A NEW APPROACH FOR INNOVATING IN A MILITARY CONTEXT

A qualitative study on the implementation of Concept, Development and Experimentation at TNO

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Title: **A new approach for innovation in a military context. A qualitative study on the implementation of Concept, Development and Experimentation at TNO.**

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Abstract

Historically, military organizations tend to be highly innovative. In fact some of the major breakthrough innovations from gunpowder to the Global Positioning System derive from the military. The ever-changing environment forces the military to adapt to new situations and to new challenges. The newest adaptation effort of the Dutch Ministry of Defence is the implementation of Concept, Development and Experimentation (CD&E) as a new innovation approach, thereby increasing the throughput time and quality performance of capability development projects. Provided that the financial situation of the organisation is taken into account, and the costs do not increase. As a strategic partner of the Ministry of Defence, TNO is one of the independent research institutes conducting applied studies on behalf of the Ministry of Defence. The implementation of a new innovation approach is of major impact on the activities TNO currently performs during their project management procedure. This led to central question of this study:

What should TNO modify to optimally align their current project management procedure with Concept, Development and Experimentation, contributing to the throughput time and quality performance of the capability development projects of the Ministry of Defence, without increasing the costs of these projects?

During the study a theoretical framework was designed with the use of agile approach literature, a development approach originating from the field of software development. With this theoretical framework semi-structured qualitative interview protocols were created and used to interview employees of TNO, the Ministry of Defence and the NATO. These interviews made clear what experiences the interviewees gained with the execution of the first CD&E projects. The results indicated challenges occurring from the higher dependency and the higher integration needed between the involved organisations, for a proper execution of CD&E. The dependency was found in the involvement of end-users, dependency on a variety of knowledge and expertise, dependency on team members' level of competence with CD&E, and dependency on other parties, such as controllers.

Based on these results, solutions and recommendations were formulated, contributing to the throughput time and quality performance of capability development projects of the Ministry of Defence, without increasing the costs of the projects. On an organisational level both TNO and the Ministry of Defence should increase the CD&E knowledge of their employees. It is recommended to start reflecting on CD&E in both organisations and start with inter-organisational reflection workshops as these improve the implementation of CD&E and increase the spreading of CD&E knowledge. On a process level, TNO and the Ministry of Defence should start with guiding their CD&E projects based on product-features instead of time, budget and quality indicators that are currently used. Concept Maturity Levels, created by TNO, should be used to guide the CD&E projects. In addition, TNO should start with prioritizing product-features based on the value these features add for the end-user. On a project level it is critical to involve the end-user during the CD&E projects. These end-users should be involved on a daily base during the projects and they should have full-authority from their organisations to be involved in the decision-making. These recommendations should be introduced in a short term, beginning with new CD&E projects that are to be launched. An interesting follow-up on this study is measuring of the impact of the presented recommendations on CD&E projects in a longitudinal study. This research could be of great interest for both the agile approach literature and for strengthening the CD&E knowledge base of TNO, contributing to the position of TNO as a knowledge agent.

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List of abbreviations

TNO	: Toegepast-Natuurwetenschappelijk Onderzoek
MARIN	: Martiem Research Instituut Nederland
NLR	: Nationaal Lucht- en Ruimevaartlaboratorium
CD&E	: Concept Development and Experimentation
NATO	: North Atlantic Treaty Organisation
DMP	: Defensie Materieel Process
SKIA	: Strategie, Kennis en Innovatie Agenda
MSV	: Militair Strategische Visie
DIS	: Defensie Industrie Strategie
DKIP	: Defensie Kennis en Innovatie Plan
AGCDS	: Algehele Gereedstelling Commandant Der Strijdkrachten
BPB-procedure	: Beleids-, Plannings-, en Begrotingsprocedure
CCPlan	: Comprehensive Campaign Plan
DOTMLPFI	: Doctrine, Organisation, Training, Material, Leadership, Personnel, Facillities, Interoperability
NDPP	: NATO Defence Planning Process
SME	: Subject Matter Expert

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1. Introduction

The research starts with an introduction about TNO. An outline of the situation and the research goals will lead towards a central research question. After defining the research question the research strategy and structure will be introduced to complete this chapter.

TNO is the Netherlands Organisation of Applied Scientific Research; TNO is the abbreviation of Toegepast-Natuurwetenschappelijk Onderzoek. TNO is an independent research organisation that was founded by the Dutch government in 1932 by law in order to contribute and support companies and the government with innovation. This resulted in the mission of the organisation: connecting people and knowledge, thereby contributing to innovation (TNO, n.d.). The organisation is spread through the Netherlands over 23 different locations and has its offices in Belgium, Qatar and on Aruba. In 2012 the organisation employed 3892 people of which 58 are located outside the Netherlands (TNO, 2013b). In the 80 years of history the organisations structure has changed, currently the organisation is using a matrix structure which includes two areas of expertise and seven themes. The two areas of expertise are Earth, Life, & Social Sciences and Technical Sciences. The seven themes which TNO uses: industrial innovation, healthy living, energy, mobility, built environment, information society and defence, safety, and security (TNO, 2013b).

