linked to form a model was first done by Dickinson & McIntyre (1997) (Figure 2.7). In their research, many studies were combined in order to create a small framework with all essential elements. This framework exists of seven critical components of which "communication is a mechanism that links the other components of teamwork" (Dickinson & McIntyre, 1997). Besides all the elements frequently used in earlier literature, the learning loop was added as teamwork processes are considered to be adaptable and dynamic, requiring team members to remain open towards changing environments. This model centres around the idea of teams being self-managing,

[4] The information system is the technical strength of the resultant system coming from the project (Tam, 2017)

meaning that team members are allowed to take decisions and leadership is shared among several team members (Johnson, Hollenbeck, Scott DeRue, Barnes & Jundt, 2013). This manifests itself in the teamwork components Team orientation and Team leadership, as Team leadership is assumed to be a good attitude in all team members, not solely project managers. Monitoring, Feedback and Back-up are teamwork traits that form the teamwork processes necessary to ensure effective teamwork, being followed by the coordination which eventually defines the performance of the team (Moe et al., 2010). These elements will be discussed after all models have been introduced.

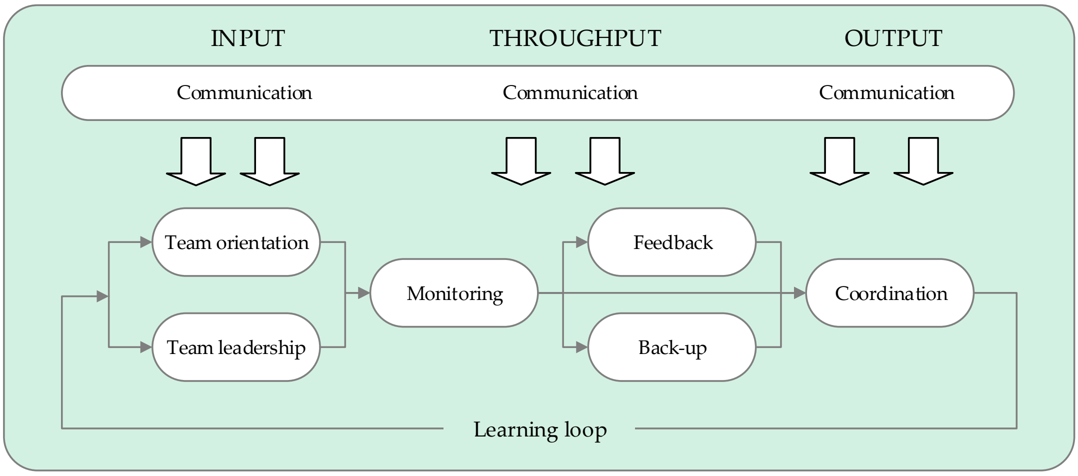

Figure 2.7 Conceptual teamwork model– Adapted from Dickinson & McIntyre (1997)

The Dickinson and McIntyre model is used to identify the core components of teamwork and is focussed on its practical use to support project teams. A later research by Hoegl & Gemuenden (2001) constructed the construct of Teamwork Quality not only to identify the elements but also to quantify the contribution of teamwork effectiveness to project success. This Teamwork Quality (TWQ) construct filters out aspects that are not influenced by the quality of individual team members and distinguishes team performance from personal success. It is primarily designed to describe the collaborative work process and illustrates how this affects various team outcomes. Figure 2.8 depicts which factors are important in the TWQ construct and how this displays into team performance and personal success (Hoegl & Gemuenden, 2001).

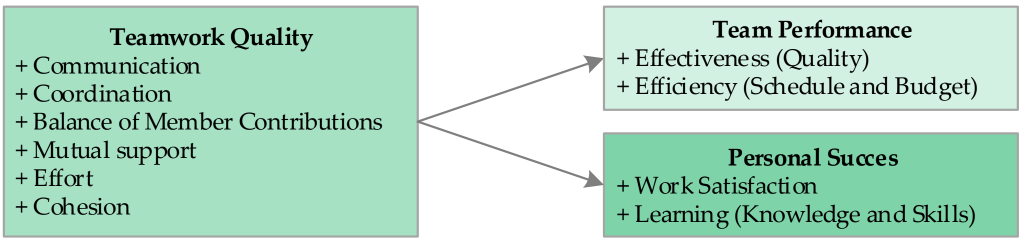

Figure 2.8 Conceptual model of TWQ– Adapted from Hoegl & Gemuenden (2001)

A third model on teamwork effectiveness has been constructed by Salas, Sims & Burke (2005) to redefine the core components that promote team effectiveness and define its coordinating mechanisms. Inspired by the “Big Five” personality factors in psychology, this resulted in the “Big Five” of teamwork and three coordinating mechanisms as depicted in Figure 2.9. In this figure, Team leadership, Mutual performance monitoring, Team orientation, Back-up behaviour and Adaptability together form the “Big Five.” It is discussed that team members must be highly interdependent for the “Big Five” to function as this will raise the sense of responsibility to one another.

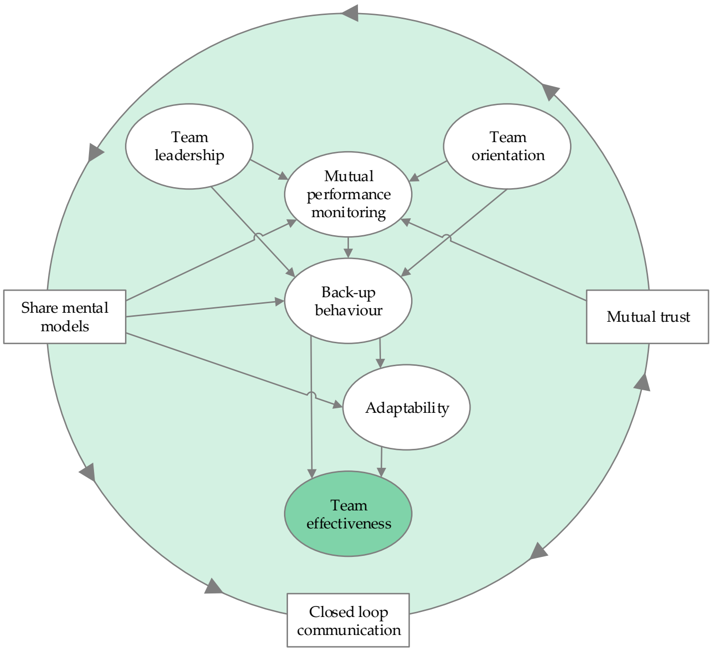

Figure 2.9 Conceptual teamwork model – Adapted from Eduardo Salas, Sims, & Burke (2005)

Discussion of models

By investigating these three models it becomes clear that there are numerous similarities and that the differences are limited. Of these differences, the largest contrast can be found in the Dickinson model and Hoegl model emphasising the need for learning in teams, whereas Salas et al. (2005) do not mention its significance. Through literature review it shows that a certain consensus has been reached on which elements are regarded mandatory in a model of teamwork effectiveness, which results in these models having a similar philosophy.

This also shows in the similar terminology in the Salas model and Dickinson & McIntyre model. This can be partially attributed to their use of similar literature in their research and earlier cooperation between the authors (Dyer, 1984; Salas, Dickinson, Converse & Tannenbaum, 1992) but also partially to the fact that most teamwork literature revolves around the aspects used by Salas and Dickinson (Marks, Mathieu & Zaccaro, 2001). However, the definition of the individual elements is not coherent in all literature. This shows by adding the Hoegl model to the comparison as different terminology is used, yet five of the seven components can be directly linked to the elements of the Dickinson model (Table 2.3). How the elements relate to one another exactly is explained in the section 2.3.4.

Table 2.3 Comparison of teamwork elements (Own table)

Dickinson & McIntyre	Hoegl & Gemuenden	Salas, Sims & Burke
Communication	Communication	Closed loop communication
Team orientation	Effort Balance of member contributions	Team orientation
Back-up	Mutual support	Back-up behaviour
Monitoring		Mutual performance monitoring
Coordination	Coordination	Coordinating mechanisms: Mutual trust Shared mental models
Team leadership		Team leadership
Feedback & Learning loop		
	Cohesion	
		Adaptability

Hoegl & Gemuenden (2001) have validated their model at the time of their paper, showing a significant contribution of all investigated elements to both team performance and personal success. Although validated through literature review, a validation of the Dickinson model through means of a statistical analysis could not be found. However, by sharing a significant amount of factors with the Salas model, the validation of the Salas model by van Roosmalen (2012) also partially validates certain factors of the Dickinson model. From these validating studies, it becomes clear that all three models have a high degree of significance with regard to defining teamwork.

Principles for measuring teamwork skills

Before attempting to measure teamwork skills of a project team, it is important to realise that measuring teamwork does not mean that the functioning of all teamwork components together can be quantified. Due to the exploratory nature of this research, the exact influence of the components on overall teamwork is unknown and therefore only a qualitative conclusion can be drawn when analysing the research data. Bearing this in mind, Baker & Salas (1992) have identified six key principles that need to be followed in the process of developing a measurement framework for teamwork quality. As the six key principles are rather abstract, twenty principles that emerge from these first set of principles are presented in Table 2.4 (Baker & Salas, 1992). During the research, these principles will be honoured.

Table 2.4 Principles for measuring teamwork skills – Adapted from Baker & Salas (1992)

Original principles	Emerging principles
1. For understanding teamwork, there is nothing more practical than a good theory.	a. Full understanding of team performance requires behavioural, cognitive and attitudinal-based measures. b. The development of team performance measures must be guided, in part, by theory and, in part, by empirical research
2. What you see may not be what you get.	a. Measures must capture the dynamic nature of teamwork b. Measures and measurement tools must reflect the maturation process of a team. c. Measures must account for team member experience with a team.
3. There is no escaping observation.	a. Team performance is not simply represented by what team members do. b. Observation is critical for measuring and providing feedback regarding team behavioural skills. c. Measures that assess team member shared mental models and interpositional knowledge must be developed and validated.
4. Applications, applications, applications.	a. Team performance measures must be developed, implemented, and evaluated for a wide variety of teams in a wide variety of settings. b. Psychometric data must be collected on all new measures of team performance. c. Measures that assess team knowledge, attitude, and skill competencies must be developed, applied, and evaluated.
5. Judges and measures must be reliable.	a. Reliability studies must reflect characteristics of the measurement tool. b. Team performance expert observers must demonstrate high levels of agreement (around 90%). c. Team performance measures must demonstrate internal consistency. d. Measures must establish the reliability of team performance.
6. Validation for practice and theory.	a. The content and construct validity of team performance measures must be determined. b. Valid team performance measure must contribute to the development of valid team performance theories. c. The criterion-related validity of team performance measures must be determined. d. Team performance measures must predict outcomes. e. Team performance measures must look like they assess team performance.

2.3.3 Team performance measurement in agile environment

In a survey, conducted by the ScrumAlliance (2015), 87% of the respondents said Scrum improves quality of work life. However, the results of the survey do not state which teamwork factors are involved and if this eventually also enhances project performance. Furthermore, a low amount of research has been performed into the effect of APM on team performance. This also shows from literature where only one significant research on teamwork quality in agile environments has been performed (Lindsjørn, Sjøberg, Dingsøyr, Bergersen & Dybå, 2016). Via a questionnaire 477 respondents from agile teams were asked for their opinion on the TWQ of Hoegl & Gemuenden (2001). This survey found that when applying APM in its original form on software development projects, APM is a major factor in improving team performance.

However, the research of Lindsjørn et al. (2016) found that the effect of teamwork quality on team performance was only marginally greater for the agile teams than for traditional teams in the survey by Hoegl & Gemuenden (2001). Although this difference can be attributed to the differences in expectations of teamwork now and fifteen years ago, it is important to keep in mind. The concept of personal success, which comprises of work satisfaction and learning, does show higher personal success with agile teams than with traditional teams.

2.3.4 Discussion of teamwork elements

To further investigate the correlation between the listed teamwork elements (Table 2.2) and agile values, in the following paragraphs, the elements of the models of Dickinson & McIntyre (1997), Hoegl & Gemuenden (2001) & Salas et al. (2005) are discussed. This section ellaborates on how agile project management is expected to affect these elements and which elements relate to one another.

(Closed-loop) Communication

A good line of communication is vital in every team, independent of the type of project. All three teamwork models acknowledge this, yet Salas et al. (2005) include the aspect of closed-loop communication which entails the control mechanism of verifying that the information is not only transferred, but also received and understood. Especially when introducing Scrum, a project team is forced to communicate daily which ensures the first step of communication, transferring information. However, if the receiver does not understand the information and decides to disregard it, using time consuming communication channels will backfire and damage the project processes.

Team orientation / Effort & Balance of member contributions

Team orientation as defined by Salas et al. (2005) is "not only the preference for working with others but also a tendency to enhance individual performance through the means of coordination, evaluation and utilisation of task inputs from other members while performing group tasks." Teams with a proper team orientation are thereby aware of the importance of the contribution of other team members and will not display individualistic behaviour. Team orientation can be considered as a positive attitude towards team members and the acknowledgement of team members' contributions to the project. Having balanced contributions of team members is thereby profoundly connected to team orientation as Hoegl & Gemuenden (2001) state that to achieve a balance of member contributions team members will have to respect the contribution of team members and avoid decision making-processes and discussions being dominated by individuals. On the element of effort they state "workload sharing and prioritising of the team's task over other obligations are indicators for the effort team members exert to the common task." This also highly relates to team members having a team orientated attitude towards one another. The cross-functionality of Scrum teams also requires a team that does not display individualistic behaviour and therefore this teamwork element is expected to be important for teams in agile environments as well.

Back-up (behaviour) / Mutual support

The definition giving to back-up behaviour by Salas et al. (2005) matches perfectly with one of the main purposes for organising daily meetings in Scrum. Back-up behaviour is "the discretionary provision of resources and task-related effort to another . . . [when] there is recognition by potential backup providers that there is a workload distribution problem in their team" (Salas et al., 2005). This entails that team members will attempt to help one another when support seems to be required. During the Scrum meetings it is essential that team members step in to provide support when problems are identified and this teamwork element is therefore expected to score highly in agile project management (Moe & Dingsøyr, 2008).

(Mutual performance) monitoring
Through the use of Scrum meetings, it is also easy to monitor the progress of team members. This awareness of task progress will result in more possibilities to intervene when problems arise and is thereby directly linked to providing mutual support. This element however, only concerns the monitoring and whether team members take action is not analysed. It is hypothesised that mutual performance monitoring will rate extremely high in Scrum teams as it is forced upon team members by Scrum methodology (Moe & Dingsøyr, 2008).

Coordination
The teamwork element of coordination is of high importance within the teamwork models. This element structures team members' activities and is also highly depended on the organisation forms assigned by the used project management method (Hoegl, Weinkauf & Gemuenden, 2004). If contributions of team members are not coordinated well, the contributions could lose their value. For this teamwork element as well, Scrum should be promising because due to the many feedback stages, coordinating team members and one's own work should be less complicated.

Team leadership
Team leadership is essential in teamwork for almost all other teamwork elements. To facilitate coordination, back-up behaviour, mutual performance monitoring and feedback, leadership qualities should be present to enable these elements within other team members. It is important to note that this element does not comprise "handing down solutions to the team but rather facilitating team problem solving through cognitive processes" (Salas et al., 2005). Other key components of team leadership elements are to ensure that team members understand their interdependence and realise how working together could benefit the project.

In Scrum, team members have more autonomy in choosing their tasks. Therefore, the element of team leadership is of less importance within the product owner. However, as team members are given more responsibility on the project, it is expected that on average the team leadership element in teams will increase (Moe & Dingsøyr, 2008).

Feedback & Learning loop
Dickinson & McIntyre (1997) present the only model that emphasises the need for learning within project teams. The philosophy is that team members have to collaborate intensively to actually learn from their activities. This learning is enforced by remaining to communicate on the tasks achieved, only then team members will be able to learn. The feedback element of teamwork can therefore be closely linked to the closed-loop communication, however, closed-loop communication is focussed on verifying information while feedback encompasses the commenting on the information as well. Although with proper communication channels, upholding the closed-loop communication element will almost certainly lead to receiving feedback.

Providing feedback on the tasks achieved is a regular activity within the Scrum process. With evaluation sessions at the end of each sprint, Scrum provides the team with tools to actively involve all team members in the learning loop. Therefore, this element is expected to improve due to APM as well (Cockburn & Highsmith, 2001).

Cohesion

The element of cohesion is mentioned by Hoegl & Gemuenden (2001) alone, yet can be observed as a theme within the other two models. The definition given is that cohesion refers to the degree to which team members desire to remain on the team (Hoegl & Gemuenden, 2001). This can be subdivided into three aspects;

1. Interpersonal attraction
2. Commitment to the team task
3. Group pride-team spirit

Especially the second and third aspect of cohesion can be considered to exist in the teamwork element team orientation.

Adaptability

Salas et al. (2005) introduce adaptability within teams as an important element of teamwork. The ability to adapt to environment changes and complexity can help the team control unexpected demands it encounters. This will benefit the team as they can move more effectively toward its objectives. The ability to adapt is stated to require a large amount of collaboration from the team to effectively engage complexity. It is said to be more present in innovative processes as these projects tend to lay outside of the habitual ways of the team members and will therefore require adaptability to new situations.

Within a Scrum process, the moments of adaptation are limited to the sprint planning and review meetings. In the rest of the sprint, the requirements are fixed and the ability to adapt is tested to a lower extent. It is anticipated that this will show when comparing the routine daily process to the planning and evaluation meetings (Moe & Dingsøyr, 2008).

2.4 TEAM PROCESSES

To help understand how the teamwork elements are manifested in the execution of projects, the model of Marks et al. (2001) is used, which describes the processes of tasks (Figure 2.10). In this model three processes in the execution of normal project team tasks are distinguished:

1. Transition processes
2. Action processes
3. Interpersonal processes

The transition process concerns the phases in which the team is performing organisational activities such as planning activities and evaluations. This entails the analyses of the project goal and the road required to reach this target as this is observed in the transition phases of projects. Thereby, whenever these require changes, it is in the transition phase that the project course is adapted. The action phases include the actual execution of all tasks needed to reach the project target. During this phase the actions have to be monitored and coordinated in order for the project to retain its course. The third process is the interpersonal process that is required for the team to encounter the other two processes effectively and closely relates to high teamwork effectiveness.

Marks et al. (2001) subdivide the interpersonal processes in three dimensions:

1. Conflict management
2. Motivating/confidence building
3. Affect management

All these tasks are focussed on making the team collaborate effectively and thereby form the basis of teamwork.

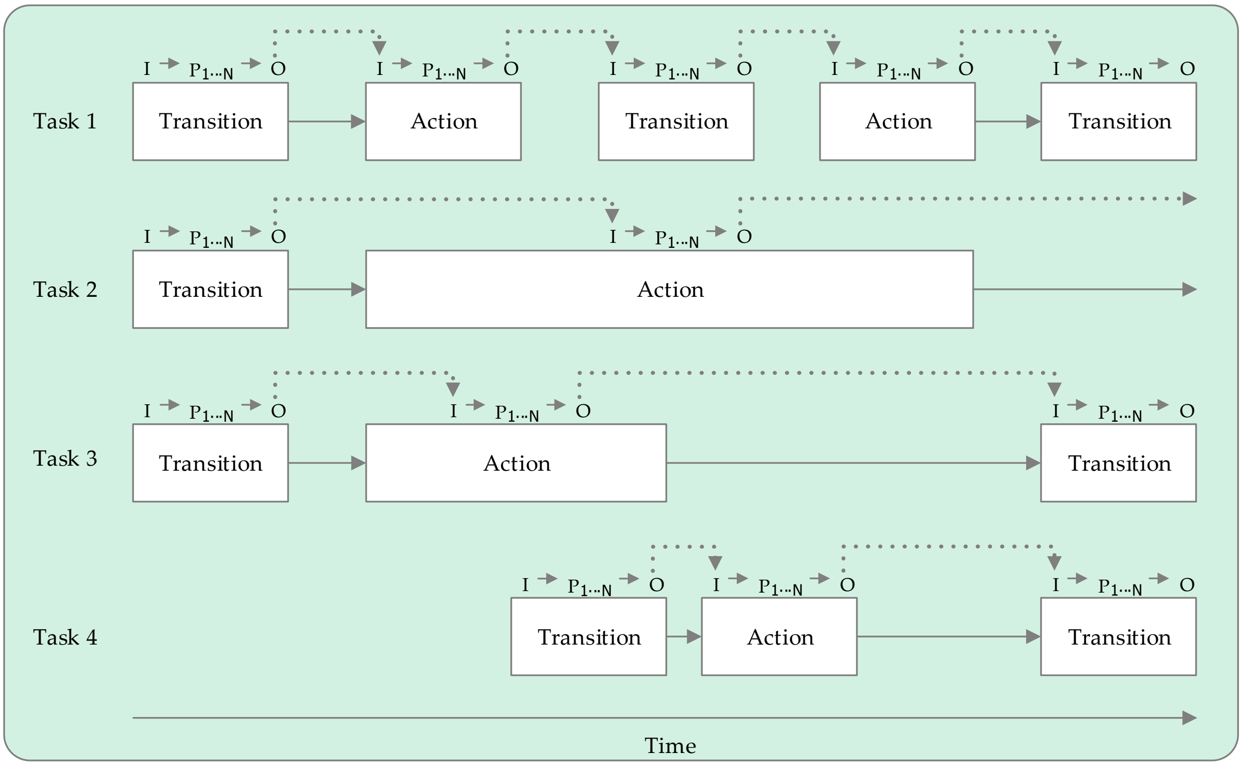

Figure 2.10 The rhythm of team task accomplishment – Adapted from Marks et al. (2001)

Projects can be organised differently to execute the three phases of task accomplishment proposed by Marks et al. (2001). Where the interpersonal processes are present throughout every part of the project, the transition and action phase always alternate (Figure 2.10). In this model of team tasks accomplishment, Task 1 illustrates a process with a fast cycle rhythm with cyclical transition and action phases whereas Task 2 shows almost no evaluation of project progress at all. Tasks 3 represents a project that is somewhere in between and Task 4 is comparable to the first task, but with a delayed onset. Especially Task 1 and Task 2 are of importance for this research to show the difference between APM and TPM. In Scrum, the short sprint periods correspond perfectly with the description of Task 1, whereas TPM can be better established in the Task 2 or 3 categories with less evaluation moments.

2.5 EVALUATION LITERATURE REVIEW

In this section of the literature review, the findings of the literature review are summarised and discussed. As the literature review consists of several separate topics, a discussion on how they relate to one another is required. In the following paragraphs, the found knowledge gaps are debated as well as how the present literature can contribute to this research.

The comparison between APM and TPM showed that there are significant differences between the two approaches. This also means that the shift from TPM towards APM will require a considerable culture change within conventional engineering companies. This required culture change does not mean that the application of APM is unattainable. However, before such a shift can be made, adaptations should be made to the agile philosophy as some aspects of Scrum do not show any potential for the engineering industry and even indicate signals that some aspects may endanger projects. It is for this reason that multiple researchers have suggested a cocktail approach of APM and TPM, which keeps the best of both worlds. Given that both share the same goal and building blocks, it is well conceivable that the combination of an agile approach and a conventional approach could benefit teamwork, and thereby projects, in the engineering industry. How these building blocks have to be scrambled to form a functioning project management tool are discussed in the following chapters of this research. Important to take into account is that a more adaptable project-based process is hard to realise with solely a TPM approach, as the principles of Prince2 state that projects should be managed in stages. For achieving a more adaptable project-based process the agile philosophy shows that iterations are more effective.

A remarkable finding of this literature review is that there is a reasonable amount of literature available on both APM and teamwork, however, the combination between these two themes is not discussed to a significant extent. Many papers on agile shortly touch the subject of teamwork, but in-depth researches of the impact of APM on teamwork are limited. This reinforces the earlier made problem statement that research into the effects of APM on teamwork in the engineering industry is required. Especially as the people-centric control aspect of agile implies that the form of collaboration will change and this needs to be investigated thoroughly.

The lack of literature on team performance measurement in agile teams also requires adaptations to the existing teamwork measurement models. Mainly, because at this point, the teamwork elements are not adequately detailed to quantitatively measure teamwork performance. For a qualitative analysis they suffice, however, for a quantitative analysis, the fundamentals of these teamwork elements have to be studied.

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3 RESEARCH METHODOLOGY

This chapter describes the phases that the remainder of the research entails. To derive an answer to the main research question, firstly, the methodology of acquiring research findings for this research is elaborated in section 3.1. Secondly, section 3.2 describes the different methods of validation of all research findings.

3.1 COLLECTION OF RESEARCH DATA

The methodology of acquiring the research findings can be broken down into four steps:

1. The APM and TPM methodology have been used to create the cocktail project management method for the engineering industry.
2. Parallel to the development of this new approach, teamwork quality elements have been studied and adapted to form the basis of the framework that will measure teamwork quality in the agile teams.
3. While constructing the elements that are relevant to measure the teamwork quality, the compatibility of this measurement framework with the project management approach is ensured. The aim of this step is to guarantee a measurement framework that is compatible with both a TPM team, an APM team and a team with mixed methods.
4. Lastly, all steps will be combined in a framework that measures the effects of APM on the functioning of teams.