In this research the focus will be on the strategic partnership between TNO and the Dutch Ministry of Defence, referred to as the Ministry of Defence. TNO is a strategic partner of the Ministry of Defence in the area of research and development. Unlike other countries defensive forces, the Ministry of Defence does not execute applied studies. This type of research is outsourced to three independent research organisations, of which TNO is one. The others are the Maritime Research Institute Netherlands (MARIN) and the National Aerospace Laboratory (NLR). Together these organisations form one angle on what is called the 'golden triangle' (Figure 1) in which innovation at the Ministry of Defence occurs. This 'golden triangle' consists of the Ministry, the three Dutch research institutes and the Dutch defence industry.

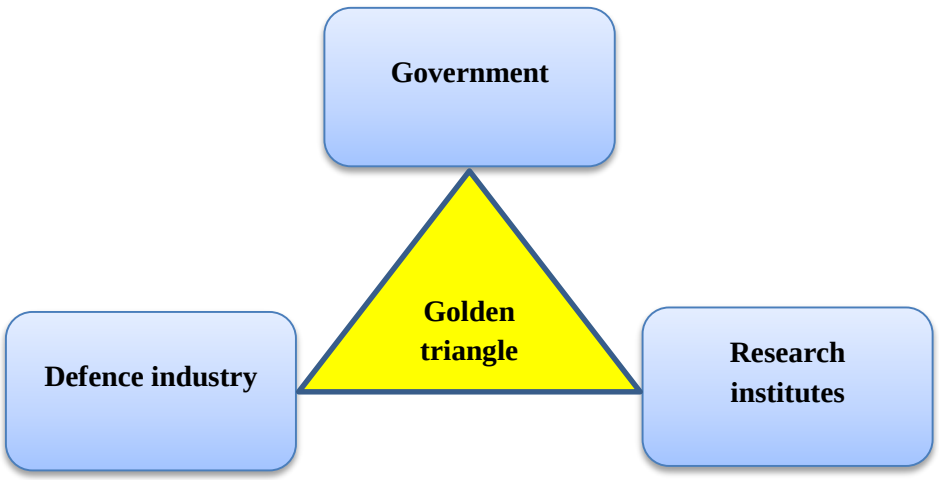


Figure 1 (Ministerie van Defensie, 2007a)

The perspective of this research is the implementation of the innovation approach Concept Development & Experimentation (CD&E) in the capability development projects of the Ministry of Defence. CD&E is a capability development method designed by the North Atlantic Treaty Organization (NATO). The goal of CD&E is to support the NATO transformation, by delivering increased capabilities for the NATO and thereby increasing the military effectiveness of the NATO (North Atlantic Treaty Organization, 2010). Increasing these capabilities is done by enabling a structured development of creative and innovative ideas into viable solutions for complex problems. This process is conducted in a iterative manner, of which the purpose is to capture the best ideas, thoroughly explore the potential solutions, and testing and validating the solutions by experimenting (North Atlantic Treaty Organization, 2009). CD&E is a component of the NATO Defence Planning Process, which consists of five steps (Figure 2). In this process CD&E is applicable to steps 2, 3, and 4. With this NATO Defence Planning framework, national and multi-national innovation activities can be aligned (North Atlantic Treaty Organization, 2010).

Figure 2: NATO Defence Planning Process (North Atlantic Treaty Organization, 2010)

The Ministry of Defence stated the goal of increasing the speed in which innovative concepts are converted into effective capabilities, whiles taking the financial situation of the organisation into account (Ministerie van Defensie, 2013). In order to do so, a new approach (Concept, Development and Experimentation) will be structurally embedded in the capability development projects of the Ministry of Defence, starting with the Royal Netherlands Army (Ministerie van Defensie, 2013). The speed in this goal is explained as both the duration of a project and the flexibility towards new developments during a project (Ministerie van Defensie, 2013). During this research this goal is described via the concepts throughput time and quality performance. As the financial situation of the organisation should be taken into account, achieving this goals should be done without increasing the costs of projects of the Ministry of Defence. As a strategic partner, the implementation possibly has a great influence on the project management procedure TNO performs in the capability development projects of the Ministry of Defence. The project management procedure contains the organising of the project, the planning of the project and a description of the project. In this research these projects are part of the capability development projects of the Ministry of Defence. The expectations are that

problems of alignment will arise between the project management procedure and the capability development projects of the Ministry of Defence, performed with the use of CD&E. The first few projects with the use of CD&E have been executed and some problems have been experienced and others are anticipated with the structural implementation of CD&E.

An example of a problem is the difficulty in selecting the right employees at TNO with the required variety of knowledge and skills, as a result of the functional specialization of TNO's employees. CD&E projects require different knowledge and skills opposed to conventional projects, and lead to the question of which problems arise with finding the necessary skills or knowledge for CD&E projects?

CD&E projects are more expensive than conventional capability development projects at the start-up. Due to the use of real and simulated environments, the stakeholders in a CD&E project can experience the use of the concepts. However, the creation, which is done by TNO, of these real or simulated environments is costly. Considering the financial situation of the Ministry of Defence, what are the advantages of CD&E regarding the costs of projects?