These steps together will lead to a measurement framework of teamwork quality on the proposed cocktail project management approach. These steps are displayed in Figure 3.1, in which the numbers represent the abovementioned steps. Thereafter, a more elaborate explanation on the steps individually has been given.

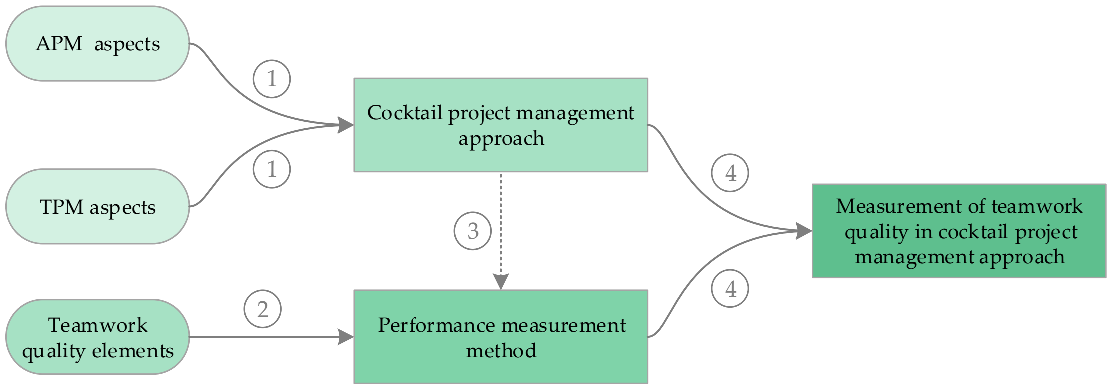

Figure 3.1 Methodology of acquiring the research findings (Own illustration)

Cocktail approach

To create the so-called cocktail approach of APM and TPM for the engineering industry, it is important to choose one project management method on which the cocktail approach is founded. This is important to direct the philosophy of the cocktail approach, which can either be mainly agile or mainly traditional. For this research, the decision has been made to base the cocktail approach on the philosophy of APM, as it is important to observe how teams react on this new philosophy rather than on a few changes to common practice. The further reasoning behind this decision is explicated in section 4.1.

The literature review presented some key issues concerning the implementation of APM in the engineering industry. To derive which aspects of APM can be used for the new project management approach, these findings from the literature review have been combined with the results of discussions with team members of a software development team at Allseas, to form guidelines for project teams. These guidelines are discussed in section 4.1.

Measurement framework

The guidelines have to be validated to determine whether teamwork has improved. In section 4.2, a measurement framework is constructed which validates the findings on Scrum guidelines by means of a quantitative analysis. To construct a framework to which the guidelines could be tested, the three teamwork models of Dickinson & McIntyre (1997), Hoegl & Gemuenden (2001) and Salas, Sims & Burke (2005) have been combined to be applicable on both agile teams and traditional teams. Moreover, to get a better understanding of the different team processes within projects, the literature from Marks et al. (2001) has been added to the measurement framework. Approaching the comparison of APM and TPM from this perspective shows how different teamwork elements are manifested during the project phases.

Pilot project

To determine the effectiveness of the newly developed guidelines, the actual implementation of the guidelines in a project is the most optimal scenario. Mainly because the literature review has shown that the effect of implementing APM aspects in the engineering industry on teamwork has not been measured before. Therefore, a pilot project at Allseas has been commenced to test the effect of the cocktail approach on an engineering team. Section 4.3 introduces the setting of this pilot project and discusses the hypothesised outcome of implementing APM aspects in an engineering team process.

The pilot project has been intensively monitored throughout a period of two-and-a-half months and the observations of the project are considered to be of a validating nature. These observations are used to determine whether the proposed methodology improves teamwork and therefore exemplify the course of the pilot project.

3.2 VALIDATION OF RESEARCH FINDINGS

To determine whether the proposed guidelines on the Scrum methodology benefit the teamwork within an engineering team, the research findings have to be analysed. The analysis of the pilot project has been performed via continuous observation and a survey amongst the pilot project team and the department of Innovations at Allseas. The purpose of the survey was twofold:

1. To validate the teamwork aspects of the conceptual framework.
2. To quantify the quality of teamwork within different teams to support the observations. Different methods of validation have been applied, primarily because the method of observation on itself could still be influenced and subjective.

An extra step was necessary to validate the observations as the sample size of the pilot project team members was not large enough for the statistical analysis to generate a valid conclusion.

3. Therefore, four validation interviews with members of the pilot project team have been executed in order for the observations to be validated.

These analyses have been performed in chapter 5.

4. Thereafter, the results of the conceptual framework and the observations form the basis of the conclusions and recommendations in the next chapter.

Figure 3.2 displays the abovementioned steps, in which the number represent the steps.

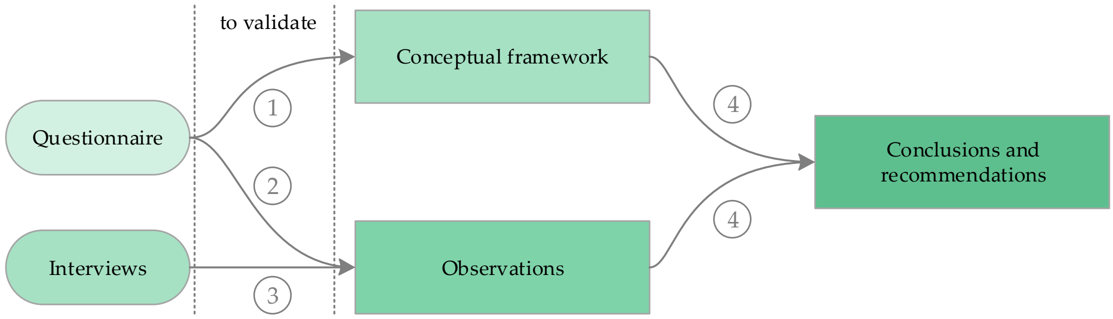

Figure 3.2 Methodology of data analysis (Own illustration)

Structured questionnaire

The validation of the conceptual framework is performed via a structured questionnaire on the nine teamwork elements. To validate the framework, a confirmatory factor analysis (CFA) is executed on the data of the questionnaire. Suhr (2006) states that the "CFA allows the researcher to test the hypothesis that a relationship between the observed variables and their underlying latent construct(s) exists." Therefore, the CFA determines whether the aspects of the conceptual framework actually belong to the teamwork elements. The following approach to perform a CFA has been suggested by Suhr (2006):

1. Review the relevant theory and research literature to support model specification.
2. Specify a model.
3. Determine model identification.
4. Collect data.
5. Conduct preliminary descriptive statistical analysis.
6. Estimate parameters in the model.
7. Assess model fit.
8. Present and interpret the results.

In the execution of the CFA, these steps have been followed. Step 1 refers to the literature review. Step 2 and step 3 are executed by the construction of the conceptual framework. Step 4 has been achieved through means of the questionnaire. Step 5 through 8 have been performed through the use of SPSS, a software package of IBM to perform statistical analyses.

To collect the data, 68 statements were given to all respondents which could be rated on a scale of (1) Completely disagree to (5) Completely agree. These 68 statements are derived from the different teamwork aspects and measure the different aspects. To compose a large sample size to ensure validity, 74 employees have been asked to fill in the questionnaire. These employees have been selected based on the character of the projects that they work on. The selected projects have the same characteristics as the pilot project, which makes a comparison more reliable.

The statements in the questionnaire focus on the opinion of the interviewee as well as the observations of the interviewee. Some aspects revolve around how the interviewee feels and some aspects fixate on how the team interacts with each other. Examples of this are distinct in questions such as ‘team members enjoy working together’ and ‘most communication is face-to-face’, where the first question is opinion-based and the second is an observation.

Besides validating the conceptual framework, the second objective of the questionnaire is to determine whether the teamwork quality has changed in the pilot project team since the implementation of Scrum. Therefore, all nine members of the pilot project team have filled in the questionnaire twice, once on the situation before Scrum has been implemented and once on how they rate teamwork quality since the implementation of Scrum. This has been performed seven weeks into the project because literature states that the implementation of Scrum can be troublesome as it requires a large effort from the project team in the first stages. Both questionnaires have been conducted at the same time to guarantee that the measured difference between traditional and Scrum in the pilot project team is not influenced by time. By surveying simultaneously, the results show the difference in teamwork quality before and after.

By means of a Multi-Criteria analysis (MCA), the differences between the three different target groups have been analysed. These groups are:

1. The pilot project team before the implementation of Scrum.
2. The pilot project team after the implementation of the new project management method.
3. The group of employees at the same department.

In the MCA, the results of the questionnaire have been translated into a linear scale between -0.5 and +0.5. The grades were adapted so a comparison between the different target groups could be possible. The results of the MCA give a direction to the interviews as it identifies possible changes within the team performance.

Observations

The guidelines that have been proposed on the cocktail approach have to be tested. Therefore, they have been implemented in the pilot project. Throughout the implementation of Scrum, the pilot project team has been monitored daily to observe the teamwork quality changes and effectiveness of the guidelines. The conclusions of these observations are noted in section 5.2. The purpose of these observations is to determine the applicability of the Scrum guidelines and note whether changes are required. As one of the characteristics of Scrum is that the exact application has to develop within project teams, the observations have been categorised in terms of sprints. The less functioning aspects of the proposed guidelines have been noted and if possible, have been adapted during the Sprint its Retrospective sessions.

Interviews

As the observations are purely qualitative, it delivers an analysis of a qualitative nature which can be vulnerable to subjectivity and bias. Therefore, four interviews have been conducted with members of the pilot project team to validate the observations. The interview structure is set up to cover each of the nine teamwork elements and link them to the observations. Furthermore, all debatable findings have been presented to the four interviewees in order to reflect their opinions on all changes that the project team has undergone. The four interviewees are selected based on their function within the project team and their different opinions on the transitions that the team has made since the implementation on APM. The overall opinion of the interviewees on APM was evident before the interviews took place as the project team had already been observed.

The MCA suggested a number of differences between the pilot project team without Scrum and the pilot project team when applying Scrum. However, the number of respondents of target group 1 and 2 of the MCA are limited as the pilot project team only consist of nine team members. As this analysis was not statistically valid, the quantitative data analysis has been used as reference to steer the direction of the interview.

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4 RESEARCH FINDINGS

In this chapter, the literature review has been translated into guidelines on how project team performance within the engineering industry is expected to be improved by using the agile philosophy. To validate these propositions, a conceptual framework on teamwork performance has been constructed. To start with, the guidelines on a hybrid project management method are presented in section 4.1. These will be tested against the conceptual framework on teamwork quality, which is introduced in section 4.2. In section 4.3, the pilot project at which the guidelines have been implemented is elaborated upon. To conclude this chapter, in section 4.4 all research findings have been discussed.

4.1 SCRUM GUIDELINES FOR THE ENGINEERING INDUSTRY

The literature review showed that one project management methodology had to be taken as a foundation. With the focus of this research being on APM, APM is taken as the foundation for the project management method. This decision finds its origin in the research objective to contribute to the literature on APM, not TPM. When implementing Scrum, literature shows that it is most beneficial to entirely or almost entirely apply Scrum and solely applying a limited amount of aspects is counterproductive (Section 2.1.2). Therefore, APM and Scrum have been analysed on which aspects are applicable in the engineering industry and which aspects have to be deleted, adapted or replaced. If many aspects have to be deleted, the method becomes a simplified version of Scrum. Therefore, the principles of APM and aspects of Scrum that did not work in the engineering industry are mostly adapted. This will be performed both on high level; the APM philosophy, and on low level; the application of Scrum.

In literature, the cocktail approach represents a mixture of APM and TPM. However, the suggested approach in this thesis is primarily agile and it is debatable whether it can be considered as a cocktail approach. Yet, the adaptations to the APM philosophy and the application of Scrum direct certain agile aspects towards conventional project management practices. Moreover, the Scrum aspects that have been removed to adequately implement Scrum, leave a gap that will automatically be filled in by conventional approaches as project teams have the tendency to fall back into old habits where possible (Chakravorty, 2010). This theory also implies that the complete process improvements could go to waste. However, to prevent process improvements from dissipating, the proposed guidelines will concentrate on the agile aspects of the new cocktail approach that should most definitely remain. To illustrate this methodology of developing the cocktail approach, a martini is taken as example in which the vermouth and ice cubes represent TPM and the gin symbolises APM. The conventional mind-set that the engineers are used to is already present in the form of ice cubes, onto which a large amount of gin is poured. To conclude, a small part of the gin is replaced by vermouth after which the martini is shaken to form the cocktail approach.

To implement the cocktail approach, strict guidelines have been constructed for project teams to follow. These guidelines have been added as a separate chapter in Appendix A, in order for them to be utilised in engineering teams as a manual, independent from this thesis. In this section, the decisions that were made to draft the guidelines are further explained.

As discussed, the guidelines are based on the agile philosophy, upholding most of the values and principles of the original APM methodology. The next step is to determine how these values and principles can be put into practice. In the literature review, it became apparent that Scrum would be the best agile tool to implement the agile philosophy in an engineering team (Section 2.1.5). However, as aspects of the agile philosophy have to be adapted, so do aspects of Scrum in order to be compatible with engineering project teams. In the next paragraphs, the adaptations to the agile values and principles have been explicated (Section 4.1.1), after which the actual deliverable of this report, adaptations to the Scrum methodology, are introduced (Section 0).

4.1.1 Adaptations APM philosophy

By means of the literature review and discussions with an agile software development team at Allseas, the following adaptations are suggested to the agile philosophy, categorised per value. Thereafter, in Table 4.1, the twelve agile principles have been analysed and rated on their applicability.

Individuals and interactions over processes and tools

The interaction of agile will remain a central focus point. Enhancing the interaction of engineers with one another has the most potential to be improved by the introduction of the APM philosophy. As a result, this should show itself by team members starting to value individuals instead of the processes or tools. It is therefore important that the implementation of Scrum in a project team should be seen as a tool that is purely meant to generate more interaction between individuals and not as fully imposed project management tool. Researchers, Product owners and Scrum masters should therefore be receptive to suggestions on improving the used method of Scrum.

Working software over comprehensive documentation

For software developers who apply APM, not much documentation is used to deliver a software product. Mainly this documentation is of relatively low importance to the client and development decisions are often made in cooperation with the client. However, within the engineering industry, if a project team delivers a faulty construction, the origin of flawed design decisions has to be retraced for insurance purposes and for the development of replacing products. Documentation is therefore essential in the delivery of an engineering project although a shift from complete focus on comprehensive documentation can be made towards working software. Where working software can be read as finished detailed reports on components, high level construction decisions or design drawings as presenting working software has to be interpreted differently in the engineering industry.

Customer collaboration over contract negotiation

In the engineering industry, this value can create large benefits for both the customer and the engineers. Close collaboration can adjust expectations of both parties, it increases the flow of information and it limits the chance of misinterpretations already in the early stages of an engineering project. However, the agile philosophy implies that the customer is also actively present during the development phases of a project, which will demand a great effort from the customer. The benefits of applying this value are therefore noted and implementation is desirable, however, it remains to be seen whether a customer in the engineering industry is willing to support a project team by means of weekly collaboration.

Responding to change over following a plan

The ability to respond to changes is not yet a strong characteristic within the engineering industry. Partially due to the attitude of engineers who are not always as willing to accept that hard work has been for nothing, but mainly due to the fact that whenever the design stage reaches a certain level of completeness, items have to be ordered to have the items fabricated and delivered in time. This has as a result that the implementation of this value will be difficult. Therefore, it will be upheld during the primary stages of engineering, but the expectation is that at a certain moment a more detailed plan than usual in APM has to be drawn up in order to have products ready for fabrication and testing phases.

Agile principles

To construct Table 4.1, the agile principles have been analysed on their applicability in an engineering project team and re-defined for the engineering industry. Re-defined principles are of high importance when adjusting the Scrum methodology as the Scrum methodology has to be applied while respecting the agile principles. Relatively little has been changed, however, the interpretation and implementation differ from APM in software development. This is caused by translation issues from the software development industry to the engineering industry. The purpose of the principles in the software development industry are clear. However, as this industry functions differently than the engineering industry, a number of principles lose their logic and value if explained with the same intention in the engineering industry. It is for this reason that the principles can be interpreted in different ways in engineering industry. To create a set of principles that leave no options for multi-interpretability, the principles are adapted and provided with comments on how they should be interpreted.

Table 4.1 Adaptations to agile principles (Own table)[5]

Adapted agile principles	Comments on interpretation of agile principles
1. **A high** priority is to satisfy the customer through early and continuous delivery of valuable **deliverables**.	This principle can only be a priority if the customer is receptive of a high level of collaboration during the design phase which will also require a high effort of the client. This principle will have to develop in the engineering industry.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.	In the first stages of development, this principle can be implemented safely. To be able to accept changes also requires the team to accept that mistakes were made, this change in mind-set could be difficult. During the later stages, the team must be very aware of the effect of welcoming changes.

[5] The highlighted texts are the parts of the original agile principles that have been adapted.

3. Deliver **deliverables** frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.	The essence of this principle remains effective as intended.
4. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.	The essence of this principle remains effective as intended.
5. Businesspeople and developers/**engineers** must work together **frequently** throughout the project.	It is of high importance that the businesspeople realise the value of the work of the engineers. If this is achieved, businesspeople will also have a higher incentive to invest time in supporting the engineers.
6. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.	Trust is an essential aspect in this principle. Engineers have to agree that mistakes will be made in order to create the environment of this principle.
7. **Finished drawings, completed reports and substantiated design decisions are** the primary measure of progress.	During the FED, to create the dolphin-like reporting of Figure 2.4, it is important to frequently deliver. Working parts of the system in early development stages will not be possible, but deliverables such as aforementioned proof-of-concepts and models can be delivered.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.	The constant pace can be achieved by creating a plan for short periods of time only. For short phases it is easier to estimate what can be delivered and therefore a more constant pace can be maintained.
9. Continuous attention to technical excellence and good design enhances agility.	This principle focusses on fixing mistakes right away as this will save time in the long run. When mistakes are found in designs, they should be picked up straight away.
10. Simplicity—the art of maximizing the amount of work not done—is essential.	This principle can be closely linked to Lean project management. It aims at making solutions less complex, however, it may block an innovative thinking process as the focus will always be on the simplest solution. Therefore, this principle will be upheld, yet if it seems to block innovative creations, it can be disregarded.
11. The best architectures, requirements, and designs emerge from self-organizing teams **with a low level of involvement from higher management**.	This principle is focussed on spreading responsibility for the project among the project team away from the project manager. With a TPM approach, one large design would be developed at the beginning of the project, having all requirements already defined before this design process begins. Applying an agile approach should lead to less complex designs and promote an incremental design, which leads to a design more accessible for modifications. However, the expectation is that project management will still remain involved in the allocation of project tasks, thereby reducing the level of self-organisation of the project team.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.	The essence of this principle remains effective as intended.

By relating these proposed adaptations to the principles of Prince2, it becomes clear that a number of principles of Prince2 are present in the adapted agile principles. Besides, some Prince2 principles that are not present, can be implemented as complimentary principles. For all principles it has been explained how they are present in the proposed cocktail approach in Table 4.2.

Table 4.2 Presence of Prince2 principles in the cocktail approach (Own table)

Prince2 principles	Presence in the cocktail approach
1. Continued business justification	This principle is present within adapted agile principle 1 and 5. By involving customer and businesspeople in the project to a higher extend, the team will receive more feedback from the customer and thereby receive continued business justification.
2. Learn from experience	This principle is not present within the adapted agile principles, but it is of high importance that project teams learn from experience. This principle is therefore added to the cocktail approach.
3. Define roles and responsibilities	Within an agile team there are not that many roles and everyone shares the responsibility of the project. However, it is important that the roles that are present, are well-defined and that the team members are aware of the shared responsibility. Therefore, also this principle is part of the cocktail approach.
4. Manage by stages	The to be used approach focusses on iterations and less on stages. This principle is therefore not present within the cocktail approach. However, the traditional stages that are present within the front-end development are clearly separated from the fabrication phases in this research as the scope focusses on the front-end development phase only.
5. Manage by exception	This principle is fully disregarded. Management by exceptions involves that higher management should only be addressed if big issues occur. However, within the new approach, this hurdle to address higher management should not be present and by continuously involving managers, the managers should be aware of day-to-day business as well.
6. Focus on products	This principle is disregarded as the essence of it implies that the product description should be written as soon and as clear as possible. This is in direct conflict with adapted agile principle 2.
7. Tailor to environment	This principle is present in adapted agile principle 12. By reflecting on how to become more effective, the project team tailors the project management method to the environment.

When summarising Table 4.1 and Table 4.2, it shows that the cocktail approach is based on twelve adapted agile principles and four Prince2 principles. The Prince2 principles that taken into account are principle 1, 2, 3 and 7, of which principles 1 and 7 are partially present within the adapted agile principles already. This cocktail approach is illustrated in Figure 4.1.

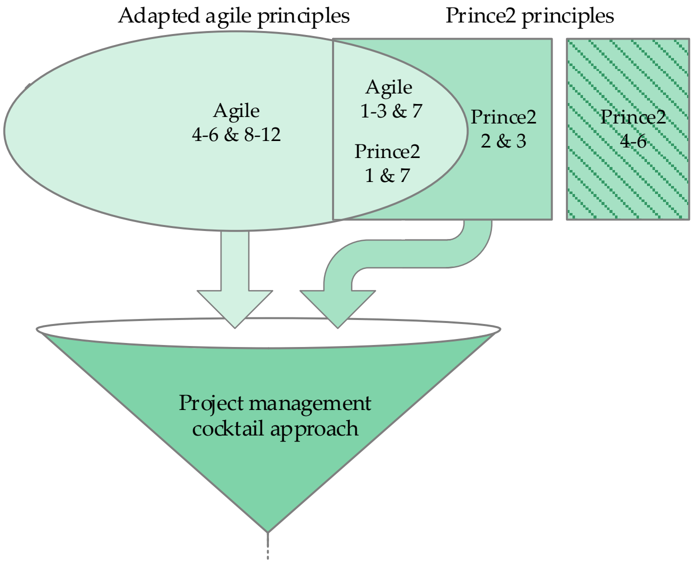

Figure 4.1 The cocktail approach (Own illustration)[6]

4.1.2 Adaptations Scrum methodology

As this research focusses on implementing the agile philosophy with adaptations, the Scrum methodology should be adapted to be fit for purpose likewise. The explanation of the agile philosophy alone is too abstract to implement. Guidelines have therefore been derived, based on the Scrum Guide (Schwaber & Sutherland, 2013) and adapted to be applicable in the engineering industry. The guidelines have been written down and proposed to the pilot project team. Via observation of the pilot project, the proposed guidelines will be validated. This validation has resulted in an adjusted version of the guidelines which have been added as a separate report in Appendix A.

4.2 Measurement framework

To be able to measure the effect of the proposed Scrum guidelines, a measurement framework has been developed. Through the use of this framework, the teamwork quality of a Scrum team can be measured and compared to teams that apply a TPM approach. This framework has been developed in four steps.

1. By analysing teamwork elements (section 4.2.1).
2. By determining the identifying aspects of these elements in order to generate a sub-level that can be easily measured (section 4.2.2).
3. By combining the identified teamwork elements with the theory of rhythm of team task accomplishment of Marks et al. (2001) (section 4.2.3).
4. By analysing which Scrum artefacts influence which teamwork element (section 4.2.3).

[6] In this figure it is illustrated that all adapted agile principles are used in the cocktail approach. Prince2 principles 1-3 & 7 are also implemented. Prince2 principles 1 & 7 have a close relation to adapted agile principles 1-3 & 7 and can therefore also be regarded as agile.

4.2.1 Teamwork elements

In Table 2.3 the teamwork elements of Dickinson & McIntyre (1997), Hoegl & Gemuenden (2001) and Salas, Sims & Burke (2005) have been compared. To construct a measurement framework for this research, nine elements were found essential and form the foundation of the framework (Table 4.3.

Table 4.3 Teamwork elements of conceptual model (Own table)

1. Team leadership	4. Adaptability	7. Back-up behaviour
2. Team orientation	5. Feedback & Learning loop	8. Mutual performance monitoring
3. Cohesion	6. Closed-loop communication	9. Coordination

All elements of the three models are used. Yet, to limit the amount of teamwork elements in the eventual model, the elements effort and balance of member contributions will be added to the definition of team orientation as the descriptions of Dickinson & McIntyre (1997) and Hoegl & Gemuenden (2001) are closely related and share common ground. This has been taken into consideration when developing a strategy to measure team orientation. Also, the elements of cohesion and adaptability were added, as the importance of these elements in teamwork quality were found significant and of added value.

Clustering of teamwork elements

The nine teamwork elements can be organised in clusters to distinct the main topics within teamwork. Clustering is performed to create structure in the conceptual framework. Three different groups can be distinguished: Commitment and trust, flexibility and communication. These three clusters are based on the different characteristics of the teamwork elements. Some of these elements are expected to have high causalities and have therefore been grouped together. The clusters are as follows:

1. Commitment and trust – Team leadership, Team orientation and Cohesion
2. Flexibility – Adaptability and Feedback & Learning loop
3. Communication – Closed-loop communication, Back-up behaviour, Mutual performance monitoring and Coordination.