The Defence Materiel Process (DMP) is designed by the Ministry to cope with the constantly changing environment and stakeholders in projects that extend over many years, by regulating and directing the requirements of a project (Ministerie van Defensie, 2007b). The project management procedure of TNO is adjusted to this DMP, and also contains the regulating and directing of the requirements of a project. The embracement of change in projects with CD&E is in clear contrast with the defined requirements and parameters of the project management procedure of TNO. What are the disadvantages of the way the DMP is organised? The results of CD&E projects will mostly be presented in the form of tacit knowledge and experience amongst the participants of the CD&E projects, instead of results only in the form of documents and tangible products. These results are completely different from what the project management procedure of TNO requires and values as results of conventional capability development projects. Resulting in the question: What are the differences between the results of traditional approaches and CD&E?

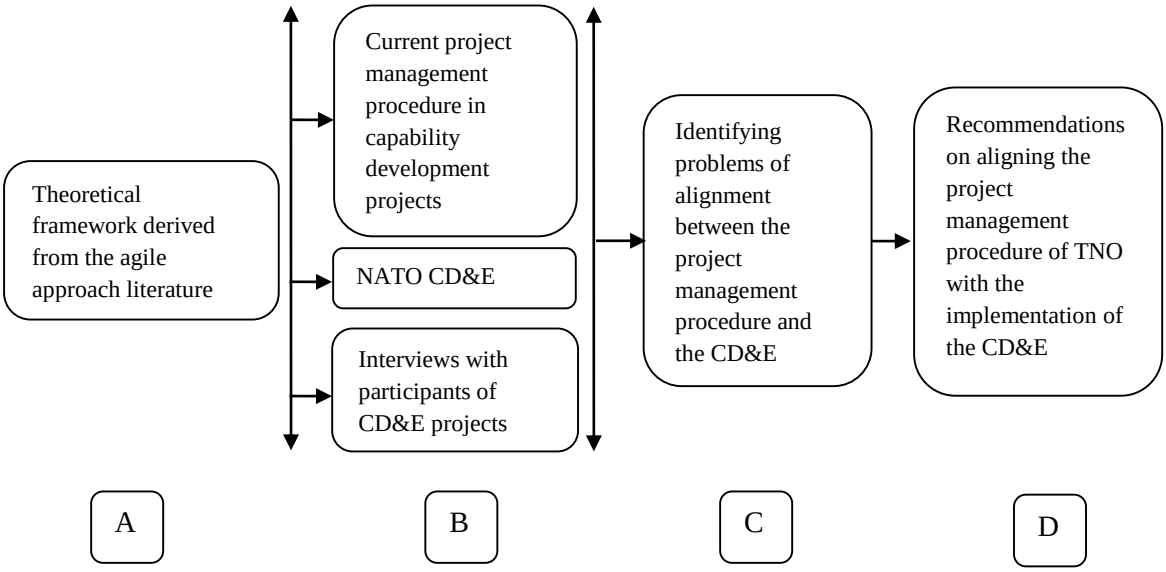
These are a few examples of the questions the implementation of CD&E raises. Through this study TNO seeks to explore and obtain knowledge regarding the implementation of CD&E.

Goal of the research

For TNO it is important to identify the problems occurring from the misalignment of the project management procedure of TNO with the capability development projects using CD&E as designed by the NATO. Furthermore it is important for TNO to contribute to the goal of the Ministry of Defence, which is increasing the speed in which innovative concepts are converted into effective capabilities. The current execution of CD&E at the Ministry of Defence in collaboration with TNO is of major importance in identifying these misalignments in an early phase. Some NATO members already introduced CD&E in their capability development projects which is an important source of data for this research as well.

The goal of the research is to make recommendations on aligning the project management procedure of TNO with concept, development and experimentation and thereby improving the throughput time and quality performance of the capability development projects of the Ministry of Defence, without increasing the costs of these projects.

In the following diagram the model of the research is visualized. This helps with gaining better understanding and a better overview of is done during the research. Beneath the diagram the model is verbalized, which also contributes to the understanding of the research (Verschuren & Doorewaard, 1995).



(A) With the use of the agile approach literature a theoretical framework is designed, which (B) is used to discuss the current project management procedure, CD&E as designed by NATO and to design interview protocols, which are used to gather the CD&E experiences participants gained during CD&E projects. By confronting the description of the current project management procedure of TNO in the capability development projects of the Ministry of Defence, the description of the CD&E and the experiences of participants and information from managers responsible for implementation (C) problems of alignment between the current project management procedures of TNO and CD&E can be identified. From these problems of alignment (D) recommendations on improving the alignment, between the project management procedure of the TNO and CD&E can be derived, and thereby contributing to the throughput time and quality performance of capability development projects of the Ministry of Defence.

1.1 Central and research questions

Now that the goal of the research is clear the central and research questions can be formulated. In order to make recommendations on aligning the project management procedure of TNO with CD&E and thereby improving the throughput time and quality performance of the capability development projects of the Ministry of Defence, a detailed description of the current situation including the use of CD&E needs to be derived by gathering relevant data from documents, literature and qualitative interviews. In order to gain the relevant data to achieve the goal of this research, the following central question is prepared:

1. What should TNO modify to optimally align their current project management procedure with Concept, Development and Experimentation, contributing to the throughput time and quality performance of the capability development projects of the Ministry of Defence, without increasing the costs of these projects?

To answer the central question, research questions will be created and answered.

1. What are the characteristics of the current project management procedure of TNO regarding the throughput time and quality performance of the capability development projects of the Ministry of Defence?
2. What are the characteristics of Concept Development and Experimentation regarding the throughput time and quality performance of capability development projects?
3. What are the experiences and expectations of stakeholders with Concept, Development and Experimentation, regarding the throughput time and quality performance of capability development projects?
4. What problems of aligning the current project management procedure arise with the implementation of Concept Development and Experimentation, regarding the throughput time and quality performance of capability development projects?
5. What solutions can be identified to solve the problems of alignment, improving the throughput time and quality performance of capability development projects?

1.2 Theoretical framework

To find the answer to the central question, relevant literature is used in order to guide this research with the information that has already been found in studies conducted on this topic. Considering the goal of the Ministry of Defence, theory on the agile approach is able to contribute to this research, as the principles of the agile approach are similar to those of the Ministry of Defence. A few of the important principles of the agile approach are to satisfy the customer by delivering valuable and working products, and embracing change during these projects (Fowler & Highsmith, 2001). The agile methods arose out of the need to develop new products faster and cope with the continuous change happing in the environment of the products by embracing the change (B. Boehm & Turner, 2005).

The theory on the agile approach contributes to this research in several ways. Theory and empirical studies on the implementation of such agile methods in a traditional organisation are used to guide this research in the direction of previously experienced and studied difficulties with the implementation of an agile approach (B. Boehm & Turner, 2005; Nerur, Mahapatra, & Mangalaraj, 2005; Vinekar, Slinkman, & Nerur, 2006).The framework furthermore contributes in the form of improvements to the ability of CD&E to improve the throughput time and quality performance of capability development projects without increasing the costs of the projects, and the improvement of the current execution of CD&E at TNO and the Ministry of Defence. In chapter two, the concepts throughput time and quality performance are discussed in depth. With the agile approach theory, research methods are designed

with which data will be gathered on the current experiences with the execution of CD&E and the expectations on the implementation of CD&E at the Ministry of Defence, both regarding the throughput time and quality performance of the capability development projects. Based on the experienced and expected problems with CD&E, solutions can be identified from the agile approach theories and recommendations can be made for the project management procedure of TNO.

1.3 Research design

The recommendations this research is striving for are based on the explored literature, and the experiences and expectations of involved employees on the implementation of CD&E. The unit of analysis in this study is the implementation of CD&E, while the units of observation are the employees from which the experiences and expectations are collected. To answers the research questions data is gathered through the use of existing documents on the project management procedure of TNO, existing documents on the product innovation process of the Ministry of Defence, and by collecting the experiences with CD&E and expectations on the implementation of CD&E. Collecting these experiences and expectations is done by qualitative interviews with employees involved in capability development projects with the use of CD&E and employees involved in the structural implementation of CD&E. Employees are selected from both organisation, thus TNO as well as the Ministry of Defence. Qualitative interviews are selected due to scarcity of employees that have been involved in projects with the use of CD&E, the absence of documented data (both qualitative and quantitative) on the projects executed with the use of CD&E, and the search for highly detailed data on the experiences and expectations of involved employees. The interviews are developed with the use of the theories on the implementation of agile methods and are set up in a semi-structured manner. The data gathered is analysed with the use of Atlas.ti, a qualitative data analysis tool. The coding of the data is based on the differences experienced between conventional projects and CD&E projects, problems occurring due to the use of CD&E in projects, and potential solutions to these problems the interviewed employees possibly put forward. With this method the problems of alignment of CD&E with the current project management procedure occurring can be identified, as the current procedure was designed for conventional projects. Based on these findings, recommendations for the project management procedure of TNO are made.

1.4 Academic and practical relevance

This research focusses on the problems of alignment an organisation can encounter while implementing a new instruments in a particular process. New product innovation methods and approaches are constantly created and implemented at companies and organisations worldwide. In this context the results of this research are relevant to these organisations. Especially for other NATO members, the other independent research institutes (MARIN, NLR) and the remaining branches of the Ministry of Defence (the Royal Netherlands Navy and the Royal Netherlands Air Force) struggling with the implementation of such an agile approach or those who are planning on implementing ones, as the results clarify the potential problems of alignment between CD&E and the project management procedure of TNO performed in the capability development projects of the Ministry of Defence. Furthermore the results are of relevance for the improvement of CD&E as an instrument.

Academic studies on implementation of agile method in software organisations can be found in abundance, the implementation of the agile approach in non-software specific organisations is hard to find however. This research therefore enhances the literature on the difficulties encountered in non-software specific organisations and the possible solutions for these difficulties put forward by the involved employees or organisations. The focus on a governmental organisation is of added value for broadening the entire of the research field of the agile approach. Another relevant aspect is the focus on product innovation projects in a specific setting, considering the projects are surrounded by secrecy and state secrets.