In the following paragraphs, the three clusters have been explained.

Core of commitment and trust

The foundation of good teamwork starts with commitment to the project goal and trust in team members (Sheng, Tian & Chen, 2010). Especially dedication to a unified goal will raise team spirit and thereby communication and flexibility. Without a common cause to work for, team members will lose motivation to work together, resulting in all other teamwork elements to degenerate as well. Therefore, this cluster is mainly about the attitude that team members display. The elements grouped together in this cluster are team leadership, team orientation and cohesion.

Core of flexibility

The word flexibility can be applied on two different levels; a personal level, more focussed on the team member’s character traits and on a project team level, relating to the changing project requirements that require flexibility of the team. Flexibility revolves around the ability to maintain an open attitude and be receptive towards the ideas of team members (Mickan & Rodger, 2000). The elements grouped together in this cluster are adaptability and the feedback & learning loop.

Core of communication

The communication of project members with one another is essential to a project its success. This theme can be found throughout multiple teamwork elements and can therefore be used to group closed-loop communication, back-up behaviour, mutual performance monitoring and coordination.

4.2.2 Aspects of the teamwork elements

The teamwork elements are relatively abstract. It is therefore difficult to measure the teamwork quality of a project team and underlying aspects need to be determined. Per teamwork element, a set of aspects has been composed based on literature review of the teamwork elements. To derive this set of teamwork aspects, all identifiers of the teamwork elements in literature have been analysed and the set has been completed by a number of aspects that were also found declaratory. The aspects have been included in the measurement framework and are listed per teamwork element and cluster in Table 4.4. As these aspects are a finding of this research, a validation analysis has to be performed before they can be used to measure teamwork quality (section 5.1).

Table 4.4 Clusters, elements and aspects of Teamwork quality (Own table)

Clusters	Elements	Aspects
Commitment & Trust	Cohesion	Happiness
		Responsibility
		Pride
		Perception of teamwork
		Integration
		Protectiveness
		Personal conflicts
		Sympathy
	Team leadership	Characteristics recognition
		Contribution to team goals
		Focussed on team functioning
		Facilitate problem solving
		Steering of team members
	Team orientation	Teamwork priority
		Imbalance in member contribution
		Effort
		Motivation
Flexibility	Adaptability	Stubbornness
		Regular adaptations to project goals
		Reaction on changing conditions
	Feedback & Learning loop	Feedback on work
		Feedback on performance

		Aware of improvement points
		Willingness to improve
Communication	Closed-loop communication	Frequency
		Spontaneous
		Direct
		Indirect
		Openness
		Awareness of activities
		Accurateness
		Usefulness
	Back-up behaviour	Help and support of team members
		Respect for suggestions
		Suggestions stimulate follow-ups
		Conflicts are easily resolved
	Mutual performance monitoring	Aware of team member's activities
		Aware of time management
		Identifying mistakes
	Coordination	Clarity of tasks
		Goals are accepted
		Comprehensiveness of goals
		No conflicting interests regarding goals

4.2.3 Measurement framework

By combining the teamwork models with the three team processes of Marks et al. (2001), an overview forms of how certain teamwork elements are manifested during projects (Figure 4.2). This framework distributes the relevant teamwork elements among the three team processes of transition phase, action phase and the always present interpersonal process. This division shows the importance of certain teamwork elements in different phases of the project and also provides a better understanding of how certain elements will demonstrate themselves in teamwork projects.

In the paragraphs on the different teamwork elements in section 4.2.2, the underlying aspects of the teamwork elements are already discussed. In order to measure the teamwork quality of the project team, these aspects have been added to the framework and made tangible in the survey of this research. The exact impact of these aspects on the teamwork elements cannot be measured in this teamwork, however, based on literature an estimate can be made.

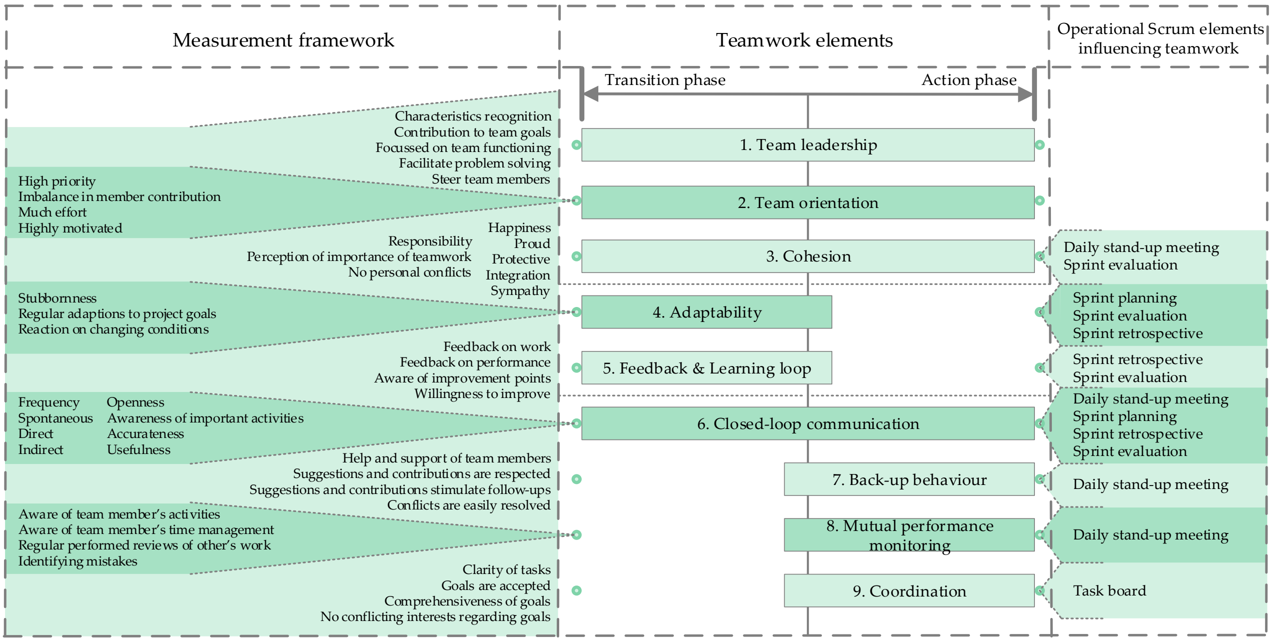

Figure 4.2 Conceptual framework teamwork quality & Scrum (Own illustration) – Appendix B.

By linking the conceptual framework to the rhythm of team task accomplishment of Marks et al. (2001), it shows that APM identifies more transition phases by the means of evaluation and planning sessions and it can therefore be expected that the Feedback & Learning loop are more present in APM than in TPM. Stating this would imply that the teamwork elements at play during the action phases of the agile projects are less practiced as relatively, there is less action phase than compared with TPM projects. However, as the focus of APM during the action phases is still highly focussed on teamwork by means of daily meetings in Scrum, it is expected that these action phase teamwork elements are also improved within APM. The elements of Team leadership, Team orientation and Closed-loop communication are equally present during both transition and action phases of the project and therefore have an overarching character throughout a project.

The aspects of the proposed framework have not been validated on belonging to the teamwork elements. Therefore, before the teamwork quality of the pilot project team can be measured, the framework has to be validated. This validation will be performed in section 5.1, after which the validated framework will be used to compare the Scrum team with an engineering team which applies a TPM approach. The validated framework is presented in Appendix B.

4.3 The pilot project

The implementation of Scrum in engineering projects is challenging. Partially because specific characteristics of Scrum are less compatible with engineering projects, but also partially because engineers are not always as inclined to change their usual habits. This section is written to describe the process of implementing Scrum at the pilot project. Both the characteristics and issues of the project will be discussed, as well as how the intended changes to the Scrum methodology are expected to affect the project team.

By analysing the process of this project and conducting interviews with the project members, conclusions and recommendations can be drawn on the main research question. Even though a pilot project is a single example of how a model could work, Flyvbjerg (2006) states that the case study is a necessary and sufficient method for certain important research tasks in the social sciences, and it is a method that holds up well when compared to other methods in the gamut of social science research methodology. Stake (1995) stated what a researcher has to focus on to make sure the pilot project is structured properly in order to obtain useful information from the project. With the theories of Flyvbjerg (2006) and Stake (1995) in mind, the data analysis phase of the pilot project has been performed.

Start of project

A pilot project within Allseas has commenced which applies the proposed agile methodology. Through means of workshops the team has been made familiar with the working of APM. During the project, which is expected to cover three months, the actions and progress have been closely supervised. The design and project goal of the pilot project are discussed in Appendix C of this report. During the project, the team members were asked to fill in a questionnaire to measure the team satisfaction and other aspects important for team performance. For this questionnaire, the expectation was that the response will be more positive on the new project management method than it will be for the old situation. However, the questionnaire was distributed a couple of weeks into the project as this returns the most valuable results. This is hypothesised as project management changes always take time to be fully accepted by employees (Project Management Institute, 2013). Moreover, to avoid that frustration during the introduction phase influences the data, the survey has been distributed later. During the pilot project, many feedback rounds were organised with the team members of the pilot project team to discuss the impact of Scrum on the project team. These feedback rounds are part of the Scrum methodology, but also extremely valuable for this research.

Also tasked at identifying possible impediments of Scrum was a workshop for the pilot project team. This workshop entertained two objectives. First, to start the pilot project, the project team needed to be trained in agile practices before commencing the actual project. Second, presenting the agile values and proposed methods would provoke a discussion on what their initial thoughts of the method were. These thoughts could then be taken into account when implementing final changes to Scrum.

4.3.1 Characteristics of the pilot project

The request to design the flooding prevention system (FPS) originally came from the insurance company of the client. Namely, if a system could prevent the pipe from flooding when a buckle occurred, the pipe lay process could be insured for a lower price. To design such a system would save the Allseas a significant amount of money and therefore the pressure to succeed from within the company was higher than it was from the actual client. For a more detailed explanation of the working of the FPS, see Appendix C. A requirement of Scrum is to have the client present at review meetings, however, who the actual client was in this project was thereby unclear as most requirements were drawn up by the management of Allseas itself. Therefore, management has also been involved to a higher extend in the project as before. Due to the fact that higher management has taken up the position of client, contract negotiation became irrelevant.

The first attempt of the project was driven by an illogical amount of time pressure. This led to a number of mistakes during the engineering of the first flooding prevention system. However, the belief among the team members is that some of these mistakes could have been prevented. They mainly accredited these preventable mistakes to a lack of communication as multiple mistakes were caused by basic miscommunication. When the system failed during its first pipe lay runs, the first thought was to quickly fix the broken elements of the system in a month. However, when during the first week an analysis was made of the damage to the system, it became clear that not only one component had failed but the complete system was flawed. For this reason, the initial deadline of one month immediately had to be postponed to 5 months as it became clear that there were structural issues with the original design. This is not according to agile principles as with agile methodology the aspect of time should be fixed. However, due to extreme unforeseen circumstances and a complete change of project scope, the project was restarted a week later with new requirements and a new deadline, with a complete realisation of proposed agile principles.

In the setup of the project design, a decision had to be made which Scrum tools to use. One software development team of Allseas already applies a Microsoft tool, named the Team Foundation Server (TFS), and therefore knowledge and licencing of the program were already available for the pilot project team within Allseas. Therefore, the TFS is the Scrum tool in which the product backlog has been programmed.

As Scrum recognises three different roles, these roles have been divided over the project team. The original lead engineer of the project will take up the role of Product Owner, which is the most logical role to be taken up by the lead engineer. The Scrum Master, however, needs a high level of understanding of the agile principles and application of Scrum. Finding or educating a suitable Scrum Master within an organisation were no one is familiar with Scrum, is challenging. A first Scrum project also requires significantly more work from a Scrum Master than sequential projects, as the complete project team is unaware of the exact application of Scrum, more guidance is needed. The amount of time that is required to set up a new Scrum team with an internal Scrum Master is high. This involves educating a team member in the functioning of a Scrum Master, the adaptation of the TFS and the education of the rest of the project team in the application of Scrum. This amount of time was not available as the project had to be initiated. Therefore, the decision was made to have this role filled in by the writer of this thesis as the required knowledge of the tasks of a Scrum Master were then present within the team. Also, the new Scrum Master would not have any project related tasks and had time to adapt the TFS. Now being present at every daily meeting and all other sprint meetings, all conflicts and issues with the project management methodology could be observed closely by the writer of this thesis.

The pilot project team consists of nine team members with varying backgrounds. Most distinguishable are the different disciplines the team members work in; mechanical, structural, electrical and software engineering. Figure 4.3 presents the experience of the project members. This shows that the team is relatively young and has limited experience. The organisation of Allseas has a structure in which each project team has a lead engineer, a project coordinator and research & development (R&D) engineers. These teams are managed by a unit head who has several project teams under his supervision. In the remainder of the report, if referred to management, the lead engineer and unit head are implied. More information on the organisation of Allseas is added in Appendix C.

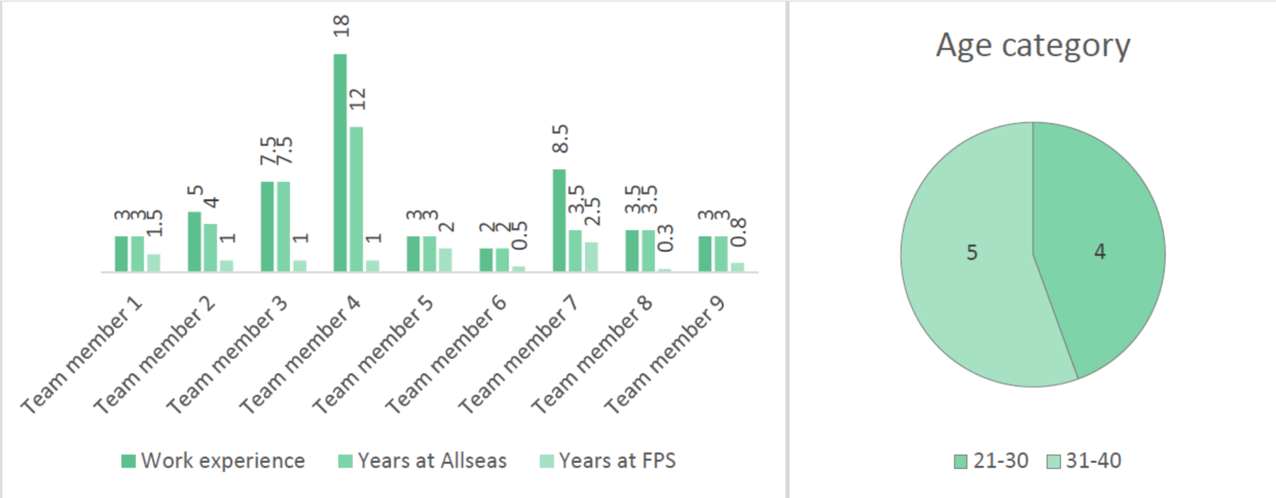

Figure 4.3 Experience and age of team members (Own illustration)

4.3.2 Uniqueness

Preferably, the results of this thesis should be generalisable and compliant with the situation outside of Allseas. Therefore, the characteristics of this pilot project are summarised in order to define the projects for which this new project management method can be applied.

- Innovative
- Complicated
- High time pressure
- Relatively short engineering phases
- Multiple disciplines (in this case mechanical, electrical, structural, software).
- In-house use of end product

4.4 DISCUSSION RESEARCH FINDINGS

The research findings have produced three distinctive deliverables:

1. The Scrum guidelines, based on the cocktail project management approach
2. The conceptual framework on teamwork quality
3. A set-up for the pilot project in which the Scrum guidelines have been implemented

The first two deliverables are validated in chapter 5, where the pilot project functions as a qualitative method of validation on the Scrum guidelines.

As discussed, the guidelines form a cocktail model which mostly upholds the agile philosophy. In literature, it is stated that the agile philosophy cannot be fully implemented in the engineering industry. This was found to be true as one principle cannot be interpreted without causing conflict with aspects of the engineering industry. An agile team should be self-organising, while often in complicated projects, lead engineers should take charge to direct team members in the tasks that should be performed. However, the remaining eleven principles require little to no adaptation. This is different than literature suggests and it can be attributed to the fact that all principles were multi-interpretable because of their translation from the software development industry to the engineering industry. When the way to interpret the principles is fixed, application in the engineering industry causes less disputes. Furthermore, the addition of four Prince2 principles to the adapted project management approach does not cause conflict with the agile aspects, primarily, because these four principles can be considered partially agile already.

Contrarily, the adaptation of the Scrum guidelines does require more adjustments before it is applicable for the engineering industry. This is mainly because Scrum dictates the project process on a lower level and with significantly more detail. However, the details in the Scrum guidelines make it less complicated to exactly determine whether the guidelines are upheld.

As the agile philosophy is abstract to a higher extent, extra awareness has to be paid in determining the presence of the proposed interpretation of the agile philosophy during the pilot project. In case this was found to be inadequate, additional questions would have been drafted up for the validation interviews.

Another topic which requires extra attention during the validation interviews, is the role of the researcher within the pilot project. Due to the active role of the researcher in the pilot project it is important to analyse the effect this might have had on the results of the research.

5 DATA ANALYSIS

In this chapter, the research findings are validated by multiple analysis methods. In section 5.1.1, the conceptual framework is validated, after which the obtained quantitative data are analysed in section 5.1.2. During the pilot project, the project team has been monitored, these observations are summarised in section 5.2 and validated in section 5.3, by means of interviews. To conclude this chapter, in section 5.4 the results of the data analysis have been discussed.

5.1 RESULTS OF STRUCTURED QUESTIONNAIRE

The structure of the questionnaire can be found in Appendix D.1. It is divided into three categories; a cluster of statements concerning commitment and trust, a cluster of statements on flexibility and a cluster on communication.

The selection of participants for the structured questionnaire has been performed based on the characteristics of the pilot project. Of the 74 invited participants who work on similar projects, 48 have completed the questionnaire. The work experience of this target group in general and at Allseas has been presented in Figure 5.1. These figures show the relative young work force of the Innovations department at Allseas, which is coherent with the age of the pilot project team.

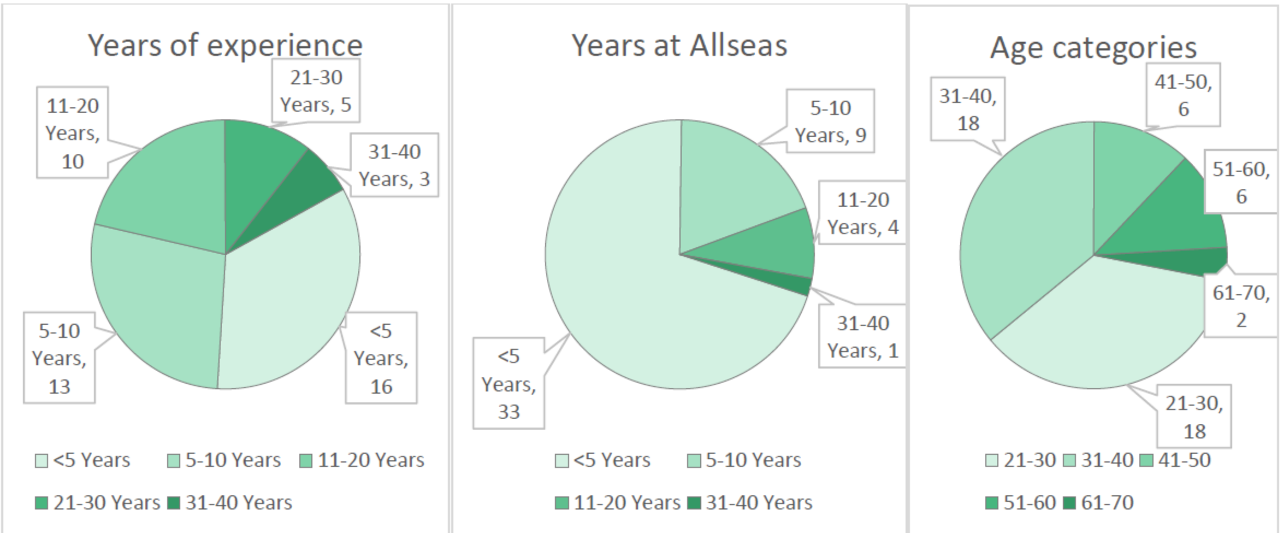

Figure 5.1 Work experience target group (Own illustration)

The substantive statistics of the questionnaire itself have been summarised in Appendix D.2. These statistics show that on average the respondents graded teamwork quality with a 3.7 out of 5, which indicates a positive attitude towards team performance. Initial observation thereby shows that the employees give the impression to be relatively content with their teamwork quality.

5.1.1 Validation of conceptual framework

To validate the measurement framework, on each teamwork element an individual CFA has been performed. Thereafter, the aspects that were not found to be contributing to their element have been switched or deleted and the CFA was repeated with the new set of teamwork elements. The exact functioning of the CFA, together with elaborative figures and execution, have been added in Appendix E.

The first CFA resulted in a number of changes to the conceptual framework. Most of the changes derived from the results of the Kaiser-Meyer-Olkin (KMO) Test and the Bartlett's Test of Sphericity. These tests, which are performed as part of the CFA, indicated that several aspects did not belong to the elements they were assigned to. The results of the initial KMO and Bartlett's Test are presented in Table 5.1 and thereafter explicated.

Table 5.1 Initial results confirmatory factor analysis on Kaiser-Meyer-Olkin and Bartlett's Test[7]

		Cohesion	Team leadership	Team orientation	Adaptability	Feedback & Learning loop
KMO[8]		.751	.620	.567	.629	.541
Bartlett's Test[9]	Approx. Chi Square	186.567	54.064	99.501	50.345	9.744
	Df	55	21	28	15	6
	Sig.	.000	.000	.000	.000	.136
		Closed-loop communication	**Back-up behaviour**	**Mutual performance monitoring**		**Coordination**
KMO		.652	.670	.704		.685
Bartlett's Test	Approx. Chi Square	240.609	114.876	55.033		53.593
	Df	91	36	6		10
	Sig.	.000	.000	.000		.000

The tests performed in the first CFA have shown that the aspects currently belonging to the teamwork elements of Team orientation and Feedback & Learning loop are not the set of aspects actually belonging to these elements. Therefore, these aspects have been analysed and deleted or allocated under different teamwork elements. This change can be made as the connection between several teamwork elements is significant and can both be demonstrated by qualitative explanations and quantitative data. This resulted in several aspects that explain more of the variance of other closely related teamwork elements as they did to the original teamwork element. An example of this is the relation between Teamwork orientation and Cohesion. Both teamwork elements concern the attitude of team members towards or their work or one another. It is not illogical that their attitude towards one, also covenants with the other. The aspects of Teamwork priority and Motivation have

[7] Measures that did not exceed the thresholds of the KMO and Bartlett's tests are marked yellow.

[8] The KMO test measures the suitability of the data for a confirmatory factor analysis. Values below .6 indicate that the sampling is not adequate and that remedial action should be taken.

[9] Bartlett's test of sphericity tests the hypothesis that your correlation matrix is an identity matrix, which would indicate that your variables are unrelated and therefore unsuitable for structure detection. Small values (less than 0.05) of the significance level indicate that a factor analysis may be useful with your data (IBM, n.d.).

been switched from the element of Team orientation towards Cohesion as the CFA validated this and it can be argued qualitatively.

Next to the minor changes, one major change to the model was directed by the CFA. The element of Feedback & Learning loop proved to exist of two different elements, receiving feedback and the response on this feedback, the learning loop. These two elements showed an insignificant low correlation and the decision was made not to split the two elements, but to dissolve the aspects of both among other elements. The aspects of Adaptability showed a high correlation with the aspects of the Learning loop and the aspects of Feedback showed a high correlation with the aspects of Back-up behaviour. The second correlation can be explained by the cluster Communication, as always providing feedback can be regarded a form of communication. The result of this deletion of the element of Feedback & Learning loop is that the descriptions of the elements of Adaptability and Back-up behaviour have to be extended by respectively the description of Feedback and the essence of Learning.

The remaining changes to the model are explained in Appendix E.1. With the new set of teamwork elements and aspects, a new CFA was performed. The results are presented in Table 5.2. With this shuffled set of teamwork quality aspects and elements, the connections between aspects and elements were validated as the KMO test returned values above .6 and for all elements, the null hypothesis of invalid factor loadings was rejected according to Bartlett's test.

Table 5.2 Final results confirmatory factor analysis on Kaiser-Meyer-Olkin and Bartlett's Test

		Cohesion	Team leadership	Team orientation	Adaptability
KMO		.804	.666	.653	.659
Bartlett's Test	Approx. Chi Square	310.026	46.601	40.116	61.267
	Df	66	15	15	21
	Sig.	.000	.000	.000	.000
		Closed-loop communication	**Back-up behaviour**	**Mutual performance monitoring**	**Coordination**
KMO		.652	.684	.704	.685
Bartlett's Test	Approx. Chi Square	240.609	167.018	55.033	53.593
	Df	91	55	6	10
	Sig.	.000	.000	.000	.000

This validation has resulted in the conceptual model being adjusted from nine teamwork elements to eight elements. These eight elements are listed below in Table 5.3 and the validated teamwork model can be found in Appendix B. The cluster of Flexibility has been adapted as the elements and aspect referring to the feedback have been exchanged from this cluster to the cluster of Communication. The cluster of Flexibility has therefore been adapted as the cluster of Adaptability.

Table 5.3 Validated teamwork elements & corresponding clusters

Commitment & Trust	Adaptability	Communication
1. Team leadership	4. Adaptability	5. Closed-loop communication
2. Team orientation		6. Back-up behaviour
3. Cohesion		7. Mutual performance monitoring
		8. Coordination

5.1.2 Quantitative analysis of pilot project

The questionnaire also resulted in a different set of data. The data shows how the teamwork within the pilot project team has been assessed prior to the project and after the implementation of the Scrum guidelines. This data has been used to indicate which areas of teamwork probably have improved the most. As the pilot project team only consisted of nine members, the results of this questionnaire are not scientifically valid as the sample size is too small.

However, the data has been analysed by the means of an MCA as the results can provide direction for the validation interviews. Therefore, the differences per teamwork element of all three target groups has been assessed. The three groups are:

- Pilot project team after implementation of Scrum
- Pilot project team before implementation of Scrum
- Department of Innovations

Analysis of this data suggests that the teamwork quality of the pilot project team has increased significantly due to the implementation of a new project management method, with 8.4% in total. It is also interesting to note that the department of Innovations, which has been used as a reference group, had teamwork quality rated 3.4% lower. These results are displayed in Table 5.4. The complete MCA has been added to Appendix F.

Table 5.4 Differences per teamwork element compared to Scrum team (Own table)[10]

	Pilot project team after implementation of Scrum	Pilot project team before implementation of Scrum	Department of Innovations
Score cohesion	24.3	-8.9%	-0.2%
Score team leadership	19.4	-8.9%	-1.1%
Score team orientation	14.2	-2.7%	+4.3%
Score adaptability	18.1	-3.4%	+1.1%
Score closed-loop communication	14.6	-8.0%	-4.7%
Score back-up behaviour	18.6	-8.2%	-4.6%
Score mutual performance monitoring	24.1	-13.9%	-6.5%
Score coordination	29.5	-11.8%	-10.9%
Overall teamwork quality	21.0	-8.4%	-3.4

10 The score of the pilot project team after implementation of Scrum is based on a range from -50 to 50. A percentage wise change of 10% is thereby also a 10 point difference on this range.

To be able to explain these differences, multiple possibilities have been drafted as to why the teamwork seems to have improved significantly within the pilot project team and why the pilot project team before Scrum has rated the teamwork performance significantly lower than the department of Innovations. First, the possibilities to justify the differences in teamwork quality within the pilot project team are discussed:

- The first explanation is that the Scrum guidelines have achieved their purpose; teamwork performance has improved.
- The team members of the pilot project could have tried to positively influence the outcome of the questionnaire. This could steer the direction of the conclusions towards a positive attitude towards Scrum and by doing so, bias is created. The reason for positively influencing the outcome could have two reasons:
  1. This is a form of delighting the researcher.
  2. The team members are in favour of applying Scrum because of other aspects than teamwork and want the research to have a positive outcome.
- The 'Hawthorne effect' was present. The Hawthorne effect is a possible explanation for positive results in intervention studies. It ascribes behavioural change to an awareness of being observed, an active compliance with the supposed wishes of researchers because of special attention received, or positive response to the stimulus being introduced (Wickstrom & Bendix, 2000).

Secondly, the possibilities to justify the differences in teamwork quality within the pilot project team are the following:

- Most of the respondents of the Innovations department have never been in touch with Scrum or any other form of project management different from the method applied at Allseas. This can result in the teams not being aware of any potential progress that can be made concerning teamwork quality.
- The teamwork quality of the pilot project team before the implementation of Scrum was far below the standard of the Innovations department. However, this still means that it has significantly improved since the use of Scrum. Nevertheless, this raises the question whether the implementation of the Scrum guidelines would improve the teamwork quality within a different project team as well.

All of the abovementioned explanations have been taken into account when executing the validation interviews with four project team members.

5.2 Observations

During the course of two-and-a-half months, the pilot project team has been intensely monitored. As the writer of this thesis also performed the role of Scrum Master within the pilot project team, the true team dynamics have been observed because both writer and pilot project team worked closely together on the FPS project. This resulted in the team dynamics not only being observed during all Daily Stand-ups, Sprint Plannings, Sprint Reviews and Sprint Retrospectives, but also in day to day engineering activities. These observations have been summarised in this section, starting with overall observations of the pilot project and continuing with observations of the first four Sprints.

Overall observations

- The team has highly increased the number of interactions. This also occurs outside of the obligatory meetings; resulting in the team members taking more time than before to discuss their work. This seems to have a positive reaction on the team's cohesion.
- Also, awareness of project progress increased significantly due to the high amount of interactions. This resulted in the easier implementation of design changes as all disciplines were aware of design problems and could respond adequately to proposed changes.
- A raised awareness of higher management on the project progress led to better allocation of the part-time team members. The expected workload could always be indicated on short term, giving management the possibility to allocate team members better.
- As the project evolved, the need for increasing Sprint durations became higher. This was due to more monitoring tasks which increased the time to realise an Increment. As the project evolved towards the fabrication phase, requests were therefore made for longer Sprint durations, which resulted in linearly increasing Sprint durations. Allocation of resources was not an option in this case as many tasks depended on external parties.
- The importance of different disciplines throughout different project phases has been noted. Where in the first few Sprints the contribution of the electrical and software engineer was significant, these disciplines were less required when the project progressed. This resulted in the software engineer receiving a more consulting role and presence was less required during Daily Stand-ups. This issue was resolved by obliging the presence of all members at both the Sprint Planning and Sprint Review and only requesting the presence of the more contributing team members at the Daily Stand-ups. This resulted in a good balance for all team members.
- An extensive amount of irrelevant work has been avoided due to discussions during Daily Stand-ups. During the explanation of the work that had to be done, all team members would react if a task had already been performed, had become trivial or if a different approach should be attempted. This resulted in a dire decrease of unnecessary work being performed.
- In the engineering industry several increments need to be developed simultaneously. To succeed, the project team sometimes had to split up into small sub-teams to work on different Increments at the same time. Some Increments were limited in size and working on these Increments in parallel was more efficient for the project team.
- During meetings, when issues were shared, team members were always willing to help out if help was required. Whether this intention to help each other has always been present needs further investigation.
- Primarily, the reaction of the pilot project team on the implementation of the cocktail approach was positive and cooperative. While before the start of the project, the reactions on the implementation of a new project management approach were cynical, this remarkably overturned during the first Sprint. It was observed that over the course of the subsequent Sprints, this cynicism fully disappeared.

The observations of the following four Sprints are mainly oriented on how the pilot project team reacted differently as expected on the guidelines. This brought forth a number of issues. When an issue occurred that could be attributed to the project management approach, two options were considered:

1. The issue occurred due to incompatibility of the specific guideline with the pilot project and therefore the guideline had to be adapted. Adaptation of a guideline was only performed after no other option was found to be possible.
2. The issue occurred because the pilot project team did not correctly apply the specific guideline. In this case, the importance of correct application of the guideline was explained.

The guidelines that affected teamwork performance positively have been discussed during the validation interviews.

Sprint 1

- The first concept engineering phases required shorter Sprints than the 7-8 days that were proposed. Concept choices have to be made almost daily, determining the rest of the engineering process. At these early stages in projects with a short lead time, shorter Sprints could provide a solution. This increased the level of coordination.
- Time estimation based on Planning Poker[11] was not effective. The discussion on assigning time to tasks created too many discussions, resulting in long meetings and inconsistency in the planning. The expectation was that this would decrease when the definition of 'Done' is more consistent and all team members become better in estimating lead times.
- Connecting technical stories to tasks does not work. Usually in Scrum, these stories comprise of mostly user stories to which tasks can easily be attached. However, too many technical stories generate multiple tasks and APM is not designed to accept this. Therefore, the set-up of the TFS has been changed to a structure that divides the project into small stages per Increment.
- Assigned times are completely off. The team clearly needed more practice in time management. This practice was also expected to enhance coordination. Over the course of the following Sprints, time assignment to tasks remained troublesome, however, did increase significantly.

Sprint 2

- The urge of finishing tasks at the end of sprint faded away. Tasks remained open for a long time, due to complexity and other activities. This resulted in team members 'juggling' multiple tasks, working on a task at random. The team members were thereby still too free to do what they deem fit. From then on stricter compliance with the Taskboard was requested.
- Detailed engineering tasks were hard to split up. Every aspect needed to be taken into account and changed regularly when working on other aspects of the same backlog item.
- The team had a high dependency on the drawing office, another Allseas department. Design, and thereby Increment, required a large input from external parties. This high dependency made tasks and Sprints difficult to plan.

[11] Planning Poker is a Scrum technique for estimating the amount of effort a task requires. In Planning Poker, all tasks are elaborately discussed.

- Steering by a Scrum Master with a lower comprehension of the engineering activities is challenging. The Scrum Master kept track of time during meetings but some items did need extra attention. For a less technical Scrum Master it was difficult to identify which topics these were. From then on, other team members supported the Scrum Master in reducing unnecessary conversations during the meetings. This improved team leadership and coordination of all team members.

Sprint 3

- The trust in some team members seemed to decrease as it became more obvious who did not work hard. These people faded to the background during meetings.
- All team members were very protective of their own tasks. When team members went on holiday, they tried to make sure that they could continue their tasks when they return, not taking into account project planning. This led to a reduced sense of overall responsibility for the project as it was not yet an 'us' but still more an 'I'. However, after having been alerted on this behaviour, all team members have loosened their grip on their own domain.
- Motivation to complete tasks at end of sprint faded as planning was done improperly. This led to the tasks being transferred to the next sprint and the idea of iterations became less important.
- More focus had to be paid on how large tasks can be split up. The task descriptions became too long, resulting in tasks taking up to three days. This reduced the advantage of Scrum, which is most effective with small iterative tasks.

Sprint 4

- In this Sprint, the first preparations were made for the fabrication phase. Therefore, less planning was needed as a lot of tasks regard the monitoring of external parties. Examples of these external parties are the drawing office, logistics department and suppliers.
- The pride of telling about one his own achievements became less. This reduced the sharing of knowledge. In Sprint planning and Sprint review meetings, it took about twenty to 25 minutes before everyone got excited about telling their progress. However, this excitement was not there in the last project, so an improvement was still noticeable.
- In the pilot project team, all starts of meetings very much depended on the project lead. All team members still expected him to take charge and if he did not start, no one else took over. The combined team leadership is therefore limited. The project lead has been made aware of this limitation and measures were taken to give more responsibility to all engineers during meetings.
- The difference in enthusiasm of team members among several Daily Stand-ups became significant. This seemed to highly depend on the mood of the employee, thereby affecting other team members and the teamwork quality in general.
- Often, when a team member shared having issues with a certain task, this task is discussed after the daily meeting and almost all members were willing to help. This signals for an increase in back-up behaviour.
- Task durations were often extended. This is caused by having multiple ideas on how a task should be performed communicated during the Sprint and not at the Sprint planning meetings. However, time estimation techniques were executed better each Sprint and all team members

indicated that it is hard to define up front how a task is going to look exactly. Yet, all team members were willing to put more effort in it.

5.3 VALIDATION INTERVIEWS

All observations can be subject to interpretation errors by the observer and therefore need to be validated. This validation has been executed by interviewing four team members, who all have been noted to have different visions on the pilot project. The interviews have been recorded and a summary of the answers to each interview question is given in Appendix G.2. In this section, the findings of the interviews are discussed.

The four different team members that were selected for the interviews all used to play different roles within the pilot project team before the use of Scrum. The interviews were conducted with the unit head, lead engineer and two R&D engineers of whom one also fulfilled project coordinator tasks. More information on the organisation of Allseas is added in Appendix C.

The interview questions, of which the structure is added in Appendix G.1, are based upon the findings of the observations and the results of the MCA. During the observations many adaptations have been made to the Scrum guidelines in order for the teamwork to achieve its full potential, while still upholding all proposed agile values and principles. The observations thereby primarily focus on how to improve the Scrum process, while remaining independent and regarding the objective of improving teamwork. To determine whether teamwork performance had indeed been improved, the interviews focus on the combination of changes in teamwork elements and the specific Scrum guidelines that these can be attributed to. Per interview, the sequence of questions has been rearranged for the interview to achieve a high level of fluency. The themes that are discussed in this section are as follows:

1. Awareness
2. Group dynamics
3. Trust
4. Motivation and effort
5. Adaptability
6. Manageability
7. Bias

Per discussed theme, an expectation will be given on which teamwork elements should be influenced by the changes. Except for adaptability, no teamwork elements were taken as a theme for this analysis as many changes impact multiple teamwork elements.

Awareness

The most distinctive change within the pilot project team concerned the level of awareness. All interviewees attributed many improvements in their functioning to the level of awareness that was created. Due to the increased number of interactions they knew what current design issues were, who was facing problems, who was working on which tasks, what the project progress was and what the project goals were. Thereby, all interviewees unanimously stated that the awareness can be attributed to the structured form of daily meetings.

The teamwork element aspects that concern the level of awareness are linked to the teamwork elements of Closed-loop communication and Mutual performance monitoring.

Group dynamics

These daily meetings also improved the group dynamics. In the previous project, the project team did not 'feel like a team' but more separate individuals. This has completely transfigured during the pilot project as all interviewees now indicate to feel more like a project team. Due to the high amount of interactions, the team started to collaborate on a much more sophisticated level, which is a logical improvement when the time spent together is extended. Although, this could have resulted in a negative spiral if the team had thought that the level of interaction was too high. However, this level was indicated to be an adequate balance.

The teamwork elements that can be theoretically be expected to increase with an increased level of group dynamics are the elements of Cohesion and Closed-loop communication.

Trust

During the observations it was observed that the trust in some team members lowered, however, during the interviews this finding was refuted. All interviewees indicated that when tasks were not completed by team members, it only confirmed their opinion on those colleagues. This can be explained by assumption that team members have always had suspicions on the effort that some team members invested in the project. However, these suspicions were hard to verify with a low number of interactions. Now that every team member is aware of the complete progress, these suspicions are only confirmed and no decrease in belief in the performance of colleagues occurred. On the contrary, team members were not aware of who worked extremely hard on the project and under the current project management approach this became possible, improving the opinion of colleagues. Therefore, the amount of trust in colleagues only increased.

If this development is to be measured by the measurement framework, it should show in the elements of Team orientation and Cohesion. It can also be argued that an increase in trust generates more Back-up behaviour as team members could be more willing to assist colleagues whom they trust.

Motivation and effort

Determining an increase or decrease in motivation in comparison to the previous project is difficult. Therefore, all interviewees were asked whether they were more motivated. The initial response for everyone was that his was true. However, after having considered the question more thoroughly, the team members explained that they were not more motivated to finish the project successfully. It only felt as if they were more motivated, because the new project management form created the platform to express this motivation and to use it more beneficial. This was exemplified by all interviewees explaining that they were aware of the product backlog and the activities of their colleagues, which made it easy to translate that motivation into substantial action. The interviewees were divided on whether the team worked harder. Yet, they agreed that they worked more effectively, resulting in a higher amount of work performed in less time.

Motivation and effort belong directly to the element of Team orientation. Although the interviewees were conclusive that motivation and effort could be expressed better, the motivation and effort that team members put in was not improved. This finding thereby is a positive feature of the Scrum guidelines, however, it does not directly improve teamwork performance.

Adaptability

The Scrum guidelines prescribe strict rules for dealing with design changes. To follow these rules was found difficult as the engineers were used to implement changes whenever needed, without letting it rest to the next progress meeting. However, when strictly applying the rules on design changes, they acknowledged that a minimum amount of time was spent on unnecessary work.

Concerning self-development, all interviewees unanimously stated that they did not feel like they learned more than in previous projects. This is remarkable as the amount of interactions between different disciplines is higher, which could suggest that team members would automatically learn about other fields of work. On this finding, the unit head elaborated more thoroughly. He had also expected the team members to eagerly explore other areas of knowledge. However, he saw that they were simply not interested in exploring new areas of knowledge, even though the opportunities were present with the new project management approach.

It can be concluded that for the teamwork element of Adaptability, a few aspects have improved and the aspects concerning the learning loop were not improved significantly.

Manageability

In the interviews with the unit head and the lead engineer, one theme was present in nearly all answers that were given; manageability. The engineers of the pilot project team explained that their activities, aside from the new meetings, were not influenced by the introduction of the Scrum guidelines. For the unit head and the lead engineer, however, many things have changed. When asked if their job had changed, both managers declared that their worries decreased significantly and they did not feel like controllers. In the previous project, weekly progress meetings were the only structured form of contact between the managers and the team. In the pilot project, with structured meetings daily, much more information was shared among the project team in the presence of the unit head and lead engineer. This meant for the managers that there was no need to check up on every team member individually, which saved a significant amount of time.

Interesting to note is that self-organisation was observed to be absent, however, all interviewees explained that although limited, self-organisation was present to some extent. This has also relieved the managers of activities to worry about. This is why the lead engineer also stated that the steering of team members became considerably easier. As the pilot project team was highly aware of what had to be done, it is logical that the managers did not have to instruct the engineers in the same way as before.

The theme of manageability is present in many teamwork elements; Team leadership, Cohesion, Adaptability, Closed-loop communication, Back-up behaviour, Mutual performance monitoring and Coordination. All these elements are affected, yet these effects are only present for the management of a project team.

Bias

Several issues concerning the possibility of bias in the pilot project had to be investigated by means of the validation interviews. This was necessary because the data could contain three different elements of bias that had to be discussed with the interviewees:

1. It was the second attempt of the project.
2. The Innovations department rated teamwork to be almost equal to the pilot project.
3. The involvement of the writer of this thesis as Scrum Master could influence data.

As the pilot project team started a second attempt to deliver a functioning FPS, many thoughts had already been given to possible design solutions and the team was considered to be more experienced in designing an FPS system. However, the interviews clarified that many engineering functions had to be completely re-designed from scratch. Moreover, during the FED phase of the previous project, it was not known that the design contained design flaws. Therefore, the FED phase of the pilot project was perceived to be similar to the previous project, although now only different design decisions were taken. This leaves the sole difference between the two projects to be the application of different project management approaches.

The MCA that was performed on teamwork performance in the pilot project and the reference group of the Innovations department showed a limited difference in teamwork quality between the two groups. The main hypothesis concerning this result is based on the ignorance of the department of Innovations. The pilot project team measured a large increase in teamwork quality after the implementations of the new agile guidelines and this was also confirmed during the interviews. When asked how they would have graded the original teamwork quality if they had not been familiar with Scrum, all interviewees stated that they would have given higher grades. As only 16,7% of the Innovations department had worked with Scrum, the high grade on teamwork quality of the Innovations department could be affected by employees unaware of other project management methodologies. This means that also compared to the reference group, the teamwork quality of the pilot project team was higher. However, it is important to realise that this is based on the response of four interviewees only.

The observations could have been influenced by the presence of the researcher within the pilot project team. Therefore, the interviewees were asked about their opinion on how the role description of Scrum Master compared to the functioning of Scrum Master during the pilot project and whether having an engineer as Scrum Master would make a difference. The results on this question were inconclusive as there are some aspects of the role of Scrum Master that could better be filled by an engineer from the pilot project team. An engineer has more technical knowledge and can better determine the value and necessity of each conversation. On the other hand, an engineer from the pilot project would not be eager to accept all functions that are assigned to a Scrum Master as this would lower his amount of engineering related tasks. A suggestion was made to distribute the tasks of the Scrum Master among several team members, however, this suggestion has not been checked.

All interviews were concluded with the question whether Scrum helped to perform their job and were conclusive on the fact that Scrum had a positive impact on the pilot project team.

5.4 Discussion on data analysis

In the data analysis chapter, the measurement framework has been validated and thereafter been used to measure the teamwork performance of the pilot project team. Also results on the functioning of the Scrum guidelines within the pilot project have been analysed and thereafter validated by interviews. With results on all deliverables of this thesis, a discussion can be generated on the results. Therefore, this section discusses the validity of the framework and the applicability of the guidelines in combination with the improvement of teamwork quality.

While the measurement framework was validated, it can be debated whether no teamwork aspects were left out. This framework was based on the available literature on teamwork, however, it could be that also in literature, other teamwork elements and aspects have not been considered. Therefore, this research does deliver a valid measurement framework for team performance in both an agile and a conventional setting, but other elements or aspects could be added.

Due to the low sample size, the quantitative analysis of teamwork performance in the pilot project team was assessed to be statistically invalid. However, the results from the MCA and the interviews were conclusive on all teamwork elements. Of the eight teamwork elements, the elements of Team orientation and Adaptability were statistically found to have improved only marginally due to the implementation of the Scrum guidelines. During the interviews, considerable improvements were noted on all other teamwork elements and explanations were presented on the minor improvements of Team orientation and Adaptability. Even though the MCA was not statistically valid, utilising it for the interviews showed the applicability of the measurement framework.

The concept of the Hawthorne effect has not been involved in the interviews as it can already be stated that the Hawthorne effect was present. The pilot project team did receive more attention than before, although it was in the form of a researcher who proposed to comprehensively adjust their common practice. As a change in working method was not received emphatically at first, the team received more attention and was thereby aware that they were being observed. Therefore, the Hawthorne effect was present. After the initial phases, not more attention was spent on the pilot project team by the Innovations department or the writer of this thesis than was spent during the previous project. Yet, it is hypothesised that the Hawthorne effect remained present, but in a different way than before. Scrum itself revolves around more communication with team members, which unequivocally means that the team members give more attention to one another and are very much aware that they are being observed. However, in this case they are the observers themselves.

To conclude this chapter, the statement can be made that the proposed Scrum guidelines have been implemented successfully and improved the teamwork performance. Primarily, this statement is based on the results of the observations and the interviews which were generally positive. However, as the guidelines have only been validated on one project, further tests will possibly lead to further improvements.

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6 CONCLUSIONS AND RECOMMENDATIONS

In this chapter, all findings of the previous chapters are combined to conclude this research. This has led to an answer on the main research question in section 6.1. This answer is discussed on its limitations in the following paragraph (section 6.2), followed by recommendations for both Allseas as the engineering industry (section 6.3). In the final section of this report, the writer reflects on the executed research (section 6.4).

6.1 CONCLUSION

In this paragraph, the initial objective of this research is shortly recapped. This leads to the research question that has remained leading in this research. By first answering the four sub-question which were introduced in section 1.3.2, the combination of these answers forms the foundation for the answer on the main research question.

The literature review has shown that the effect of APM on the teamwork quality of engineering project teams has not been thoroughly studied before. While literature does imply that this relation is expected to be positive, no evidence has been adduced. Therefore, this research focussed on how the implementation of the APM philosophy in the engineering industry affects the teamwork quality of project teams, thereby adapting APM to the needs of the engineering team. This has led to the following main research question:

> *How to enhance **teamwork quality** within a **project team** in **engineering** projects by building **agile teams** in the front-end development**?***

With this research question, two deliverables of this project could be directly derived. To answer the research question, a proposal was needed that aims on enhancing teamwork quality (Appendix A). To validate whether the proposal enhances teamwork quality, a measurement framework had to be constructed (Appendix B). Therefore, the conclusion of this research revolves around those two deliverables. In the following paragraphs, references are made to these two deliverables when answering the sub-questions.

Sub-question 1

> *What are the differences between the **agile way of organising teams** and the organisation of teams with a **traditional project management methodology**?*

To answer this question, literature on both APM and TPM has been studied to determine the differences. In the literature review (chapter 2), both methods have been compared and can be summarised in multiple statements that differentiate agile teams from teams that have adopted a TPM methodology:

- Working in co-located teams, in which responsibility of the product is shared among all team members.
- Small teams, with a maximum of ten team members, are highly responsive to change, making them able to quickly adapt to dynamic environments.

- The client has a high level of involvement. Where in TPM teams, the client often has a more reserved role, in APM teams, the client is expected to actively participate in refinement of the project requirements. As within APM, this refinement is performed during the project, the client is actively present during the FED phase.
- Working in self-organising teams, which ensure without interference from managers, that all necessary tasks are executed.

Following the comparison of traditional and agile teams, the cocktail approach and corresponding Scrum guidelines were drafted on how agile aspects could benefit teamwork quality in engineering teams. In sub-question 4, these guidelines are discussed further.

Sub-question 2

> *What is the best **measure** of **performance** of project teams in both traditional and agile environments?*

As this research focusses on how project team performance can be improved, the methods to investigate teamwork quality had to be studied. While project performance can relatively straightforward be measured by cost and time, measuring the performance of project teams is of a more difficult nature. According to literature, three distinct models have been developed to measure the performance of teamwork quality. All three models describe different elements which are essential to measuring team performance in project teams. However, these models of Dickinson & McIntyre (1997), Hoegl & Gemuenden (2001) and Salas, Sims & Burke (2005) were found to be less compatible with a conventional environment and an agile environment at the same time as the models have not fully embraced the agile values in the elements that are used in the models. Moreover, the models described teamwork quality on a relatively high level, making them unfit to directly translate them to a measurement framework.