1.5 Outline of the research

The preceding chapter introduced the situation and the goal of this research. From this information the research questions and strategy were derived. The outline of this research will be explained here. Chapter 2 presents a theoretical framework. In chapter 3 the methodology is elaborated and the type of research methods and selection is discussed in depth. Later in the chapter the interviews are designed with the help of the theoretical framework presented in chapter 2. Chapter 4 describes the current project management procedure of TNO and the product innovation process of the Ministry of Defence. Chapter 5 clarifies concept, development and experimentation. Chapter 6 elaborates on the expectations and experiences of stakeholders with CD&E found during the interviews. During chapters 4, 5 and 6 problems of alignment are identified due to the implementation of CD&E. Chapter 7 identifies solutions for the found problems of alignment. Finally, chapter 8 starts with the conclusions of the research and ends with the recommendations for TNO and discusses the limitations of this research and future research possibilities.

2. Theoretical framework

This chapter will discuss the theoretical framework of this research. The rationale of this theoretical framework is to find theories that shorten the duration and improve the flexibility of complex product innovation projects, thereby potentially contributing to the throughput time and quality performance of the capability development projects of the Ministry of Defence. The theoretical framework will consist of three different parts. The first part, will elaborate on the product innovation process, for a general overview of the change of the product innovation process over the years. The second part is focussed on explaining the agile and traditional approach. The third part is paying attention to the implementation of the agile approach. The results of this chapter are used to evaluate the current procedure of TNO and the Ministry of Defence. The results are furthermore used for the design of the interviews.

2.1 Product innovation process

In order to answer the first research question the project management procedure of TNO in the capability development projects of the Ministry, the context and change of the product innovation process models over the years is to be discussed. There is a lot of literature to be found on models of product innovation processes, and over the years these models have evolved. The first generation of innovation process models assumed a linear evolution of new products from the scientific discovery, through technical development in to the marketplace. This is explained as a technology-push model (Rothwell, 1994)(Figure 3). During this generation it was assumed that higher investments in R&D assured a higher innovation output (G. Boehm & Fredericks, 2010), this was possible due to the market demand matching or exceeding the supply (Nobelius, 2004).

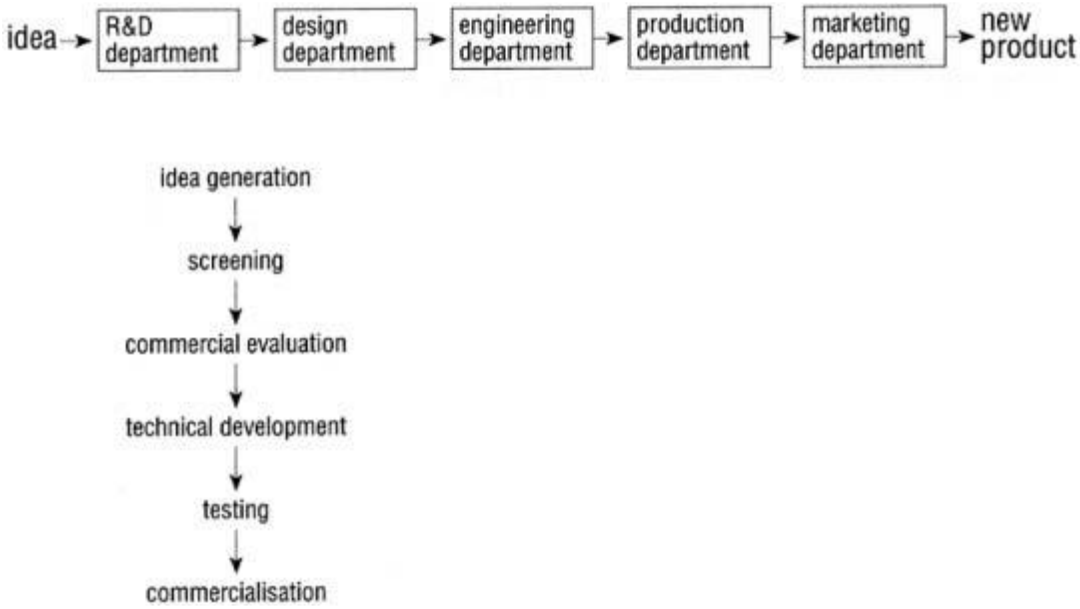


Figure 3: Technology-push model and market-pull model (Buijs, 2003)

Over the decades more generations of product innovation processes have emerged. The second generation was the market-pull model (Figure 3). During this generation the demand and supply were better balanced and the competition stronger, in which companies reacted by putting effort in marketing to increase sales. The source of the new product ideas shifted from the originating in the R&D departments towards the originating from the market. This generation also introduced project management, in order to track the progress of the R&D creations and achievements (Nobelius, 2004). During the period the third generation came up, the worldwide economy was troubled by the oil-crisis, high inflation and demand saturations. This changed the focus from the market-demand towards the