Based on these three models, this research has developed a framework to which teamwork quality can be measured (Appendix B). Although based on the three models, it fully incorporates both agile and traditional teamwork values, which makes it possible to measure teams in both agile as traditional environments. As the framework has been extended with forty-four underlying teamwork aspects, measurement of the top-level teamwork elements became feasible.

Sub-question 3

> *How does the **application of agile project management aspects** in the engineering industry relate to the **reviewed literature** on sub-question 1 and 2?*

To determine how agile project management aspects function in practice and to determine how this relates to the reviewed literature, a pilot project has been carried out at Allseas. In this pilot project, the pilot project team was introduced to the agile philosophy, the developed Scrum guidelines and adaptations to the philosophy. These Scrum guidelines are primarily based on APM and Scrum in particular and have been adapted by TPM standards. This has resulted in the so-called cocktail project management approach.

For two-and-a-half months, this pilot project has been studied to determine how the application of APM relates to the reviewed literature on sub-question 1 and 2. In practice, the aforementioned characteristics that distinguish agile teams from conventional teams can be recognised in agile teams. However, within the pilot project team of this research, the level of self-organising was limited. Besides, the involvement of the client had only been realised to a certain extent, so it can be concluded that the level of involvement that is pursued by agile teams has not yet been reached in the pilot project team. These and other discrepancies with literature can however also be attributed to the relatively inexperience of the team in the application of the APM philosophy. Nevertheless, to reach the level of involvement of clients in the software development industry, the engineering industry will need to undergo a change of attitude between clients and contractors. The mind-set will have to change for them to form teams. Only then can a real APM team can be achieved.

Sub-question 4

> *What changes have to be made to the agile project management philosophy concerning teams before it can be applied in the FED of the engineering industry?*

This research has stipulated several aspects that should be changed on both philosophical as practical level for APM to work in the engineering industry. These aspects have been developed into guidelines and thereafter been validated and improved by means of a pilot project. The most important change to the APM philosophy can be said to be the delivery of working software iteratively. In an APM engineering environment, deliverables have to be developed in parallel and often cannot be created by a complete engineering team. However, when developing constructions, different Increments of a construction are often highly dependent of each other. This makes engineering in sequence as prescribed by APM unlikely to be successful.

Furthermore, the involvement of the client is at this point in time in the engineering industry not accustomed and it will require a large effort of persuasion to get closely involved clients. However, the value of customer collaboration of APM is appreciated and it will benefit the engineering industry if implemented. Nevertheless, this will take time.

Considering the agile principles, only one agile principle was found to create conflict within engineering teams. The principle concerning self-organisation was highly challenging to implement. It was therefore adapted to the acceptation of a low level of involvement from higher management as it turns out that engineers within agile teams still require a form of steering from their managers. The remaining agile principles did not require a significant amount of adaptation and are multi-interpretable due to the translation from the software development industry in which multi-interpretability is not possible. This multi-interpretability did make it possible to implement the agile principles in the engineering industry after a single interpretation was determined. This leads to the conclusion that apart from the principle on self-organisation, only minor changes have to be made to the APM principles before it can be applied in the FED of the engineering industry. However, for the engineering teams to uphold these principles, agile tools do need a significant amount of adaption before they are fit-for-purpose in the engineering industry. Hence, the Scrum guidelines have been developed to accommodate this implementation in the engineering industry.

The project management approach of the pilot project was not solely based on the adapted agile principles and four Prince2 principles were added to create the cocktail approach. Sub-question 4 refers to the changes that should be made to the APM philosophy, however, the cocktail approach exists of several other principles as well. To adequately answer this sub-question, the cocktail approach should therefore be presented to answer this sub-question as only by the full set of principles, the agile philosophy can be applied in the FED of the engineering industry. In Table 6.1 the principles of the cocktail approach are displayed.

Table 6.1 Principles of the cocktail approach (Own table)

Principles	Based on
1. A high priority is to satisfy the customer through early and continuous delivery of valuable deliverables.	APM
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.	APM
3. Deliver deliverables frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.	APM
4. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.	APM
5. Businesspeople and developers/engineers must work together frequently throughout the project.	APM
6. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.	APM
7. Finished drawings, completed reports and substantiated design decisions are the primary measure of progress.	APM
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.	APM
9. Continuous attention to technical excellence and good design enhances agility.	APM
10. Simplicity—the art of maximizing the amount of work not done—is essential.	APM
11. The best architectures, requirements, and designs emerge from self-organizing teams with a low level of involvement from higher management.	APM
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.	APM
13. Continued business justification	TPM
14. Learn from experience	TPM
15. Define roles and responsibilities	TPM
16. Tailor to environment	TPM

Main research question

By combining the answers to all sub-questions, the main research question can be answered.

> *How to enhance **teamwork quality** within **project teams** in **engineering** projects by building **agile teams** in the front-end development?*

A significant part of the report focussed on adapting the agile philosophy and Scrum guidelines in order for them to become applicable for engineering teams. While the agile philosophy did not require much adaptation before implementation, the Scrum guidelines did. This was required because especially within the Scrum guidelines, aspects were found that could cause conflicts when implemented in engineering teams. To encounter these conflicting aspects, complementary guidelines to the Scrum Guide of Ken Schwaber and Jeff Sutherland (2013) have been developed (Appendix A). This guide was previously only applicable for software development teams because a considerable amount of aspects of Scrum were not applicable within the engineering industry.

To determine whether these guidelines improve teamwork quality, a pilot project has been carried out at Allseas. With the use of the teamwork measurement framework and four validation interviews, the team performance of the pilot project has been assessed. This assessment demonstrated a significant increase in the level of teamwork quality within the pilot project. However, this only signifies that the enhancement worked for this specific team. To generalise the findings of this research, the characteristics of the pilot project have been studied. If a project has the following characteristics, applying the guidelines presented in this report will boost teamwork quality:

- Innovative
- Complicated
- High time pressure
- Relatively short engineering phases
- Multiple disciplines (in this case mechanical, electrical, structural, software).
- In-house use of end product

The innovative and complicated character of this project highly defined the actions of the pilot project team. That the end product would be used in-house also illustrated a number of decisions. However, on the characteristics of high time pressure, short engineering phases and multiple disciplines it can be discussed that these characteristics did not define the project to such an extent that without these characteristics, agile teams do not enhance teamwork quality.

Therefore, considering that these characteristics were present in the pilot project team the following conclusion to this research can be given: If the complementary guidelines to the Scrum Guide (Appendix A) are used and the cocktail approach is adhered to, teamwork quality within project teams in engineering projects is enhanced.

6.2 LIMITATIONS

Some notes can be drawn up for this research. Therefore, in this section, the limitations of the research are discussed.

Pilot project

The opportunity to execute a pilot project with a serious deadline has been a wonderful chance to closely monitor the effects of APM on a project team. However, the pilot project also limited this research. Below, several aspects of the pilot project are mentioned that could have affected the results of this study.

The projects that are being executed at Allseas, all hold a high level of innovation. This characterises the company, but also limits the generalisability of this research. Due to this slightly unique character, the developed Scrum guidelines are tentatively only applicable in projects which comply with the following characteristics:

- Innovative
- Complicated
- In-house use of end product

This does not imply that the guidelines are not applicable for projects that lack these characteristics, it only means that further research on projects with different characteristics are necessary.

No tool to determine how agile a project is, has ever been developed. Although the interviewees have been asked to rank the presence of the project its agile principles, this provisional method of measuring the agility is not validated. Therefore, the agility of the pilot project can be estimated, yet cannot be determined completely.

The pilot project only covered two-and-a-half months and nine project members. This has resulted in a limited dataset, which hindered the possibility to validate statistically what the teamwork quality of a project team was before and after the implementation of Scrum.

Another limitation of this research, is the direct involvement of the researcher within the pilot project team. Although direct involvement was more preferable than other options, it did influence the functioning of the pilot project team both positively and negatively.

Expert involvement

No Scrum experts have aided the implementation of Scrum in the pilot project team. With the vision of an experienced Scrum Master a slightly better guideline could possibly have been constructed. With the experience taken from the software development industry, provided that an open-minded attitude is upheld, the Scrum guidelines can most probably be further improved.

6.3 RECOMMENDATIONS

Many recommendations can be drawn from limitations, issues or questions that have been raised in this research. The recommendations are divided into recommendations for further research (section 6.3.1) and practical recommendations on how to create agile teams in other projects (section 6.3.2).

6.3.1 Research recommendations

Below, suggestions for further research are presented.

Application of guidelines in projects

To start with, the constructed guidelines should be tested against other engineering projects. Important for those projects is that there will be a variation in:

- Project team size. The previous pilot project comprised of nine team members. It will be interesting to investigate how these guidelines will perform in different team sizes. As the maximum team size for agile teams is ten, a study can also be performed into the concept of Scrum of Scrums. In this method, multiple Scrum teams together form a larger Scrum team, with the high-level Scrum team composing of a maximum of ten Scrum teams. Of all teams one representative is present in the high-level Scrum team, thereby making a Scrum project with a large number of team members possible.
- Type of pilot project. The observed pilot project was rather unique. If the guidelines can be tested in future projects with different characteristics, this could increase the applicability. Therefore, further research is needed to determine for which other types of projects these guidelines or even agile is applicable.

Project performance

Having concluded that the cocktail approach of this research does improve teamwork quality, it is important to consider how this influences project performance. The idea behind APM is to improve the value of a project and not to improve teamwork quality. However, this research shows that teamwork quality is significantly improved when creating agile teams. At the start of this research, the decision was made to leave project performance out of the scope. However, during the observations several indications were noted which suggested an improved value of the project. As this remained outside the scope, in further research project performance should be evaluated as well. Consider improving the engine block of a car. By adjusting certain valves inside the engine block, the performance of the engine block itself increases significantly. However, if the change has resulted in extra weight or interface problems when placed inside the car, it could result in a decrease of the overall performance of the car. Therefore, the effect of the Scrum guidelines on other project performance indicators should be measured.

Agility

As already stated in the limitations, there is no knowledge of the exact level of agility. There is no measurement framework that measures how agile a project is. The development of such a framework could be of value in future agile projects, to increase agility or to prove its worth. Not only can this framework measure agility, it can also be used to determine a certain threshold above which agile teams are advantageous.

Next project phases

In this project, only the FED has been analysed. In the latest stages of the FED, APM also showed prospects to be used in the fabrication phase. However, since the scope of this research was limited to the FED, further research could study the applicability of agile teams in the fabrication phase.

6.3.2 Practical recommendations

With the execution of a pilot project and the development of Scrum guidelines for further use, there was a high amount of practicality present in this research. This paragraph lists how the Scrum guidelines can be used in future engineering projects.

Scrum guidelines

The developed Scrum guidelines are complementary to the Scrum Guide of Ken Schwaber and Jeff Sutherland (2013). As this guide is highly detailed on which steps have to be taken, the guidelines can be introduced to each team that is aware of the original values of APM. As the number of engineers that is familiar with APM is limited, agile training is advised.

Training

In future projects with project teams which are completely new to APM, an introductory workshop is advised. Hiring an agile expert for this is the most effective, however, having an own employee study APM in order to teach the rest of the team members is also an effective option. In the latter option, some contact with an expert is still advised.

Digital Taskboard

The pilot project team used a digital Taskboard to keep track of the product backlog and the Scrum board. The use of a digital Taskboard is highly recommended as it establishes the possibility for the engineers to review the board wherever they are. Also, with the addition of several functions to the board, the project progress reporting will become easier as the Taskboard will contain all information on the project.

6.4 REFLECTION

To conclude this research, a reflection is appropriate to examine the research steps that were taken. This reflection both comprises of personal experiences to the general graduation process and a reflection on which elements of this research could have been improved.

Kick-off

To get acquainted with the research topic, I had many conversations with engineers and managers at Allseas. While this is time consuming, the knowledge that I gathered made it easier to pinpoint the issues that I could research and increased my own understanding of APM. I also considered the involvement of my first supervisor to be high, which I think contributed to how the thesis proposal was received by the complete committee. However, I think more contact with all other committee members would have been better, but as I was not sure of the exact direction of my research yet, I was very hesitant in contacting the other supervisors. I found out that I should not have been hesitant as more contact will only help steer the research in earlier stages where adaptations are easier to implement, typical agile project management.

Pilot project

The pilot project played an important role in how I conceived my graduation project. As a person who finds it difficult to work on a project solely, the pilot project was a positive change from the day-to-day research activities. It formed the feeling that I was contributing to a team with a tangible goal. It also provided the opportunity to generate data for my research in an informal setting, in which the team members did not fully experience me as a researcher, but also a part of the team.

The start of the pilot project was very hectic. As the choice to implement the agile guidelines within this project was made on short notice, the preparations were limited. Having positioned myself in front of this project team, immediately organising a workshop and having to convince them that APM can be of value, felt like being thrown in at the deep end. However, it did speed up my research as many guidelines had to be made ready for testing. Also, by presenting one of the deliverables of my research at an early stage contributed a lot to my own understanding of APM.

To be able to implement the guidelines in a pilot project, was an amazing opportunity for both my own development and the research and for that I want to thank Allseas. By seeing how the guidelines were used, made the adaptations increasingly more practical.

Decide on one research method

As most parts of this research are qualitative I had the idea that I needed quantitative data to support my findings. This resulted in a lot of extra work with the CFA and MCA while the contribution of the MCA to this research in the end has been limited. This high amount of work on multiple research methods resulted in the separate analyses being less in-depth. Although I do think that the analyses complemented one another.

Different project management methodology

Finally the question remains: Could teamwork quality have also been improved without agile project management? Based on the observations of the project team, I think the answer is yes. The implementation of a new project management method will increase the attention that a team receives and will create a different atmosphere in the team which will probably result in better team performance. However, the cocktail approach that was used in this project has had a large positive impact on the team which to my opinion could not have been achieved by small adjustments to the TPM philosophy. Moreover, the continuous communication also resulted in less design errors and no unnecessary work was performed, speeding up the process. These are project success criteria that have not been researched in this project, but also the complete project performance seemed to have improved. There were also no indications that any other aspect of project performance was negatively affected. Therefore the assumption by which the direction of this research was justified appears to be correct. "Successful project teams lead to more successful projects" (B. N. Baker, Murphy & Fisher, 2008; Beleiu, Crisan & Nistor, 2015).

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APPENDICES

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A SCRUM GUIDELINES FOR THE ENGINEERING INDUSTRY

With the success of Scrum in the software development industry, claims have been made about its applicability in the engineering industry. From initial research it follows that Scrum will have to be adjusted for it to work properly within the engineering industry. In the following chapter, guidelines are presented on how Scrum can benefit the engineering industry.

A.1 The Scrum Guide

There are plenty manuals on how to apply Scrum in the software development industry. To adapt Scrum for the engineering industry, the manual developed by Ken Schwaber and Jeff Sutherland (2013) has been chosen as a starting point. This manual has been chosen as the Scrum Guide for this research as it is a complete, yet concise guide to all important aspects that are needed to know to implement Scrum in a team. The guidelines described in Table A.1 are complimentary to the manual and will add, elaborate on, adapt or delete instructions in the Scrum Guide of Schwaber & Sutherland (2013). When these actions have been changed the Scrum Guide, it is immediately ready for use.

The presented guidelines have been applied at the pilot project team and were found significantly contributing to team performance. Multiple other suggestions have been introduced, but were considered to hinder project performance significantly or to reduce team performance. These suggestions have been discussed in Chapter 5 and have thereafter been taken out of the validated Scrum Guide modifications in Table A.1.

Table A.1 Scrum Guide modifications

Page	Chapter	Rule	Adapt, add, delete	Description of change
5	The Development Team	Development teams are cross-functional	Adapt	Development Teams are not fully cross-functional. Within engineering teams help is required from supporting services such as draftsmen. With more disciplines required within engineering teams, supporting services cannot be embedded within the team as to prevent exceeding the team size limit.
6	The Development Team	Scrum recognizes no sub-teams in the Development Team	Delete	In the engineering industry several increments need to be developed simultaneously. To succeed, collaboration is allowed in small sub-teams.
6	Scrum Master	Should be a team member	Add	The danger of external Scrum Masters is a lack of knowledge of the project. For the start of the project, defining the requirements and creating the Product Backlog, help from an external Scrum Master is acceptable due to the high workload of creating the Product Backlog.
7	Scrum Events	Sprint durations can be adjusted during the Sprint	Adapt	Although not desirable, the situation can occur that an increment can benefit from one extra day of work. This increment should not be transferred to a next Sprint, but finished in this Sprint.

7	The Sprint	Consistent durations throughout development	Delete	In the initial phases of development, many design choices have to be made based on new found information and calculations. These choices redirect the direction of the project. To avoid a loss of time due to waiting on the next Sprint, the Sprint durations should increase.
8	The Sprint	Advised starting sprint duration	Add	To be able to quickly respond to new information, the starting Sprint duration should not exceed 7-8 days.
8	The Sprint	Linearly increasing Sprint duration	Add	The nature of tasks changes throughout the project. At the start of the project, the direction of the project can change weekly and Increments can be realised in a short period of time. Towards fabrication phase however, longer sprints are required as a significant amount of tasks depend on external parties, which extends task durations and thereby the time to complete an Increment.
8	Sprint Planning	Preparation of Sprint Planning	Add	If the team properly prepares Sprint Plannings by pre-assigning expected task durations to tasks not typically performed by himself, discussions on time allocation are kick-started.
12	Sprint Retrospective	Improve Scrum process	Add	The Scrum Master should track the improvements during a Sprint and present solutions to problems at the Retrospective. This will limit the meeting duration and gives more value to the meeting. If the meeting length can be reduced, it can be combined with the Sprint Review.
13	Product backlog	A digital Taskboard	Add	A digital Taskboard is recommended as this will give the team an overview of the activities wherever they are. The problem of not co-located teams is easily solved by this Taskboard.
13	Product backlog	A digital Taskboard	Add	Managers are often interested in the productivity statistics of their teams. These can be measured by digital Taskboards. However, managers should be hesitant on using this information against team members, it can demotivate proper use of the Taskboard and thereby reduce communication.
13	Product backlog	Construction of backlog	Add	Reshaping Scrum tools to be fit for purpose is more demanding in the engineering industry. The tools have been developed for software development and need proper adjustments before application in engineering teams. At the start of projects, Scrum Masters should be aware of this.
13	Product backlog	User stories	Add	User stories are to be written in separate documents and should not be used to subdivide tasks. User stories replace requirements, but should often engineering requires multiple technical user stories per task, which makes subdivision of tasks under user stories impossible.

13	Product backlog	User stories	Adapt	The product backlog should be structured based on increments, the interfaces between the increments and the project phases (e.g. electrical concept engineering of cabinets), to realise completion within Sprints of these increments and an easier structure of task assignment to increments.
15	Increment	Multiple increments	Adapt	Within engineering, increments can often only be completed in parallel as there is a maximum of number of members that can work on an increment. Therefore, multiple increments per Sprint are accepted.
15	Increment	Finished increment	Add	Increments within engineering teams not necessarily have to be working products. Especially in the FED phase, many deliverables can be design choices, drawings or reports.
16	End note	Implementation	Add	As the guide specifies, implementing only parts of Scrum results in a methodology that is not Scrum. It can therefore be considered to rename the methodology that is used by the project team as a new project management method that is imposed by senior management. Also a change in used terminology can be considered as engineers are hesitant towards managing terms as Scrum Master.

B CONCEPTUAL FRAMEWORK OF TEAMWORK ELEMENTS & SCRUM

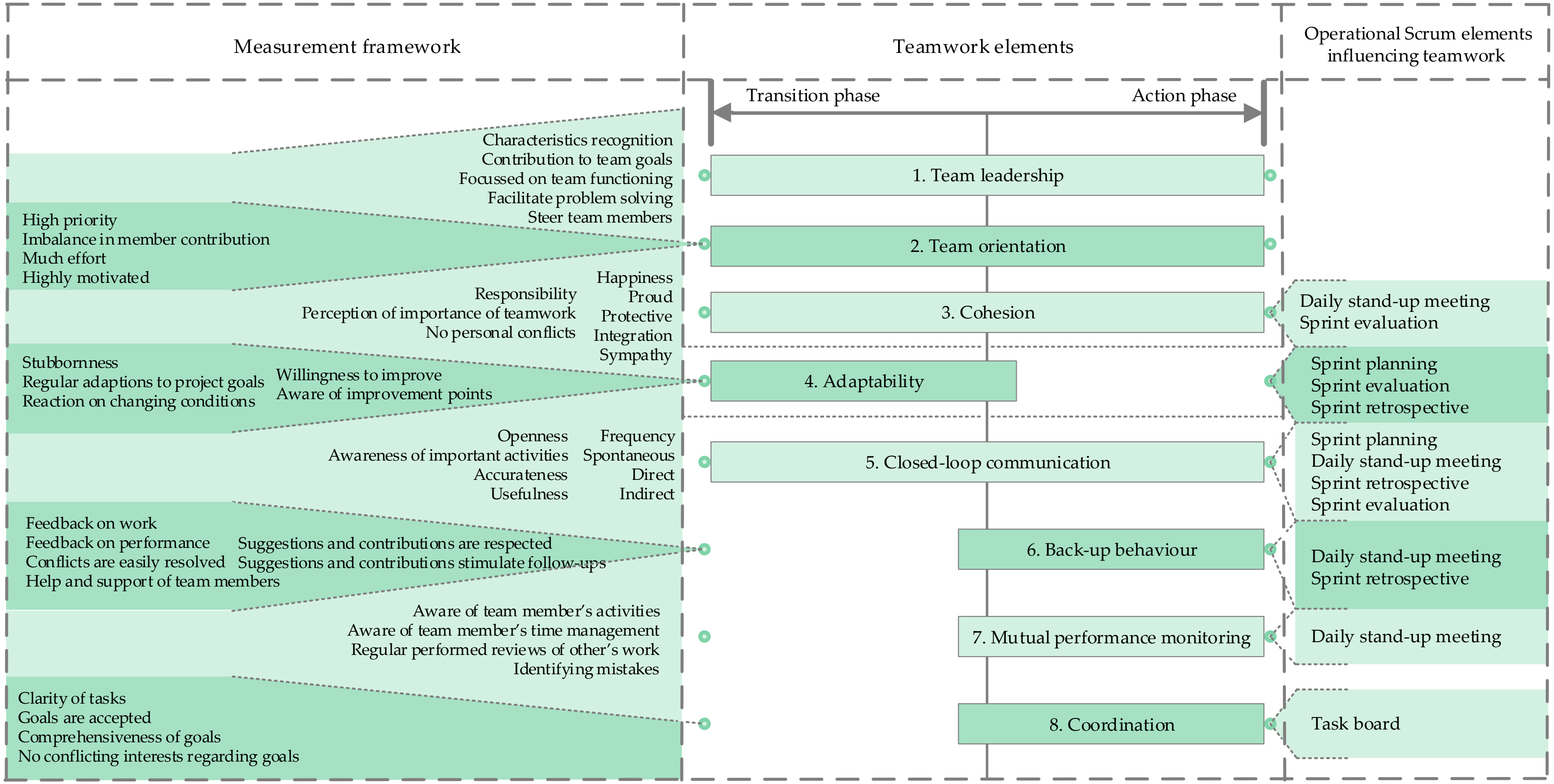

Figure B.1 Validated Conceptual Framework

C BACKGROUND INFORMATION ALLSEAS

Allseas originally started off as an offshore contractor in pipeline installation. However, the director envisioned a ship that could lift complete large offshore structures. Mainly with in-house engineering Allseas developed the largest construction vessel in the world, the Pioneering Spirit, which is designed for single-lift and removal of large oil and gas platforms as well as traditional pipe-lay installation. The project on which this research can be carried out is an innovative project for a flooding prevention system during the pipe lay process of the Pioneering Spirit. To comprehend the project, a short introduction of the pipe lay process is required.

C.1 Organisation of project teams

Within a project team at Allseas, four different roles are recognised:

1. Unit head
2. Lead engineer
3. Project coordinator
4. R&D engineer

The unit head manages multiple project teams and guides the projects on a more remote basis. The lead engineer is the day to day manager of the project who assigns resources to tasks and together with the project coordinator keeps track of the project progress. The project coordinator primarily fulfils engineering tasks together with the standard R&D engineers of the project. Within Allseas, a high level of technical knowledge is expected of the lead engineers and this leads to many lead engineers also performing engineering tasks as that is where their affinity lies.

C.2 Pipe lay process

The pipe lay process aboard the Pioneering Spirit makes use of the S-lay principle of installing pipelines on the bottom of the ocean/sea. This means that pipes of roughly 12 meters are transported to the pipe lay ship and can then be welded together in a horizontal plane, the firing line, after which the pipeline leaves the ship horizontal by means of a "stinger." The stinger smoothens the transition from horizontal to vertical direction of the pipe. At the seafloor, the pipeline bends horizontally again, as to form an S-shape from firing line to seafloor (Figure C.1).