control and reduction of costs. This period of less economic prosperity triggered a number of empirical studies in order to understand the successful practices of the innovation process. These studies indicated that the technology-push and market-pull were extreme examples of the innovation processes used at the time. The empirical result of the studies introduced a process of interaction between the available technologies and the demands from the markets. The process was still a sequential one, but feedback loops made their first appearances. This model was called the 'coupling' model of innovation (Rothwell, 1994)(Figure 4). In some other studies this generation is also called the portfolio model (G. Boehm & Fredericks, 2010; Nobelius, 2004). In this model, the first two stages (strategy formulation and design brief formulation) can be seen as the technology-push side, while the third and fourth stages (product development, and product launch and use) can be seen as the market-pull side (Buijs, 2003). Buijs (2003) also defines the process of the first two stages as experimental, chaotic, hard to plan and uncertain (Figure 7). The process of the third and fourth phase is logical, methodical, disciplined, goal-oriented and planned (named NPPD in Figure 7). The fourth generation if the innovation process focussed on the involvement and integration of suppliers and other companies in strategic partnerships, to speed up the process in order to cope with the shorter life cycles of products (Figure 5). Another aspect of the fourth generation innovation process is the parallel integration of the different departments in projects. This allows for the execution of different activities at the same time in the process rather than sequentially (G. Boehm & Fredericks, 2010; Nobelius, 2004; Rothwell, 1994). The fifth generation of the innovation process is an advancement of the fourth generation, in which the overall integration of the process is further intensified and the flexibility and adaptability of the process is of even more importance. The collaboration between companies and their business environment intensified as well, due to the need for sharing the ever larger technology investments and the strategic importance of being timely with innovations (Nobelius, 2004). A newer aspect of the fifth generation is the usage of electronic toolkits during the process, for example the use of CAD (Computer-aided design) software. These toolkits allowed for computer based heuristics, expert systems, simulation modelling and the co-development of new products together with suppliers. (Rothwell, 1994).

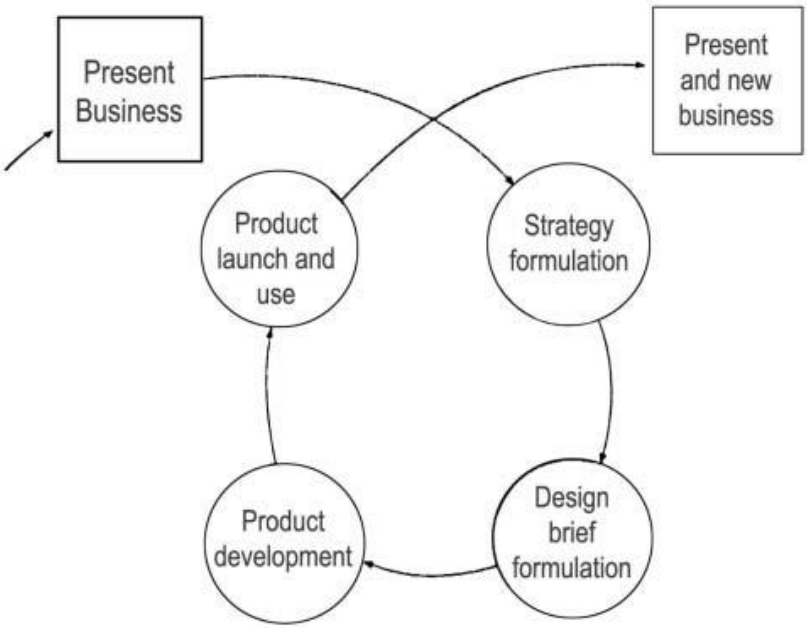


Figure 4: The coupling model (Buijs, 2003)

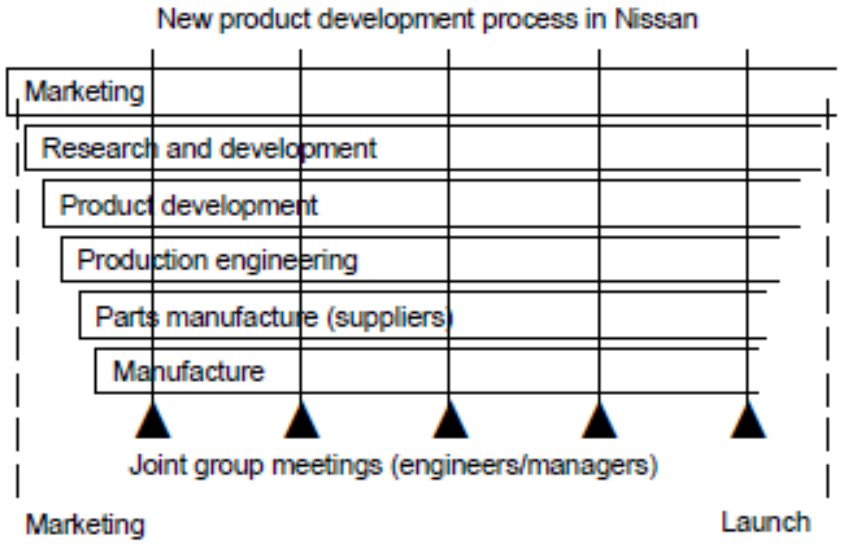


Figure 5: The integrated model (Rothwell, 1994)

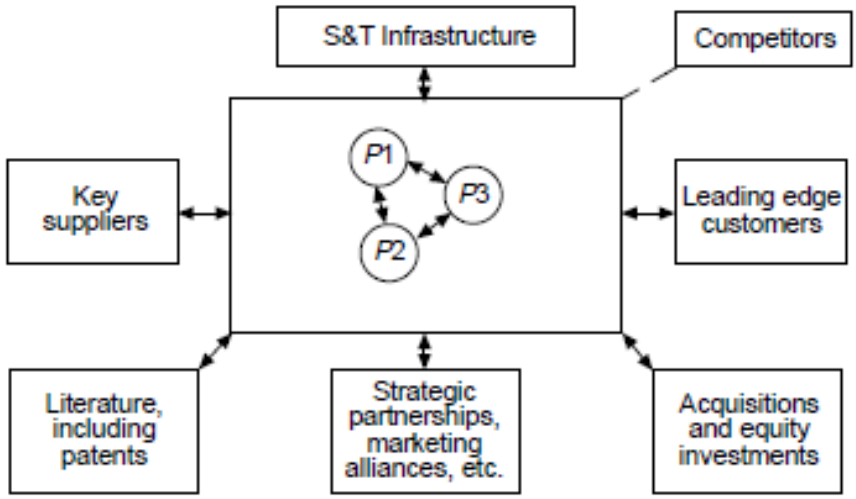


Figure 6: The network model (Rothwell, 1994)

During the different generations a transformation is visible of the product innovation process from logical and linear towards a more chaotic and non-linear manner of innovating (Buijs, 2003). This is not directly visible in the models of the different generations, because a lot them still show the process like they would be executed by one person in a logical way. While in reality the process is done in teams, and the different tasks can be performed in parallel by the different team members. Due to the different throughput times of tasks in the product innovation process, the tasks will be completed in a non-structured order. The completed tasks in a project will however influence the non-completed tasks again, which makes the entire process more chaotic (Buijs, 2003).

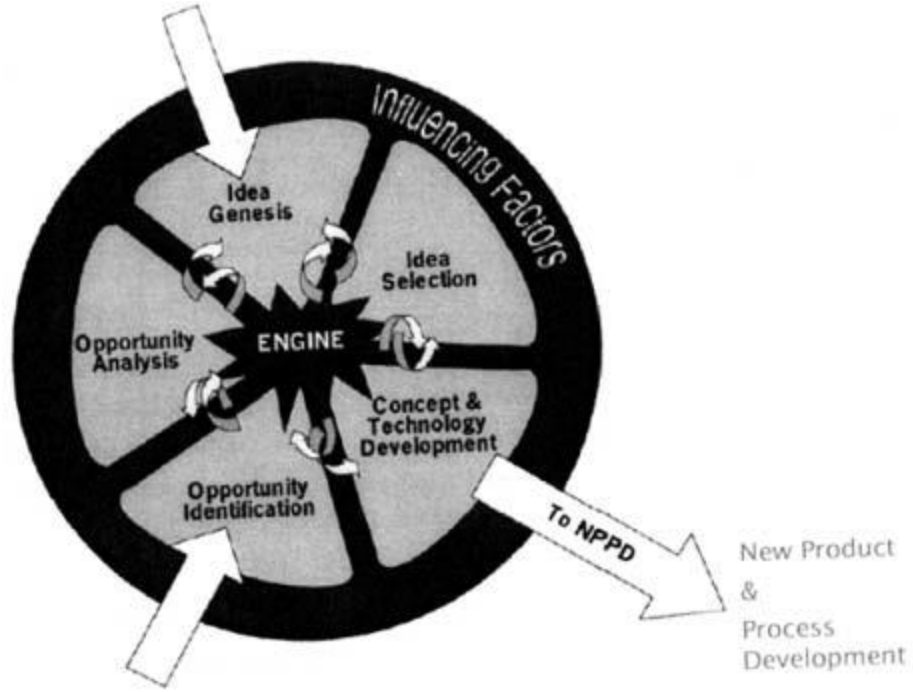


Figure 7: Visualization of the first two stages (Buijs, 2003).

2.2 Agile approach

The transformation of the product innovation process is shown in the five generations of innovation models. These models visualize the changing processes, but do not show the implications of the changes for the management of innovation projects and their influence on duration and flexibility of these projects. Theories on the agile and traditional approaches potentially do however. During the nineties, agile approach made their appearances in the software development business and since the zero's the interest in agile approach and methodologies also reached the academic world. The agile approach emerged in order to cope with the business and technological environment that is always in motion (Highsmith & Cockburn, 2001), as seen in the better integration of the entire process in the fifth generation product innovation model (Figure 6). B. Boehm and Turner (2005) stated that the agile approach arose out of the need to develop new products faster and cope with the continuous change happing in the environment of the products by embracing the change. The traditional approaches had the assumption that putting a lot of effort in the planning of the project, would identify the necessary requirements and could remove most variations, making it easier to execute the project (Highsmith, 2002; Vinekar et al., 2006). This can be observed in the earlier generations of the product innovation models, except for the technology push model, which were more structured and linear. The software developers experienced that this approach made it harder to cope with the inevitable changes that occur during the timespan of a project. These inevitable changes could be the change of requirements or the scope of the product, or relevant new technologies that emerge in the world during the project. Rather than trying to exclude the variations that might occur during the timespan of a project, the developers started to embrace them and focus more on satisfying the customers at the finishing of the project (Cockburn & Highsmith, 2001; Vinekar et al., 2006). The agile approach copes with inevitable changes by commencing short iterative cycles, in which all the changes that occurred can be taken into account. Projects are executed by small teams, in which the customer is permanently involved. This makes it possible to take collective decisions with all the stakeholders of a project (Nerur et al., 2005). Cockburn and Highsmith (2001) explained these characteristics in the form of two concepts: Working code is unforgivably honest and the effectiveness of collaborating with people that truly want to