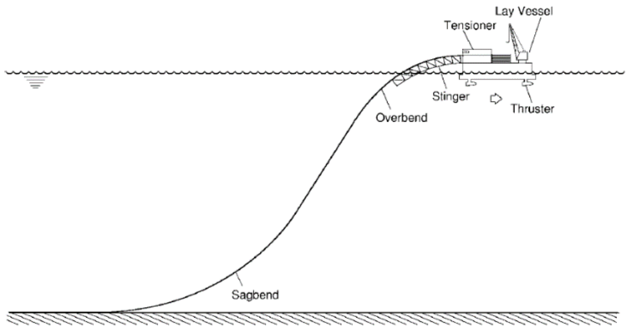

Figure C.1 S-lay pipeline installation – adapted from Aziz (2011)

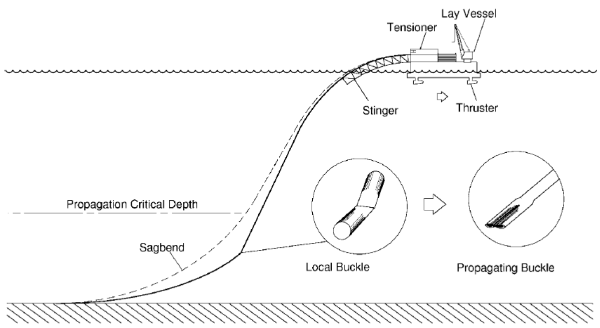

Figure C.2 A buckling pipeline (Aziz, 2011)

C.3 Flooding Prevention System

Pipelines have to be watertight in order to keep the inside clear of water and to prevent spills into the ocean. On the ship, tensioners are installed to keep the sagbend on a safe low angle. If tension on the pipeline is lost, the angle of the sagbend can increase and a buckle can occur (Figure C.2) as pipes are not flexible material. Via a buckle, water can enter the pipe and flood the full length of the pipeline, this increases the weight of the pipeline significantly and can eventually cause a break at the buckle location. The recovery and dewatering of a dropped pipeline can take weeks and cost millions for pipe lay and insurance companies. The flooding prevention tool is a tool that is positioned on the location where the pipeline touches the seafloor. When the tool detects water, which enters via a buckle in the sagbend, it expands and seals of the part of the pipeline that is already on the seafloor. Now, the flooding will be limited to the pipeline in the S-trajectory and not the kilometres of pipe thereafter and the risk of a pipeline break will be limited. The flooding prevention system has to be designed to hold the flooding prevention tool at the point where the pipeline touches the seafloor, this point moves during the pipe lay process and therefore the flooding prevention tool has to be pulled through the pipeline during pipe lay.

To design this system an innovative solution has to be engineered and therefore a team of ten engineers, of which two electrical engineers and eight mechanical engineers have been assigned to the project. The first attempt to deliver a working solution has failed as in the testing phase the system broke down on multiple places and most parts of the system have to be redesigned. The project has to be completed in early November to be ready once the next pipe lay project commences.

It is unclear whether the failure of the first attempt can be attributed to project management errors. Nevertheless, when changing the project management method on the same project, with the same team members, many variables can be disregarded during the analysis phase of this research. The only significant environment change to take into account concerns the knowledge that the engineers have developed during the first attempt of the project.

D SURVEY

The survey was split up in two parts. One part for the pilot project team and one part for the complete department. Where the pilot project team received questions on how their team performed before and after Scrum, the department only received a survey on how their team currently performed. Below, both surveys are combined. Where the department only received questions b., the Scrum team received the complete survey. To clarify which questions belonged to which teamwork quality aspects, the framework has been included as well. For questions 6, 7 and 8 the respondents were asked to grade the statements on a scale of completely disagree, disagree, neutral, agree and completely agree.

D.1 Structure of survey

Q1
In which age category are you?
21-30 31-40 41-50 51-60 61-70

Q2
Gender
Male Female

Q3
How much work experience do you have…
... since graduation?
... at Allseas?
... at the FPS project/ your current position?

Q4
Function

Q5
Agile project management
I am familiar with the principles of agile project management
I have worked with agile project management before

			Q6
Cluster	**Element**	**Aspect**	For the following statements, rank every statement on a scale of 1 to 5 for both the Allseas way of working and the scrum way of working
(A) Commitment and trust	Cohesion	Happiness	1a. Allseas - I was happy to be part of this team
			1b. Scrum - I am happy to be part of this team
			2a. Allseas - I enjoyed working together
			2b. Scrum - I enjoy working together
			3a. Allseas - I always worked together with team members
			3b. Scrum - I always work together with team members
		Responsibility	4a. Allseas - I felt responsible for my tasks in the project
			4b. Scrum - I feel responsible for my tasks in the project
		Pride	5a. Allseas - I was proud to be part of this team
			5b. Scrum - I am proud to be part of this team
		Perception of teamwork	6a. Allseas - I realised the importance of good teamwork
			6b. Scrum - I realise the importance of good teamwork
		Integration	7a. Allseas - I felt integrated and part of the team

			7b. Scrum - I feel integrated and part of the team
		Protectiveness	8a. Allseas - I was protective of my team members' work external parties
			8b. Scrum - I am protective of my team members' work external parties
		Personal conflicts	9a. Allseas - There were no personal conflicts in the team
			9b. Scrum - There are no personal conflicts in the team
			10a. Allseas - Personal conflicts were easily resolved
			10b. Scrum - Personal conflicts are easily resolved
		Sympathy	11a. Allseas - I sympathised with my team members
			11b. Scrum - I sympathise with my team members
	Team leadership	Characteristics recognition	12a. Allseas - I recognised the strengths and weaknesses of my team members
			12b. Scrum - I recognise the strengths and weaknesses of my team members
		Contribution to team goals	13a. Allseas - I kept the team goals in mind while working on individual tasks
			13b. Scrum - I keep the team goals in mind while working on individual tasks
		Focussed on team functioning	14a. Allseas - Interfaces between different disciplines/functionalities were well managed
			14b. Scrum - Interfaces between different disciplines/functionalities are well managed
			15a. Allseas - Cooperation was promoted
			15b. Scrum - Cooperation is promoted
		Facilitate problem solving	16a. Allseas - If I encountered a problem, I brought it to attention of all team members
			16b. Scrum - If I encounter a problem, I bring it to attention of all team members
			17a. Allseas - I ensured that my problems were addressed
			17b. Scrum - I ensure that my problems are addressed
		Steering of team members	18a. Allseas - I directed other team members in their tasks
			18b. Scrum - I direct other team members in their tasks
	Team orientation	Teamwork priority	19a. Allseas - Teamwork had the highest priority
			19b. Scrum - Teamwork has the highest priority
			20a. Allseas - I found cooperation essential
			20b. Scrum - I find cooperation essential
		Imbalance in member contribution	21a. Allseas - The contribution of team members to the project differed greatly
			21b. Scrum - The contribution of team members to the project differs greatly
			22a. Allseas - The imbalance in member contribution caused conflicts or annoyance
			22b. Scrum - The imbalance in member contribution causes conflicts or annoyance
			23a. Allseas - I found it troublesome that there was an imbalance in member contribution
			23b. Scrum - I find it troublesome that there is an imbalance in member contribution
		Effort	24a. Allseas - Every team member put a lot of effort in teamwork
			24b. Scrum - Every team member puts a lot of effort in teamwork
			25a. Allseas - I worked hard on this project
			25b. Scrum - I work hard on this project
		Motivation	26a. Allseas - I was highly motivated to deliver a good product
			26b. Scrum - I am highly motivated to deliver a good product
			Q7
Cluster	**Element**	**Aspect**	For the following statements, rank every statement on a scale of 1 to 5 for both the Allseas way of working and the scrum way of working
(B) Flexibility	Adaptability	Stubbornness	1a. Allseas - I was willing to change my habits to benefit the team
			1b. Scrum - I am willing to change my habits to benefit the team
			2a. Allseas - I was open towards other ideas on the project
			2b. Scrum - I am open towards other ideas on the project

		Regular adaptations to project goals	3a. Allseas - The team made regular changes to the project goal (that I was aware of)
			3b. Scrum - The team makes regular changes to the project goal (that I am aware of)
		Reaction on changing conditions	4a. Allseas - The team structured the way of adapting project goals
			4b. Scrum - The team structures the way of adapting project goals
			5a. Allseas - I could understand sudden unforeseen project changes
			5b. Scrum - I can understand sudden unforeseen project changes
			6a. Allseas - I was NOT afraid of unexpected scope or design changes
			6b. Scrum - I am NOT afraid of unexpected scope or design changes
	Feedback & Learning loop	Feedback on work	7a. Allseas - I always reviewed team members' works
			7b. Scrum - I always review team members' works
		Feedback on performance	8a. Allseas - I always reflected on my own and team members' performance
			8b. Scrum - I always reflect on my own and team members' performance
		Aware of improvement points	9a. Allseas - I was aware of my shortcomings as a teamplayer
			9b. Scrum - I am aware of my shortcomings as a teamplayer
		Willingness to improve	10a. Allseas - I was eager to improve and learn on the job
			10b. Scrum - I am eager to improve and learn on the job

Q8

Cluster	**Element**	**Aspect**	For the following statements, rank every statement on a scale of 1 to 5 for both the Allseas way of working and the scrum way of working
(C) Communication	Closed-loop communication	Frequency	1a. Allseas - There was daily communication in the team
			1b. Scrum - There is daily communication in the team
		Spontaneous	2a. Allseas - The form of communication was spontaneous
			2b. Scrum - The form of communication is spontaneous
		Direct	3a. Allseas - All communication was face to face
			3b. Scrum - All communication is face to face
		Indirect	4a. Allseas - All communication was written (e.g. messages, e-mails etc.)
			4b. Scrum - All communication is written (e.g. messages, e-mails etc.)
		Openness	5a. Allseas - I was able to express myself within the team
			5b. Scrum - I am able to express myself withinin the team
			6a. Allseas - I was transparent regarding my work towards team members
			6b. Scrum - I am transparent regarding my work towards team members
			7a. Allseas - Team members were transparent in their work
			7b. Scrum - Team members are transparent in their work
		Awwareness of activities	8a. Allseas - I was up to date on important project progress
			8b. Scrum - I am up to date on important project progress
			9a. Allseas - I was aware of important milestones
			9b. Scrum - I am aware of important milestones
		Accurateness	10a. Allseas - The provided information was usually accurate
			10b. Scrum - The provided information is usually accurate
		Usefulness	11a. Allseas - The provided information was usually useful
			11b. Scrum - The provided information is usually useful
			12a. Allseas - I confirmed that feedback is received
			12b. Scrum - I confirm that feedback is received
			13a. Allseas - I confirmed that feedback is understood
			13b. Scrum - I confirm feedback is understood
			14a. Allseas - I expressed how feedback is perceived
			14b. Scrum - I express how feedback is perceived

	Back-up behaviour	Help and support of team members	15a. Allseas - I provided support for team members wherever I could
			15b. Scrum - I provide support for team members wherever I can
			16a. Allseas - I always received feedback on my work
			16b. Scrum - I always receive feedback on my work
			17a. Allseas - There were enough opportunities to comment on each other's work
			17b. Scrum - There are enough opportunities to comment on each other's work
		Respect for suggestions	18a. Allseas - I reacted positive towards input of colleagues
			18b. Scrum - I react positive towards input of colleagues
			19a. Allseas - I showed an open attitude towards suggestions of colleagues
			19b. Scrum - I show an open attitude towards suggestions of colleagues
		Suggestions stimulate follow-ups	20a. Allseas - Suggestions and contributions were usually considered
			20b. Scrum - Suggestions and contributions are usually considered
			21a. Allseas - Suggestions and contributions were usually discussed and further developed
			21b. Scrum - Suggestions and contributions are usually discussed and further developed
		Conflicts are easily resolved	22a. Allseas - Disagreements were easily resolved
			22b. Scrum - Disagreements are easily resolved
			23a. Allseas - I always found a consensus on important conflicts
			23b. Scrum - I always find a consensus on important conflicts
	Mutual performance monitoring	Aware of team member's activities	24a. Allseas - I was aware of my fellow team members' activities
			24b. Scrum - I am aware of my fellow team members' activities
		Aware of time management	25a. Allseas - I was aware of my fellow team members' availability
			25b. Scrum - I am aware of my fellow team members' availability
			26a. Allseas - I was aware of my fellow team members' priorities
			26b. Scrum - I am aware of my fellow team members' priorities
		Identifying mistakes	27a. Allseas - It was acceptable to point out errors in other's work
			27b. Scrum - It is acceptable to point out errors in other's work
	Coordination	Clarity of tasks	28a. Allseas - I knew what was expected per task
			28b. Scrum - I know what is expected per task
			29a. Allseas - I knew who to ask for help if support is needed
			29b. Scrum - I know who to ask for help if support is needed
		Goals are accepted	30a. Allseas - I was aware what the project goals are
			30b. Scrum - I am aware what the project goals are
		Comprehensiveness of goals	31a. Allseas - I completely comprehended the goals of the project
			31b. Scrum - I completely comprehend the goals of the project
		No conflicting interests regarding goals	32a. Allseas - There were no conflicting interests regarding these goals
			32b. Scrum - There are no conflicting interests regarding these goals

D.2 Questionnaire results

Table D.1 displays the results of the questionnaire. This comprises of a summary of the number of votes per grade and an average grade on each statement of all 48 respondents. Of these 48 respondents, 16,7% had worked with APM before.

Table D.1 Results of questionnaire

Statements	Number of votes					Average grade
	1 - Strongly disagree	2 - Disagree	3 - Neu-tral	4 - Agree	5 - Strongly agree	
1. I am happy to be part of this team	1	0	5	26	16	4,2
2. I enjoy working together	1	1	4	24	18	4,2
3. I always work together with team members	0	4	8	26	10	3,9
4. I feel responsible for my tasks in the project	0	2	0	20	26	4,5
5. I am proud to be part of this team	0	2	10	25	11	3,9
6. I realise the importance of good teamwork	0	0	1	22	25	4,5
7. I feel integrated and part of the team	2	1	8	27	10	3,9
8. I am protective of my team members' work external parties	0	3	16	21	8	3,7
9. There are no personal conflicts in the team	1	7	13	19	8	3,5
10. Personal conflicts are easily resolved	0	6	18	20	4	3,5
11. I sympathise with my team members	0	0	9	31	8	4
12. I recognise the strengths and weaknesses of my team members	0	1	6	35	6	4
13. I keep the team goals in mind while working on individual tasks	0	0	9	32	7	4
14. Interfaces between different disciplines/functionalities are well managed	4	11	16	16	1	3
15. Cooperation is promoted	1	4	19	20	4	3,5
16. If I encounter a problem, I bring it to attention of all team members	0	4	14	24	6	3,7
17. I ensure that my problems are addressed	1	0	9	27	11	4
18. I direct other team members in their tasks	1	4	16	21	6	3,6
19. Teamwork has the highest priority	1	12	17	14	4	3,2
20. I find cooperation essential	0	2	4	29	13	4,1
21. The contribution of team members to the project differs greatly	0	4	16	23	5	3,6
22. The imbalance in member contribution causes conflicts or annoyance	1	7	18	18	4	2,6
23. I find it troublesome that there is an imbalance in member contribution	0	13	14	18	3	2,8

24. Every team member puts a lot of effort in teamwork	1	10	22	15	0	3,1
25. I work hard on this project	1	0	5	30	12	4,1
26. I am highly motivated to deliver a good product	1	0	3	18	26	4,4
1. I am willing to change my habits to benefit the team	0	0	12	30	6	3,9
2. I am open towards other ideas on the project	0	0	1	32	15	4,3
3. The team makes regular changes to the project goal (that I am aware of)	2	8	20	16	2	3,2
4. The team structures the way of adapting project goals	0	11	18	19	0	3,2
5. I can understand sudden unforeseen project changes	1	2	11	22	12	3,9
6. I am NOT afraid of unexpected scope or design changes	0	2	4	26	16	4,2
7. I always review team members' works	2	12	15	13	6	3,2
8. I always reflect on my own and team members' performance	0	6	19	21	2	3,4
9. I am aware of my shortcomings as a teamplayer	1	2	19	25	1	3,5
10. I am eager to improve and learn on the job	0	0	1	28	19	4,4
1. There is daily communication in the team	3	10	10	19	6	3,3
2. The form of communication is spontaneous	0	3	7	30	8	3,9
3. All communication is face to face	3	19	12	10	4	2,9
4. All communication is written (e.g. messages, e-mails etc.)	5	24	15	4	0	2,4
5. I am able to express myself withinin the team	0	2	2	34	10	4,1
6. I am transparent regarding my work towards team members	0	0	6	31	11	4,1
7. Team members are transparent in their work	1	4	17	23	3	3,5
8. I am up to date on important project progress	0	8	16	17	7	3,5
9. I am aware of important milestones	0	6	10	22	10	3,8
10. The provided information is usually accurate	0	7	19	21	1	3,3
11. The provided information is usually useful	0	2	18	26	2	3,6
12. I confirm that feedback is received	1	6	14	25	2	3,4
13. I confirm feedback is understood	0	6	12	28	2	3,5
14. I express how feedback is perceived	1	9	23	14	1	3,1
15. I provide support for team members wherever I can	0	0	3	29	16	4,3
16. I always receive feedback on my work	2	18	17	10	1	2,8

17. There are enough opportunities to comment on each other's work	0	10	19	17	2	3,2
18. I react positive towards input of colleagues	0	0	7	36	5	4
19. I show an open attitude towards suggestions of colleagues	0	0	3	35	10	4,1
20. Suggestions and contributions are usually considered	0	2	6	36	4	3,9
21. Suggestions and contributions are usually discussed and further developed	1	4	11	30	2	3,6
22. Disagreements are easily resolved	2	2	17	24	3	3,5
23. I always find a consensus on important conflicts	1	3	11	30	3	3,6
24. I am aware of my fellow team members' activities	0	4	19	22	3	3,5
25. I am aware of my fellow team members' availability	0	5	19	21	3	3,5
26. I am aware of my fellow team members' priorities	1	6	24	14	3	3,3
27. It is acceptable to point out errors in other's work	0	0	2	32	14	4,3
28. I know what is expected per task	0	3	11	31	3	3,7
29. I know who to ask for help if support is needed	0	3	5	33	7	3,9
30. I am aware what the project goals are	0	0	8	32	8	4
31. I completely comprehend the goals of the project	0	0	13	25	10	3,9
32. There are no conflicting interests regarding these goals	4	9	14	14	7	3,2

E CONFIRMATORY FACTOR ANALYSIS

The Confirmatory Factor Analysis (CFA) has been performed on each single teamwork element. For each teamwork element the following statistics have been analysed to determine the factor loadings and to determine the significance of these loadings (Urdan, 2010).

- Correlations
- Kaiser-Meyer-Olkin (KMO) Test for sampling adequacy
- Bartlett's Test of Sphericity (significance required of $p < 0.05$)

Adaptations to the dataset

To distinguish the data of each of the different clusters from one another, the statements have been given a letter depending on which cluster they are in: (A) commitment and trust, (B) flexibility and (C) communication. Another adaptation to the dataset concern statement A22 and A23, of which the direction has been switched. Initially a 5 on these questions would be negative. This has been made coherent with the rest of the questionnaire.

Methodology

For each element the steps given by Urdan (2010) have been executed. As teamwork element does not comprise of a large number of aspects, the number of factors to extract has been limited to two. Thereafter, the datasets have been rotated by means of a Direct Oblimin (with a Delta of zero) to better define the factors. Finally, the factors have been calculated using the data analysis program SPSS, which applies the calculations of a CFA.

If the correlation matrix showed an aspect with not more than one significant correlation with another aspect, these aspects have been analysed and switched of teamwork element or deleted from the survey. Also, if a KMO or Bartlett's test showed a too low factor score or insignificance, the aspects were reanalysed on a qualitative basis and redistributed over the other teamwork elements or deleted.

E.1 Results of CFA

In this paragraph all adaptations to the conceptual framework have been explained, resulting in multiple redefined teamwork elements. Thereafter, the correlations, KMO tests and Bartlett's tests are presented per teamwork element (Table E.1 until Table E.23). If the teamwork element has been adapted due to primary analytic tests, new KMO tests and new Bartlett's tests have been performed.

The element of cohesion

A3 and A6 show low correlations with the remaining elements of Cohesion. A3 is about the working together, which is not necessarily part of the Happiness aspect and could also fit in the team orientation element, specifically the aspect of effort. In the interview, the reason for this low correlation is checked. A6 is about realising the importance of teamwork, which fits in team orientation as well. If added to Team orientation, The element's KMO increases.

A19 and A20 relate to teamwork priority. As cohesion and teamwork orientation are closely related, it is attempted to assign the aspect of teamwork priority to this element.

From the element of team orientation, the aspect motivation can also be grouped under cohesion. By shifting the aspects Teamwork priority and Motivation from Team orientation to Cohesion and Perception of Teamwork vice versa, the KMO of both elements are significantly raised.

The element of Team leadership

Question A16 had no correlation with any of the other questions of this element. This was also the case for variables in other elements. While the other question that measures the facilitation of problem solving does have significant correlation with other aspects, A16 does not seem to measure what it is expected to. Therefore, it is cancelled from the survey.

The element of Team orientation

By replacing Teamwork priority (A19 and A20) and motivation (A26) by Perception of Teamwork (A6), the KMO is significantly raised.

The element of Adaptability

Aspects B9 and B10 are added to Adaptability.

The element of Feedback & Learning loop

This element showed an insignificant Chi-square. These aspects therefore do not make up the found element of feedback & learning loop. The aspects on feedback can also be linked to the element of back-up behaviour as those have a close relation. If the aspects on the learning loop (B9 and B10) are added to the element of adaptability, the description of this element will change. However, adaptability and the aspects of learning are closely related and correlate significantly with one another. Therefore, the aspects on feedback are added to the element of back-up behaviour, and the aspects of the learning loop are added to the element of adaptability. This dissolves the element of Feedback & Learning loop.

The element of Back-up behaviour

As described above, the feedback aspects from Feedback & learning loop are added. Which raises the KMO.

The aspects of the remaining elements were found significant and could compose a factor.

E.2 CFA statistics

The following nine tables are correlation tables of all teamwork elements . The yellow-marked cells have a significant correlation (higher than .3). By assigning colours to all cells with significant correlations, a quick impression can be created of the questions that might be misinterpreted or show conflicting results.

Table E.1 Correlation table on Cohesion

		A1. I am happy to be part of this team	A2. I enjoy working together	A3. I always work together with team members	A4. I feel responsible for my tasks in the project	A5. I am proud to be part of this team	A6. I realise the importance of good teamwork	A7. I feel integrated and part of the team	A8. I am protective of my team members' work external parties	A9. There are no personal conflicts in the team	A10. Personal conflicts are easily resolved	A11. I sympathise with my team members
A1. I am happy to be part of this team	Pearson Correlation	1	.728**	.162	.471**	.679**	-.050	.656**	.110	.342*	.275	.461**
	Sig. (2-tailed)		.000	.271	.001	.000	.736	.000	.456	.017	.058	.001
	N	48	48	48	48	48	48	48	48	48	48	48
A2. I enjoy working together	Pearson Correlation	.728**	1	.154	.669**	.696**	.116	.640**	.326*	.504**	.487**	.512**
	Sig. (2-tailed)	.000		.296	.000	.000	.433	.000	.024	.000	.000	.000
	N	48	48	48	48	48	48	48	48	48	48	48
A3. I always work together with team members	Pearson Correlation	.162	.154	1	.168	.053	.232	.284	.130	.282	.177	.121
	Sig. (2-tailed)	.271	.296		.252	.723	.113	.051	.377	.052	.230	.413
	N	48	48	48	48	48	48	48	48	48	48	48
A4. I feel responsible for my tasks in the project	Pearson Correlation	.471**	.669**	.168	1	.471**	-.055	.547**	.341*	.446**	.395**	.271
	Sig. (2-tailed)	.001	.000	.252		.001	.712	.000	.018	.002	.005	.063
	N	48	48	48	48	48	48	48	48	48	48	48
A5. I am proud to be part of this team	Pearson Correlation	.679**	.696**	.053	.471**	1	.025	.554**	.268	.259	.243	.449**
	Sig. (2-tailed)	.000	.000	.723	.001		.867	.000	.066	.075	.096	.001
	N	48	48	48	48	48	48	48	48	48	48	48
A6. I realise the importance of good teamwork	Pearson Correlation	-.050	.116	.232	-.055	.025	1	.043	.331*	.077	.237	.097
	Sig. (2-tailed)	.736	.433	.113	.712	.867		.773	.021	.602	.106	.511
	N	48	48	48	48	48	48	48	48	48	48	48
A7. I feel integrated and part of the team	Pearson Correlation	.656**	.640**	.284	.547**	.554**	.043	1	.403**	.352*	.219	.460**
	Sig. (2-tailed)	.000	.000	.051	.000	.000	.773		.005	.014	.135	.001
	N	48	48	48	48	48	48	48	48	48	48	48
A8. I am protective of my team members' work external parties	Pearson Correlation	.110	.326*	.130	.341*	.268	.331*	.403**	1	.271	.389**	.331*
	Sig. (2-tailed)	.456	.024	.377	.018	.066	.021	.005		.063	.006	.022
	N	48	48	48	48	48	48	48	48	48	48	48
A9. There are no personal conflicts in the team	Pearson Correlation	.342*	.504**	.282	.446**	.259	.077	.352*	.271	1	.616**	.335*
	Sig. (2-tailed)	.017	.000	.052	.002	.075	.602	.014	.063		.000	.020
	N	48	48	48	48	48	48	48	48	48	48	48
A10. Personal conflicts are easily resolved	Pearson Correlation	.275	.487**	.177	.395**	.243	.237	.219	.389**	.616**	1	.535**
	Sig. (2-tailed)	.058	.000	.230	.005	.096	.106	.135	.006	.000		.000
	N	48	48	48	48	48	48	48	48	48	48	48
A11. I sympathise with my team members	Pearson Correlation	.461**	.512**	.121	.271	.449**	.097	.460**	.331*	.335*	.535**	1
	Sig. (2-tailed)	.001	.000	.413	.063	.001	.511	.001	.022	.020	.000	
	N	48	48	48	48	48	48	48	48	48	48	48

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table E.2 Correlation table on Team leadership

		A12. I recognise the strengths and weaknesses of my team members	A13. I keep the team goals in mind while working on individual tasks	A14. Interfaces between different disciplines/functionalities are well managed	A15. Cooperation is promoted	A16. If I encounter a problem, I bring it to attention of all team members	A17. I ensure that my problems are addressed	A18. I direct other team members in their tasks
A12. I recognise the strengths and weaknesses of my team members	Pearson Correlation	1	.372**	.145	.212	.060	.231	.413**
	Sig. (2-tailed)		.009	.326	.149	.684	.114	.004
	N	48	48	48	48	48	48	48
A13. I keep the team goals in mind while working on individual tasks	Pearson Correlation	.372**	1	.145	.255	.151	.138	.331*
	Sig. (2-tailed)	.009		.326	.081	.306	.350	.021
	N	48	48	48	48	48	48	48
A14. Interfaces between different disciplines/functionalities are well managed	Pearson Correlation	.145	.145	1	.588**	-.088	.325*	.179
	Sig. (2-tailed)	.326	.326		.000	.553	.024	.222
	N	48	48	48	48	48	48	48
A15. Cooperation is promoted	Pearson Correlation	.212	.255	.588**	1	-.021	.238	.185
	Sig. (2-tailed)	.149	.081	.000		.889	.103	.208
	N	48	48	48	48	48	48	48
A16. If I encounter a problem, I bring it to attention of all team members	Pearson Correlation	.060	.151	-.088	-.021	1	.224	.264
	Sig. (2-tailed)	.684	.306	.553	.889		.127	.069
	N	48	48	48	48	48	48	48
A17. I ensure that my problems are addressed	Pearson Correlation	.231	.138	.325*	.238	.224	1	.138
	Sig. (2-tailed)	.114	.350	.024	.103	.127		.350
	N	48	48	48	48	48	48	48
A18. I direct other team members in their tasks	Pearson Correlation	.413**	.331*	.179	.185	.264	.138	1
	Sig. (2-tailed)	.004	.021	.222	.208	.069	.350	
	N	48	48	48	48	48	48	48

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table E.3 Correlation table on Team orientation

		A19. Teamwork has the highest priority	A20. I find cooperation essential	A21. The contribution of team members to the project differs greatly	A22. The imbalance in member contribution causes conflicts or annoyance	A23. I find it troublesome that there is an imbalance in member contribution	A24. Every team member puts a lot of effort in teamwork	A25. I work hard on this project	A26. I am highly motivated to deliver a good product	A6. I realise the importance of good teamwork
A19. Teamwork has the highest priority	Pearson Correlation	1	.220	-.118	.029	-.006	.374*	.213	.476**	.064
	Sig. (2-tailed)		.178	.476	.860	.971	.019	.192	.002	.701
	N	39	39	39	39	39	39	39	39	39
A20. I find cooperation essential	Pearson Correlation	.220	1	.171	.003	.130	.025	.035	.056	.625**
	Sig. (2-tailed)	.178		.298	.984	.429	.878	.831	.735	.000
	N	39	39	39	39	39	39	39	39	39
A21. The contribution of team members to the project differs greatly	Pearson Correlation	-.118	.171	1	.481**	.320*	-.261	.121	-.169	.020
	Sig. (2-tailed)	.476	.298		.002	.047	.109	.463	.303	.905
	N	39	39	39	39	39	39	39	39	39
A22. The imbalance in member contribution causes conflicts or annoyance	Pearson Correlation	.029	.003	.481**	1	.621**	-.258	.197	-.165	-.162
	Sig. (2-tailed)	.860	.984	.002		.000	.113	.229	.314	.324
	N	39	39	39	39	39	39	39	39	39
A23. I find it troublesome that there is an imbalance in member contribution	Pearson Correlation	-.006	.130	.320*	.621**	1	-.324*	.225	-.111	-.057
	Sig. (2-tailed)	.971	.429	.047	.000		.044	.169	.500	.732
	N	39	39	39	39	39	39	39	39	39
A24. Every team member puts a lot of effort in teamwork	Pearson Correlation	.374*	.025	-.261	-.258	-.324*	1	-.080	.102	.052
	Sig. (2-tailed)	.019	.878	.109	.113	.044		.627	.538	.751
	N	39	39	39	39	39	39	39	39	39
A25. I work hard on this project	Pearson Correlation	.213	.035	.121	.197	.225	-.080	1	.449**	-.034
	Sig. (2-tailed)	.192	.831	.463	.229	.169	.627		.004	.837
	N	39	39	39	39	39	39	39	39	39
A26. I am highly motivated to deliver a good product	Pearson Correlation	.476**	.056	-.169	-.165	-.111	.102	.449**	1	.053
	Sig. (2-tailed)	.002	.735	.303	.314	.500	.538	.004		.748
	N	39	39	39	39	39	39	39	39	39
A6. I realise the importance of good teamwork	Pearson Correlation	.064	.625**	.020	-.162	-.057	.052	-.034	.053	1
	Sig. (2-tailed)	.701	.000	.905	.324	.732	.751	.837	.748	
	N	39	39	39	39	39	39	39	39	39

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table E.4 Correlation table on Adaptability

		B1. I am willing to change my habits to benefit the team	B2. I am open towards other ideas on the project	B3. The team makes regular changes to the project goal (that I am aware of)	B4. The team structures the way of adapting project goals	B5. I can understand sudden unforeseen project changes	B6. I am NOT afraid of unexpected scope or design changes
B1. I am willing to change my habits to benefit the team	Pearson Correlation	1	.417**	.120	.021	.144	.313
	Sig. (2-tailed)		.008	.467	.897	.381	.052
	N	39	39	39	39	39	39
B2. I am open towards other ideas on the project	Pearson Correlation	.417**	1	.120	.182	.140	.516**
	Sig. (2-tailed)	.008		.466	.268	.396	.001
	N	39	39	39	39	39	39
B3. The team makes regular changes to the project goal (that I am aware of)	Pearson Correlation	.120	.120	1	.476**	.164	-.023
	Sig. (2-tailed)	.467	.466		.002	.320	.889
	N	39	39	39	39	39	39
B4. The team structures the way of adapting project goals	Pearson Correlation	.021	.182	.476**	1	.118	-.039
	Sig. (2-tailed)	.897	.268	.002		.473	.813
	N	39	39	39	39	39	39
B5. I can understand sudden unforeseen project changes	Pearson Correlation	.144	.140	.164	.118	1	.391*
	Sig. (2-tailed)	.381	.396	.320	.473		.014
	N	39	39	39	39	39	39
B6. I am NOT afraid of unexpected scope or design changes	Pearson Correlation	.313	.516**	-.023	-.039	.391*	1
	Sig. (2-tailed)	.052	.001	.889	.813	.014	
	N	39	39	39	39	39	39

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table E.5 Correlation table on Feedback & Learning loop

		B7. I always review team members' works	B8. I always reflect on my own and team members' performance	B9. I am aware of my shortcomings as a teamplayer	B10. I am eager to improve and learn on the job
B7. I always review team members' works	Pearson Correlation	1	.191	-.118	.134
	Sig. (2-tailed)		.194	.423	.364
	N	48	48	48	48
B8. I always reflect on my own and team members' performance	Pearson Correlation	.191	1	.113	.360*
	Sig. (2-tailed)	.194		.445	.012
	N	48	48	48	48
B9. I am aware of my shortcomings as a teamplayer	Pearson Correlation	-.118	.113	1	.077
	Sig. (2-tailed)	.423	.445		.602
	N	48	48	48	48
B10. I am eager to improve and learn on the job	Pearson Correlation	.134	.360*	.077	1
	Sig. (2-tailed)	.364	.012	.602	
	N	48	48	48	48

*. Correlation is significant at the 0.05 level (2-tailed).

Table E.6 Correlation table on Closed-loop communication

		C1. There is daily communication in the team	C2. The form of communication is spontaneous	C3. All communication is face to face	C4. All communication is written (e.g. messages, e-mails etc.)	C5. I am able to express myself withinin the team	C6. I am transparent regarding my work towards team members	C7. Team members are transparent in their work	C8. I am up to date on important project progress	C9. I am aware of important milestones	C10. The provided information is usually accurate	C11. The provided information is usually useful	C12. I confirm that feedback is received	C13. I confirm feedback ack is understood	C14. I express how feedback is perceived
C1. There is daily communication in the team	Pearson Correlation	1	.039	.279	-.134	.370**	.268	.451**	.275	.156	.374**	.356*	.320*	.338*	.453**
	Sig. (2-tailed)		.792	.055	.364	.010	.066	.001	.059	.290	.009	.013	.027	.019	.001
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C2. The form of communication is spontaneous	Pearson Correlation	.039	1	.189	-.220	.062	.073	.048	.162	-.008	-.013	.040	-.161	-.158	.018
	Sig. (2-tailed)	.792		.199	.133	.675	.623	.746	.272	.959	.933	.786	.275	.284	.902
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C3. All communication is face to face	Pearson Correlation	.279	.189	1	.188	.018	.222	.150	.152	.151	.035	.183	.047	.071	.187
	Sig. (2-tailed)	.055	.199		.200	.906	.130	.308	.303	.305	.816	.212	.749	.633	.203
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C4. All communication is written (e.g. messages, e-mails etc.)	Pearson Correlation	-.134	-.220	.188	1	-.229	-.131	-.282	-.046	.043	-.107	-.021	-.028	-.061	-.096
	Sig. (2-tailed)	.364	.133	.200		.117	.375	.052	.754	.770	.467	.888	.851	.679	.515
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C5. I am able to express myself withinin the team	Pearson Correlation	.370**	.062	.018	-.229	1	.199	.562**	.351*	.211	.422**	.339*	.010	.036	.187
	Sig. (2-tailed)	.010	.675	.906	.117		.175	.000	.014	.149	.003	.018	.948	.810	.203
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C6. I am transparent regarding my work towards team members	Pearson Correlation	.268	.073	.222	-.131	.199	1	.288*	.289*	.240	.159	.282	.162	.060	-.023
	Sig. (2-tailed)	.066	.623	.130	.375	.175		.047	.046	.100	.280	.052	.273	.684	.875
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C7. Team members are transparent in their work	Pearson Correlation	.451**	.048	.150	-.282	.562**	.288*	1	.300*	.186	.422**	.462**	.029	.119	.115
	Sig. (2-tailed)	.001	.746	.308	.052	.000	.047		.039	.205	.003	.001	.847	.422	.435
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C8. I am up to date on important project progress	Pearson Correlation	.275	.162	.152	-.046	.351*	.289*	.300*	1	.717**	.399**	.334*	.343*	.425**	.380**
	Sig. (2-tailed)	.059	.272	.303	.754	.014	.046	.039		.000	.005	.021	.017	.003	.008
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C9. I am aware of important milestones	Pearson Correlation	.156	-.008	.151	.043	.211	.240	.186	.717**	1	.212	.247	.060	.133	.149
	Sig. (2-tailed)	.290	.959	.305	.770	.149	.100	.205	.000		.149	.091	.683	.367	.314
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C10. The provided information is usually accurate	Pearson Correlation	.374**	-.013	.035	-.107	.422**	.159	.422**	.399**	.212	1	.640**	.300*	.379**	.222
	Sig. (2-tailed)	.009	.933	.816	.467	.003	.280	.003	.005	.149		.000	.038	.008	.129
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C11. The provided information is usually useful	Pearson Correlation	.356*	.040	.183	-.021	.339*	.282	.462**	.334*	.247	.640**	1	.107	.164	.003
	Sig. (2-tailed)	.013	.786	.212	.888	.018	.052	.001	.021	.091	.000		.471	.267	.982
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C12. I confirm that feedback is received	Pearson Correlation	.320*	-.161	.047	-.028	.010	.162	.029	.343*	.060	.300*	.107	1	.834**	.306*
	Sig. (2-tailed)	.027	.275	.749	.851	.948	.273	.847	.017	.683	.038	.471		.000	.035
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C13. I confirm feedback is understood	Pearson Correlation	.338*	-.158	.071	-.061	.036	.060	.119	.425**	.133	.379**	.164	.834**	1	.421**
	Sig. (2-tailed)	.019	.284	.633	.679	.810	.684	.422	.003	.367	.008	.267	.000		.003
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
C14. I express how feedback is perceived	Pearson Correlation	.453**	.018	.187	-.096	.187	-.023	.115	.380**	.149	.222	.003	.306*	.421**	1
	Sig. (2-tailed)	.001	.902	.203	.515	.203	.875	.435	.008	.314	.129	.982	.035	.003	
	N	48	48	48	48	48	48	48	48	48	48	48	48	48	48

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table E.7 Correlation table on Back-up behaviour

		C15. I provide support for team members wherever I can	C16. I always receive feedback on my work	C17. There are enough opportunities to comment on each other's work	C18. I react positive towards input of colleagues	C19. I show an open attitude towards suggestions of colleagues	C20. Suggestions and contributions are usually considered	C21. Suggestions and contributions are usually discussed and further developed	C22. Disagreements are easily resolved	C23. I always find a consensus on important conflicts
C15. I provide support for team members wherever I can	Pearson Correlation	1	-.136	-.177	.261	.375**	-.207	-.214	-.196	-.066
	Sig. (2-tailed)		.357	.228	.073	.009	.159	.144	.181	.656
	N	48	48	48	48	48	48	48	48	48
C16. I always receive feedback on my work	Pearson Correlation	-.136	1	.521**	.074	-.025	.264	.234	.223	.225
	Sig. (2-tailed)	.357		.000	.615	.864	.070	.110	.128	.124
	N	48	48	48	48	48	48	48	48	48
C17. There are enough opportunities to comment on each other's work	Pearson Correlation	-.177	.521**	1	-.078	.020	.354*	.309*	.256	.192
	Sig. (2-tailed)	.228	.000		.597	.892	.014	.033	.079	.191
	N	48	48	48	48	48	48	48	48	48
C18. I react positive towards input of colleagues	Pearson Correlation	.261	.074	-.078	1	.359*	-.017	-.098	.149	.070
	Sig. (2-tailed)	.073	.615	.597		.012	.906	.510	.312	.639
	N	48	48	48	48	48	48	48	48	48
C19. I show an open attitude towards suggestions of colleagues	Pearson Correlation	.375**	-.025	.020	.359*	1	.061	-.111	-.025	-.028
	Sig. (2-tailed)	.009	.864	.892	.012		.681	.455	.867	.850
	N	48	48	48	48	48	48	48	48	48
C20. Suggestions and contributions are usually considered	Pearson Correlation	-.207	.264	.354*	-.017	.061	1	.641**	.454**	.442**
	Sig. (2-tailed)	.159	.070	.014	.906	.681		.000	.001	.002
	N	48	48	48	48	48	48	48	48	48
C21. Suggestions and contributions are usually discussed and further developed	Pearson Correlation	-.214	.234	.309*	-.098	-.111	.641**	1	.472**	.406**
	Sig. (2-tailed)	.144	.110	.033	.510	.455	.000		.001	.004
	N	48	48	48	48	48	48	48	48	48
C22. Disagreements are easily resolved	Pearson Correlation	-.196	.223	.256	.149	-.025	.454**	.472**	1	.717**
	Sig. (2-tailed)	.181	.128	.079	.312	.867	.001	.001		.000
	N	48	48	48	48	48	48	48	48	48
C23. I always find a consensus on important conflicts	Pearson Correlation	-.066	.225	.192	.070	-.028	.442**	.406**	.717**	1
	Sig. (2-tailed)	.656	.124	.191	.639	.850	.002	.004	.000	
	N	48	48	48	48	48	48	48	48	48

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table E.8 Correlation table on Mutual performance monitoring

		C24. I am aware of my fellow team members' activities	C25. I am aware of my fellow team members' availability	C26. I am aware of my fellow team members' priorities	C27. It is acceptable to point out errors in other's work
C24. I am aware of my fellow team members' activities	Pearson Correlation	1	.668**	.580**	.109
	Sig. (2-tailed)		.000	.000	.462
	N	48	48	48	48
C25. I am aware of my fellow team members' availability	Pearson Correlation	.668**	1	.642**	.026
	Sig. (2-tailed)	.000		.000	.859
	N	48	48	48	48
C26. I am aware of my fellow team members' priorities	Pearson Correlation	.580**	.642**	1	-.048
	Sig. (2-tailed)	.000	.000		.745
	N	48	48	48	48
C27. It is acceptable to point out errors in other's work	Pearson Correlation	.109	.026	-.048	1
	Sig. (2-tailed)	.462	.859	.745	
	N	48	48	48	48

**. Correlation is significant at the 0.01 level (2-tailed).

Table E.9 Correlation table on Coordination

		C28. I know what is expected per task	C29. I know who to ask for help if support is needed	C30. I am aware what the project goals are	C31. I completely comprehend the goals of the project	C32. There are no conflicting interests regarding these goals
C28. I know what is expected per task	Pearson Correlation	1	.256	.214	.408**	.112
	Sig. (2-tailed)		.079	.145	.004	.449
	N	48	48	48	48	48
C29. I know who to ask for help if support is needed	Pearson Correlation	.256	1	.565**	.463**	.254
	Sig. (2-tailed)	.079		.000	.001	.082
	N	48	48	48	48	48
C30. I am aware what the project goals are	Pearson Correlation	.214	.565**	1	.576**	.187
	Sig. (2-tailed)	.145	.000		.000	.204
	N	48	48	48	48	48
C31. I completely comprehend the goals of the project	Pearson Correlation	.408**	.463**	.576**	1	.383**
	Sig. (2-tailed)	.004	.001	.000		.007
	N	48	48	48	48	48
C32. There are no conflicting interests regarding these goals	Pearson Correlation	.112	.254	.187	.383**	1
	Sig. (2-tailed)	.449	.082	.204	.007	
	N	48	48	48	48	48

**. Correlation is significant at the 0.01 level (2-tailed).

The following tables show the statistics that follow from the CFA. Required for these analyses are the KMO figure which should be above .6 and the Bartlett's Test of Sphericity which should be significant. For some elements, the CFA has been executed multiple times after a shift in teamwork aspects had taken place, therefore the tables are marked with 'initial' and 'final.'

Table E.10 Initial KMO and Bartlett's Test on Cohesion

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.751
Bartlett's Test of Sphericity	Approx. Chi-Square	186.567
	Df	55
	Sig.	.000

Table E.11 Final KMO and Bartlett's Test on Cohesion

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.804
Bartlett's Test of Sphericity	Approx. Chi-Square	310.026
	Df	66
	Sig.	.000

Table E.12 Initial KMO and Bartlett's Test on Team leadership

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.620
Bartlett's Test of Sphericity	Approx. Chi-Square	54.064
	Df	21
	Sig.	.000

Table E.13 Final KMO and Bartlett's Test on Team leadership

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.666
Bartlett's Test of Sphericity	Approx. Chi-Square	46.601
	Df	15
	Sig.	.000

Table E.14 Initial KMO and Bartlett's Test on Team orientation

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.567
Bartlett's Test of Sphericity	Approx. Chi-Square	99.501
	Df	28
	Sig.	.000

Table E.15 Final KMO and Bartlett's Test on Team orientation

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.653
Bartlett's Test of Sphericity	Approx. Chi-Square	40.116
	Df	15
	Sig.	.000

Table E.16 Initial KMO and Bartlett's Test on Adaptability

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.629
Bartlett's Test of Sphericity	Approx. Chi-Square	50.345
	Df	15
	Sig.	.000

Table E.17 Final KMO and Bartlett's Test on Adaptability

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.659
Bartlett's Test of Sphericity	Approx. Chi-Square	61.267
	Df	21
	Sig.	.000

Table E.18 Initial KMO and Bartlett's Test on Feedback & Learning loop

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.541
Bartlett's Test of Sphericity	Approx. Chi-Square	9.744
	Df	6
	Sig.	.136

Table E.19 Initial KMO and Bartlett's Test on Closed-loop communication

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.652
Bartlett's Test of Sphericity	Approx. Chi-Square	240.609
	Df	91
	Sig.	.000

Table E.20 Initial KMO and Bartlett's Test on Back-up behaviour

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.670
Bartlett's Test of Sphericity	Approx. Chi-Square	114.876
	Df	36
	Sig.	.000

Table E.21 Final KMO and Bartlett's Test on Back-up behaviour

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.684
Bartlett's Test of Sphericity	Approx. Chi-Square	167.018
	Df	55
	Sig.	.000

Table E.22 Initial KMO and Bartlett's Test on Mutual performance monitoring

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.704
Bartlett's Test of Sphericity	Approx. Chi-Square	55.033
	Df	6
	Sig.	.000

Table E.23 Initial KMO and Bartlett's Test on Back-up behaviour

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.685
Bartlett's Test of Sphericity	Approx. Chi-Square	53.593
	Df	10
	Sig.	.000

F Multi-Criteria Analysis

A different approach on analysing the data for comparing the pilot project team with the Innovations department was attempted, the method of assigning coefficients as if the analysis was a Multi-Criteria Analysis (MCA). An MCA can work as a PCA of the indicator matrix (Greenacre, 2007). In this method, the coefficients need to be deduced from literature or other sources. Therefore, all elements have been given a certain coefficient in which they contribute to teamwork based on multiple sources.

All questions, aspects, elements and clusters have been graded on the level of contribution to the overall teamwork quality. Grading the coefficients of all clusters and elements has been executed based on literature in order to make distinctions between the importance of elements to the overall teamwork. In literature the papers of Dickinson & McIntyre (1997), Hoegl & Gemuenden (2001) and Salas et al. (2005) have been intensively studied to determine which teamwork elements contribute the most to teamwork. These elements have then been prioritised and assigned percentages. The relation between the aspects and the elements has been proposed in this report and can therefore not be precisely given. This has led to the decision to not distinct the rates among the aspects per teamwork element, but only to assign varying coefficients to the elements and clusters.

The coefficients that are assigned to all teamwork elements are presented in Table F.1. The MCA is used to translate the scores that were assigned to the statements of the survey into interpretable figures, which represent both the opinion of the surveyed and the importance of the aspect to teamwork. This way, the teamwork elements can be compared reciprocally, independent of their number of respondents.

The validity of this MCA cannot be tested as the pilot project team only consists of nine team members. This MCA therefore only has an indicative purpose in this research. It will be used to direct the validation interviews as this analysis does provide an image of the difference in teamwork quality between the pilot project team before Scrum and the pilot project team after Scrum.

Table F.1 Coefficients MCA (Own table)

Cluster	Percentage of teamwork	Element	Percentage of cluster	Aspect	Percentage of element
Commitment and trust	35	Cohesion	30	Happiness	12.5
				Responsibility	12.5
				Pride	12.5
				Perception of teamwork	12.5
				Integration	12.5
				Protectiveness	12.5
				Personal conflicts	12.5
				Sympathy	12.5
		Team leadership	20	Characteristics recognition	20
				Contribution to team goals	20
				Focussed on team functioning	20
				Facilitate problem solving	20
				Steering of team members	20
		Team orientation	50	Teamwork priority	25

				Imbalance in member contribution	25
				Effort	25
				Motivation	25
Flexibility	15	Adaptability	100	Stubbornness	20
				Regular adaptations to project goals	20
				Reaction on changing conditions	20
				Aware of improvement points	20
				Willingness to improve	20
Communication	50	Closed-loop communication	40	Frequency	12.5
				Spontaneous	12.5
				Direct	12.5
				Indirect	12.5
Communication		Closed-loop communication		Openness	12.5
				Awareness of activities	12.5
				Accurateness	12.5
				Usefulness	12.5
		Back-up behaviour	15	Help and support of team members	16.7
				Respect for suggestions	16.7
				Suggestions stimulate follow-ups	16.7
				Conflicts are easily resolved	16.7
				Feedback on work	16.7
				Feedback on performance	16.7
		Mutual performance monitoring	20	Aware of team member's activities	33.3
				Aware of time management	33.3
				Identifying mistakes	33.3
		Coordination	25	Clarity of tasks	25
				Goals are accepted	25
				Comprehensiveness of goals	25
				No conflicting interests regarding goals	25

To interpret the survey, the scores that the surveyed assigned to the statements which were ranked between 1 and 5, are changed to a scale of -5, -2.5, 0, 2.5 and 5. By replacing the scores, the differences in the data becomes clearer as the neutral score on the score grid with identifiers completely disagree, disagree, neutral, agree and completely agree now becomes fully neutral by the score of 0.

To be able to compare the different target groups (Innovations and Scrum team), the scores of the MCA must be divided by the number of respondents. This has as a result that the individual statements can be scored on a grid from -5 to 5. To better present the figures, all figures have thereafter been multiplied by 10, to create a scale of -50 to 50. Applying the coefficients and the ranking scale on the data set has led to scores on all elements, clusters and an overall teamwork quality score per target group (Table F.2).

Table F.2 Results of MCA (Own table)

			Pilot project team before Scrum			Pilot project team after Scrum			Department Innovations		
Score cohesion	Score commitment & trust	Score TWQ	15.4	14.1	12.4	24.3	21.7	21.0	24.1	22.2	17.6
Score team leadership			10.6			19.4			18.4		
Score team orientation			11.6			14.2			18.6		
Score adaptability	Score adaptability		14.6	14.6		18.1	18.9		19.2	19.7	
Score closed-loop communication	Score communication		6.6	10.9		14.6	20.2		9.9	13.9	
Score back-up behaviour			10.4			18.6			14.0		
Score mutual performance monitoring			10.2			24.1			17.5		
Score coordination			17.7			29.5			18.6		
			n=9			n=9			n=48		

To compare the three groups more easily, Table F.3 has been constructed which shows the differences between the two reference groups with the Scrum team more clearly.

Table F.3 Differences per teamwork element compared to Scrum team (Own table)

	Pilot project team before Scrum	Department Innovations
Score cohesion	-8.9%	-0.2%
Score team leadership	-8.9%	-1.1%
Score team orientation	-2.7%	+4.3%
Score adaptability	-3.4%	+1.1%
Score closed-loop communication	-8.0%	-4.7%
Score back-up behaviour	-8.2%	-4.6%
Score mutual performance monitoring	-13.9%	-6.5%
Score coordination	-11.8%	-10.9%

<u>Conclusion MCA</u>

Even though the MCA holds an indicative purpose, a clear distinction appears within the pilot project team which has to be further investigated during the interviews. Although not a high difference, overall teamwork quality is improved by 4.6% and overall communication by 9.3%. The coordinative role that the Taskboard holds, also improves teamwork quality as team members of the pilot project team have rated the element of coordination 11% higher.

G VALIDATION INTERVIEWS

The interviews were conducted at Allseas and follow the hereafter described interview structure (section G.1).

G.1 Interview structure

- Aim: validate observations gathered during the implementation of Scrum in the pilot project team.
- Please think of your actions in this project only, unless asked otherwise.

Table G.1 Interview structure

Interviewer	**J.R.W. (Jasper) Sonneveld**
Interviewee	
Date	
Time	
Location	

General questions	
1.	Gender
2.	Age
3.	Function
4.	Years of experience
5.	Highest education
6.	Field of education
Cohesion	
7.	How would you describe the group dynamics and how did this change with agile? Did certain people start acting differently on a character level?
8.	It became clear that people did not always do as told. How did this influence your opinion of colleagues?
Team leadership	
9.	Scrum focusses on self-organisation. This means that not everything is directed by the project manager, how do you reflect upon this change in the project organisation?
10.	PO only: Where you better able to steer team members?
Team orientation	
11.	Do you think team members worked harder now that there was more communication and everyone else was aware of their activities?
Flexibility	
12.	In what ways was it easier to implement design changes?

13.	For some people it is important to learn on the job. Did you get better opportunities to improve your own knowledge with Scrum?
Communication	
14.	How do you rate the influence of the daily meetings?
Back-up behaviour	
15.	How do you think team members were motivated to help each other? Did you see this happen a lot?
Mutual performance monitoring	
16.	Were you more aware of your team members' activities? If so, how did this influence your own functioning?
17.	The assigned time to tasks was rarely realistic, how do you think this can be improved (Broad sense, not too much detail on TFS)?
18.	In what way do you think assigning time to task was still valuable (think of forcing someone to plan)?
Coordination	
19.	Do you think that you did your job differently, now that you were better aware of project goals?
Team roles	
20.	How would an internal Scrum Guide improve the method?
21.	In essence, everyone should be able to perform all tasks. Why do you think this is not possible within an engineering team?
Bias in questionnaire	
22.	Would you have graded the original teamwork higher if you had not known about agile?
23.	Which agile principles do you think are applied and how do you see these principles manifested in the team? Rate all agile principles upon their application in the project. All agile principles were given.
Scrum overall	
24.	Do you think your work has improved since the use of Scrum? What were the most significant improvements?
25.	What effected your role as engineer/manager the most?
26.	Did Scrum help you to do your job?

G.2 Summary pilot project team interviews

Four interviews have been conducted at Allseas. In Table G.2 and Table G.3, these interviews have been summarised.

Table G.2 Summary of interviews with pilot project team members, nr. 1 & 2

	Pilot project team interview 1	Pilot project team interview 2
Interviewer	J.R.W. (Jasper) Sonneveld	J.R.W. (Jasper) Sonneveld
Interviewee	Bram	Zylvester
Date	27 November 2017	27 November 2017
Time	10:00-11:30	14:30-15:45
Location	Allseas engineering Delft	Allseas engineering Delft
1. Gender	Male	Male
2. Age	32	31
3. Function	Lead engineer	R&D engineer
4. Years of experience	7.5	4
5. Highest education	HBO	WO
6. Field of education	Mechanical Engineering	Mechanical Engineering
7. How would you describe the group dynamics and how did this change with agile? Did certain people start acting differently on a character level?	All team members were much better informed. This can be attributed to the higher number of interaction moments between the team members. Due to these interactions, the team dynamics changes for the better. The result is that team members cannot slack without being noticed.	You make a commitment every day, which also means that you recommit to tasks that are ongoing. This forces yourself onto executing the task. I did not start to like my colleagues more or see changes in their personality. But we were definitely a better collaborating team.
8. It became clear that people did not always do as told. How did this influence your opinion of colleagues?	It did not really change. It was more a confirmation of how colleagues handle certain responsibilities and promises. It also became clear when team members put in a high amount of effort, this did influence my opinion of colleagues positively.	I did not see my opinion of a team member be influenced by his work performed. Only if they had completed tasks my opinion of them changed, and almost always positive. I had the understanding that team members could be working on other projects and as long as they could justify their inactions, I found that easy to accept. Without Scrum I did become more negative about them as I was not aware of the time they put in other projects.

9. Scrum focusses on self-organisation. This means that not everything is directed by the project manager, how do you reflect upon this change in the project organisation?	This was performed to a limited extent. It was very dependent on how a person liked the new project management method. The proactive engineers decided what their tasks would be themselves, while the more reactive engineers waited on the project manager to give them a task. [brainstorming on how self-organisation can be achieved]: I think this could only work if there was only one deliverable per Sprint and no parallel engineering on different parts of the project are performed. Then no one would be more responsible for some items than others. However, this did not work in this project.	Most tasks were still imposed by the lead engineer as his overview of the project was still better than ours and he was more aware of who could do what. This also originated in an expectant attitude of the team, which was especially in the beginning, hard to overcome. However, all engineers with at least some experience know which design steps have to be taken. Follow-up tasks were thereby easy to choose by the team themselves. But these steps were already taken before Scrum as well.
10. PO's only: Where you better able to steer team members?	Yes. Thanks to the higher amount of interaction, the team members themselves explained their deliverables and tasks. This was highly dependent of the person's openness, but monitoring became much easier thanks to the Taskboard.	-
11. Do you think team members worked harder now that there was more communication and everyone else was aware of their activities?	That is difficult to say. The amount of shame that is felt when one has to explain that a certain task is not achieved, is limited. Therefore, it did not directly lead to team members being forced to work harder. The team did work harder, but not significantly. This can also be attributed to a decreasing amount of pressure by the client.	We were more motivated and we knew exactly what we were working on because of Scrum. I don't know if everyone worked harder, but at least it was way more efficient. We became more motivated because of all impulses that you get when discussing your own work.
12. In what ways was it easier to implement design changes?	Everyone is more aware of the flaws of the design and these are easy to adjust because you meet every day. On this Scrum characteristic, we did enlarge the Daily meetings with 5 minutes to discuss several technical aspects as well next to the usual organisational aspects. Without this, it wouldn't be as easy to implement design changes.	I had the feeling that we spend a minimum of time on unnecessary work. This is the case because we were always aware of the work of our team members and could redirect each other if we were doing double work. However, implementing design changes could not really be done during the daily meetings. There is also a psychological aspect to these meetings, it is that you don't want to overload your colleagues with questions and if you have already seen them, you're not going to bother them again.

13. For some people it is important to learn on the job. Did you get better opportunities to improve your own knowledge with Scrum?	Not necessarily. There were some tasks for which team members had to work outside of their comfort zone, but these tasks would have to be performed anyway.	No not really. I learned a new project management method, but that is it. I did not learn new hard skills. I was better aware of my own planning skills, but I do not count that as improvement.
14. How do you rate the influence of the daily meetings?	Extremely high. I had so much more overview of the project, and everything could be steered in the right direction at any point in time.	The meetings were the most important improvement. We had so much more communication within the team, everyone knew exactly what had to be done. Although we should keep an eye on the topics that we discuss during the daily meetings. Discussing topics over and over is a danger which should be averted
15. How do you think team members were motivated to help each other? Did you see this happen a lot?	Yes, definitely. Because all problems came to light in an early stage, all team members attempted to help one another. This does not necessarily mean that the team was more motivated to help, but Scrum created a platform where this motivation could be manifested.	No, I was not more motivated. But due to the higher amount of contact moments, I helped others way more than before. I also knew exactly what the task was when someone asked for help, and you knew how much time it would probably take to take over such a task. So, in that case, we were more willing to help.
16. Were you more aware of your team members' activities? If so, how did this influence your own functioning?	Yes. Before implementing Scrum, it cost me much more effort to stay aware of all activities. However, now I am much more aware, with a lot less effort. It made my job as a lead engineer so much more structured and clear.	Definitely. Before, I only knew about my own tasks, but now I am very aware of all tasks. It did not really influence my own functioning regarding my own tasks, but I did help out others more often and it was nice to be aware of the overall progress of the project.
17. The assigned time to tasks was rarely realistic, how do you think this can be improved (Broad sense, not too much detail on TFS)?	It is still really difficult to get statistics from the program. Therefore, it became less important for me to keep track of the time spent on all tasks. Also, many tasks take longer than software engineering tasks and often span multiple days. This lead to underestimation of times and when performing the tasks, not everyone was honest about the time it took. [Answer focussed on more practical aspects of the program only]	Now that the team is aware of their lack of planning skills, a factor should be added when assigning time, for inefficiency and other small tasks that turn out to be part of a bigger task. In the first sprints we did not add the reviewing part of documents to the time of a task, but we did include it in the task. That's why it was rarely realistic. However, in later stages this went better and better. I also think that if this project management method is more widely carried within the company, it will be easier

		to get accustomed to as it is not just an exception to normal project execution.
18. In what way do you think assigning time to task was still valuable (think of forcing someone to plan)?	When an engineer had to assign time to a task, it forced them to think about their tasks and thereby to plan as well. It also gave more clarity on how many tasks an engineer could handle, even though the assigned times were not really realistic.	It did make it highly insightful how all tasks were executed and I can understand that for a lead engineer, this helps planning of the project.
19. Do you think that you did your job differently, now that you were better aware of project goals?	It created rest for myself because I had a better overview. You still try to achieve goals which sometimes are too ambitious, but you actively check these every day and realise early on what can be completed. By actively working with the list of tasks, it also showed the rest of the team the amount of effort that still had to be done. This partially shifted my feeling of responsibility towards the rest of the team.	You're dealing with a lot shorter sections. The overview of things ahead is narrowed down a lot because of this, but still everyone was aware of the project goals. It was therefore easier to suggest new tasks that derived from current activities as you knew it would benefit the project, but also that your own workload would not be affected by it.
20. How would an internal Scrum Guide improve the method?	I don't know if this will change much. It is true that he would have more technical knowledge of the system, but I fear that it will come at the expense of his engineering tasks. You should actually have a fulltime intern who primarily focusses on being a Scrum Master.	Depends on the company culture. If it becomes usual that someone within the team puts more effort in peripheral business, then I think it would be of more value. Now there would not be many engineers willing to replace some of their tasks by the more managerial tasks that belong to the Scrum Master. I do think an engineer within the team can be of more value as they are better at filtering the conversations.
21. In essence, everyone should be able to perform all tasks. Why do you think this is not possible within an engineering team?	There are main disciplines within this project; electrical, mechanical and software. An electrical engineer won't be able to do the work of a mechanical engineer and vice versa. Also within the disciplines, it highly depended on each engineer's field of interest and excellences. Although it did happen, most engineers quickly find out who is best at what and know which tasks should be given to who. Also, engineers prefer different designing programs and styles. It is difficult to switch a design from one program to another.	Knowledge transmission takes time. Although some of it is tackled by the daily meetings, a lot of knowledge is not shared. Adaptation. It also takes time to start on a new subject. While someone else would have no adaptation time.

22. Would you have graded the original teamwork higher if you had not known about agile?	Yes. But because in the questionnaire we compared the original teamwork with agile, I graded the original teamwork lower. I was not aware how teamwork could have been improved before I was introduced to Scrum. Therefore, I can understand that the rest of the department rated their teamwork high. At the start of the project it was not clear why we would need Scrum, because we do get projects done and we didn't know why some different management method would help us improve. But this project has clearly shown that we can improve our teamwork by changing the management style.	There might be a phycological factor in it. Everyone wants to make the best of it and might therefore believe that it is indeed better. I think that it was not solely due to agile that we improved. There were some other factors, but overall, I think that I graded original teamwork lower because I am aware of the new method.
23. Which agile principles do you think are applied and how do you see these principles manifested in the team?	See Table G.4	See Table G.4
24. Do you think your work has improved since the use of Scrum? What were the most significant improvements?	Yes, definitely. The most significant improvements were that we started meeting on a daily basis which created information symmetry. The review cycles were a second incredibly valuable aspect. All decisions were reviewed shortly after the decisions were made thanks to the short Sprint cycles. This also made sure that decisions were documented properly. This is what troubled us in the past as decisions weren't reviewed.	Something that really contributed, was the presence of the more managerial persons at the daily meetings. Therefore, the supervision on this project was very high. Splitting the tasks into smaller chunks of subtasks also really contributed. It helps us manage our own work as we have a more structured overview of what to do. It helps remain focussed on the task that you promised you would do. Promises were made every morning on what you would do, this created a certain form of responsibility feeling. Planning sessions. Define upfront what needs to be done in the following sprint and also assigning time. It makes you think about the process. That has never been done in the conventional process.
25. What effected your role as engineer/manager the most?	In my role as a lead engineer, I had an amazing overview of what everyone was doing. If you would do weekly meetings, like we did before, you don't discuss as much details as you do now. And it is not necessarily that these details are	Finishing a task gives some sort of feeling of accomplishment. Next to all meetings, I did not change much in my style of working.

	discussed during the meetings, but I know what to ask after the meetings. Discussions get a lower threshold to initiate. If you are having difficulties with something, it is easier to share and can be shared exactly at the moment when you are experiencing problems	So, I think that it does not really change the actions you take as an engineer. It gives structure and defines a process to which you can adhere to.
26. Did Scrum help you to do your job?	Yes, it helped me to an enormous extent. I am in favour of using it in further projects. It should not become a goal, but it is a very nice tool for us to use. The author of APM will probably not be pleased with how we have adjusted some principles, but for us it works really well now. This does make it difficult, because we changed aspects of Scrum, it could become hazy what is obligatory and what is not. There should be a clear guideline on which aspects are really mandatory and which aspects are not. If you start cutting corners on the mandatory aspects, then it will probably lose its value.	Yes. It is a method that gives structure to our way of working. I'm not sure whether this can also be achieved with other project management methods. But I still think that whatever we choose to do next, these daily meetings should be kept.

Table G.3 Summary of interviews with pilot project team members, nr. 3 & 4

	Pilot project team interview 3	Pilot project team interview 4
Interviewer	J.R.W. (Jasper) Sonneveld	J.R.W. (Jasper) Sonneveld
Interviewee	Jessica	Kirill
Date	27 November 2017	27 November 2017
Time	10:00-11:30	14:30-15:45
Location	Allseas engineering Delft	Allseas engineering Delft
1. Gender	Female	Male
2. Age	28	40
3. Function	R&D engineer / project coordinator	Unit head
4. Years of experience	3.5	12
5. Highest education	WO	PhD
6. Field of education	Offshore engineering	Megatronica / Materials science

7. How would you describe the group dynamics and how did this change with agile? Did certain people start acting differently on a character level?	There is a definitely better teamwork. But I don't think people started to behave differently on a character level. You could see that everyone worked a little harder than before.	It was an extremely positive change. Team members more easily interacted with each other and a lot more information was being shared. The accessibility of co-workers improved significantly. You always have the engineers who only send e-mails and rarely interact face-to-face. However, now these engineers were pulled out of that comfort zone and did in fact have a lot to contribute to conversations. That's why I also don't mind that the meetings sometimes took a little longer. We discussed some extra technical aspects of the project and that invited the team members to participate. People didn't change on character level but it became more apparent what to expect. More me it was easier to estimate the value of an engineer his story.
8. It became clear that people did not always do as told. How did this influence your opinion of colleagues?	No, because I sometimes slacked in tasks as well. Besides, it compensated for the tasks that they did do properly. It made me remember the positive things primarily. I got a much better view of what they did do.	I felt some pressure during meetings if someone had not performed their task. It became clearer how someone works but it did not really change my opinion of an engineer.
9. Scrum focusses on self-organisation. This means that not everything is directed by the project manager, how do you reflect upon this change in the project organisation?	That didn't happen as often as was described in the beginning. For myself, I had many tasks that were best to be executed by someone with my skills, but for some other mechanical engineers, it worked better.	It did not work as prescribed by Scrum. Mostly because the engineers remained expectant on which task packages they should start on. At the point where a task has a clear follow-up task, the team members did do a bit of self-organisation. But still a central role had to be played by the Project owner. That might be because the team members are not extremely experienced. I think this will improve over time. They have seen how the Project owner has taken up the division of tasks, now they should be able to perform it themselves.
10. PO's only: Where you better able to steer team members?	-	Yes. I had more information on what was going on and I could ask questions really accurate.

11. Do you think team members worked harder now that there was more communication and everyone else was aware of their activities?	Yes. This was especially visible in better collaboration. In the start it worked better because most engineers were positioned fulltime on the project. Now they have less time available for this project. Even though it was not a target of Scrum, we documented way more than we are used to. Usually we document a very limited amount of design choices, requirements etc, but now every engineer wrote about their designs. I think that is because the reviewing of team members their work was supported properly by the Taskboard, but to review there is need of documentation. And that is why I think more documentation was written.	Yes, I think so. The technical communication during meetings also contributed to multiple disciplines exchanging information which made it easier for engineers to work harder on the right tasks. Not everyone worked harder, but most engineers did.
12. In what ways was it easier to implement design changes?	Yes, because everyone was aware of all activities. During the sprints it very clearly showed which design changes still had to be investigated. That led to changes being implemented easier. Usually the actual design changes are not written down and mostly only known by the lead engineer. Now it is known by everyone, because we all know what can be expected.	A little better because everyone had more knowledge. However, I think everyone was not critical enough.
13. For some people it is important to learn on the job. Did you get better opportunities to improve your own knowledge with Scrum?	No not really.	I still hope to learn more on the area of time allocation. This was not yet on the level that I hoped to understand, but I think with more practice of Scrum this will become visible and easier to understand and thereby easier to plan. For me it was interesting that not all engineers wanted to learn more about other disciplines. They did not try to venture into unknown areas of knowledge. I did expect them to, but not everyone was eager to explore. While agile did give more opportunities to do so.
14. How do you rate the influence of the daily meetings?	This influenced the team members in such a way that everyone started to act more like a team. And it creates order in the chaos.	It forced team members to open up about their work and share their issues, which will probably result in a better outcome of the project.

	The review and planning sessions are however time-consuming. You can see that those are starting to be postponed sometimes. In the end I do appreciate the awareness that was created because of the meetings.	
15. How do you think team members were motivated to help each other? Did you see this happen a lot?	Usually everyone is already motivated. But now everyone knows how you can help. Which creates a team bond and which motivates everyone even more.	Not everyone was more motivated. But most team members were more willing to help each other.
16. Were you more aware of your team members' activities? If so, how did this influence your own functioning?	It motivated myself to continue working. As you knew the speed with which the other team members were working, you also started working harder.	Yes. It was really easy for me now. I did not have to chase after engineers whether their work was done because I knew how long they still needed and what they were doing exactly.
17. The assigned time to tasks was rarely realistic, how do you think this can be improved (Broad sense, not too much detail on TFS)?	Everyone has a different perception of how long a task takes. That is what makes the discussions on time assignment endless. Maybe you can leave it up to one person to decide the time per task? Or give everyone their own set of tasks to assign time to.	No not really. I will wait on the results of the project and see what is actually delivered in the end. Maybe by showing the intention of higher management more clearly to not frighten engineers in being honest about their time spend on tasks. Now engineers are still a little hesitant to be forthcoming with the exact amount of hours a task takes because it might influence their performance review negatively.
18. In what way do you think assigning time to task was still valuable (think of forcing someone to plan)?	Yes, because an indication is better than nothing and this creates awareness. It might be better to do this for the whole department, then the unit heads know exactly how many hours he needs for his unit. Although you should not force it too much as this might affect the creativity of the engineers if they start working on a tight time schedule.	What I would like to know is how much every engineer has worked on this project. As not everyone is full-time. Then I can better plan how many hours a project needs. Then it will really be valuable for me as well.
19. Do you think that you did your job differently, now that you were better aware of project goals?	No not really. I have always been pretty up to date on the goals already.	As a unit head I was always aware of the project goals. But because the rest was more aware, I had less worries. Without Scrum, there was no guarantee for me that team members exchanged information, which they usually did not do. That's where the worries came from. But now,

		they meet every day and I know all disciplines exchange information. This saved me a lot of time. For other projects, if I do not hear anything from team members over a longer period of time I have to approach them and then they tell me what they were struggling with. With Scrum, I am aware of these problems before they occur. It required a lot less coaching from my side.
20. How would an internal Scrum Guide improve the method?	I think an internal Scrum Guide could define better when to move on to another subject.	Maybe the tasks of the Scrum Guide could be distributed over several team members. To make them more involved. But also a lot of tasks can be taken up by the Project owner as he has less tasks on managing the team.
21. In essence, everyone should be able to perform all tasks. Why do you think this is not possible within an engineering team?	Partially it is because of the disciplines. Partially because it would take engineers time to start on another subject and partially because if an engineer has made some design decisions it is best if he continues to work on it. Even though he has shared the logic behind the decision, he cannot take everything into account. It might work if all decisions are very carefully documented and the sprints are shorter. With shorter sprints, it is easier to transfer a work-package to another engineer as there is less to transfer.	Everyone has their own skills and experience. What I do before the start of a project is to match the complexity of a project with the characters of different engineers. This causes for a good mix of skills within a team, but this also limits the possibility for cross-functionality as every engineer has a different expertise.
22. Would you have graded the original teamwork higher if you had not known about agile?	I am not sure. The original project team did not cooperate as good as the Scrum team now, but I don't know if I would have graded them higher.	The communication is improved highly and that does not happen among the rest of the department. So yes, I agree that the teams which have not used Scrum are not aware of the possible improvement on teamwork. Communication wise, the rest of the department has a lot of improvement to do to get on the same level as this Scrum team. I think a part of the team has a negative perception of Scrum, just because it impacts their usual habits and this aversion of Scrum can be felt among many engineers who have never even worked with Scrum. This makes them

		automatically dislike Scrum when it is proposed. I think that if you call it different, the outcome might be even more positive. Present it just in a different way, and it might positively influence the cynical engineers.
23. Which agile principles do you think are applied and how do you see these principles manifested in the team?	See Table G.4	See Table G.4
24. Do you think your work has improved since the use of Scrum? What were the most significant improvements?	Not necessarily.	Yes. That I have to check all team members to a lower extent. 60 to 70% of the worries are gone now. I know what is worked on exactly.
25. What effected your role as engineer/manager the most?	I was very aware of the work of others. That reflects very positively on how handled my own work.	A happier team. Communication among all team members. And less of a controlling role for me.
26. Did Scrum help you to do your job?	Yes.	Yes. I am seeing a future in implementing Scrum in multiple teams. This saves me a lot of worrying. It is really important for me that the team keeps meeting face-to-face on a daily basis.

Table G.4 Application of agile principles in project[12]

Agile principles	**Interviewee 1** Lead engineer	**Interviewee 2** Engineer	**Interviewee 3** Engineer	**Interviewee 4** Unit head
Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.	~	-	~	~
Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.	~	+	+	~

[12] All interviewees have been presented the twelve agile principles and were asked to indicate which principles were present during the pilot project. These responses have been summarised by a '-' for a negative response, '+' for a positive response and '~' for partial application of the principle.

Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.	~	+	~	+
Businesspeople and developers must work together daily throughout the project.	-	+	+	-
Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.	+	+	+	+
The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.	+	~	+	+
Working software is the primary measure of progress.	-	+	~	~
Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.	~	~	~	-
Continuous attention to technical excellence and good design enhances agility.	+	~	+	~
Simplicity—the art of maximizing the amount of work not done—is essential.	~	~	+	+
The best architectures, requirements, and designs emerge from self-organizing teams.	+	-	~	~
At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly.	+	+	~	+

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