contribute (Highsmith & Cockburn, 2001). The first concept shows the focus on satisfying the customer at the finish of a project as working code is something useable and tangible for the customer. The second concept is based on the idea that by using people effectively, a project can benefit from an increase in manoeuvrability, speed and cost savings. People working together face to face can solve difficulties, set new priorities, and exchange ideas faster than when people communicate through documents and email. In 2001 the agile manifesto was published. The manifesto is a set of values for agile software development and is composed by the agile alliance, a group of 17 experts in favour of agile methodologies and their statement of the values in the manifesto is (Fowler & Highsmith, 2001, p. 2):

"We are uncovering better ways of developing software by doing it and helping others do it. We value:

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

The value statement prioritizes the different components, which means the components on the right are not useless or unvalued. The software developers value the components on the left more than the components on the right (Fowler & Highsmith, 2001).

In addition to the values the agile manifesto presents the twelve principles of the agile approach (Fowler & Highsmith, 2001, pp. 3-6):

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

Highsmith (2002) defined three characteristics of agile development: a chaordic perspective, a set of collaborative values and principles, and a barely sufficient method. A chaordic perspective arises from acknowledging and tolerating the increasing uncertainty in the environments of projects. Collaborative values and principles arise from the focus on satisfying the customer and cooperating with the stakeholders during the projects. The last characteristic, a barely sufficient method, arises from the

question about balancing flexibility with structure. Structure will make the project more cost-efficient, but creativity and innovation benefit from more flexibility (Highsmith, 2002).

2.2.1 The traditional approach

The traditional approach is completely different. In the part above, little of the traditional approach is explained. The rationale of the traditional approach is that the requirements and problems associated with development projects are specifiable and predictable, with solutions for all problems. Thorough planning will expose the problems and requirements, and is the basis of controlling and resolving these issues (Cockburn & Highsmith, 2001). The traditional approach focusses on the creation of highly repetitive and predictable processes, in order to know the outcomes of each process and get a high level of control on the entire project. This makes it possible for the participating employees of development project using the traditional approach to specialize. The emphasis on control results in a large amount of documentation on the process and the results of the project. The customer is involved in beginning of the project, to help with setting the requirements and specifications. During the rest of the project the customer is hardly involved (Nerur et al., 2005). The potential effects on the duration and flexibility on product innovation projects arise from the emphasis on controlling such projects.

	Traditional	Agile
Fundamental Assumptions	Systems are fully specifiable, predictable, and can be built through meticulous and extensive planning.	High-quality, adaptive software can be developed by small teams using the principles of continuous design improvement and testing based on rapid feedback and change.
Control	Process centric	People centric
Management Style	Command-and-control	Leadership-and-collaboration
Knowledge Management	Explicit	Tacit
Role Assignment	Individual—favors specialization	Self-organizing 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 (Waterfall, Spiral, or some variation)	The evolutionary-delivery model
Desired Organizational Form/Structure	Mechanistic (bureaucratic with high formalization)	Organic (flexible and participative encouraging cooperative social action)
Technology	No restriction	Favors object-oriented technology

Figure 8: Comparison of traditional versus Agile software development (Nerur et al., 2005)

2.3 Implementing the agile approach

Over the years numerous studies have been conducted on the implementation of the agile approach. Studies were conducted to find the critical factors for the success of agile methods. Lindvall et al. (2004) studied the implementation of the agile approach into large organizations. B. Boehm and Turner (2003b) defined five critical factors in order to select an agile or traditional approach for projects. Other studies focussed on the difficulties of implementing the agile approach into an organisation, parallel to the traditional approach (B. Boehm & Turner, 2005; Lawrence & Yslas, 2006; Nerur et al., 2005; Vinekar et al., 2006).

2.3.1 Balancing Agile and Traditional

The previous might give the impression that organisations or the organisation of projects have to choose between an agile or traditional approach. An important note in most studies is that this is not the case: it is not about choosing one approach over the other, but to balance both approaches. This optimizes the strengths of the approaches and minimalizes their weaknesses (B. Boehm & Turner, 2003b; Nerur et al., 2005; Vinekar et al., 2006). The software development projects differ in a high variety, such as the functions a project needs to incorporate or the sort of customer. The agile approach is therefore not for all development projects the best approach. Vinekar et al. (2006) found that only 16 percent of the respondents in a survey among companies in the software development industry thought the agile approach suitable for all sorts of projects. B. Boehm and Turner (2003a) concluded that there are five critical factors in choosing the agile approach appropriate for a specific project. These five factors are: the size of the project and project team, the criticality, the dynamism, the personnel and the culture. Based on these factors B. Boehm and Turner (2003a) designed a strategy for choosing the appropriate approach corresponding with the project, or the right balance between the agile and traditional approach. Cohen, Lindvall, and Costa (2004) did a research among experienced agile developers, and found culture, people and communication as the most important factors of the success of the agile approach in a project. The culture of the participating companies in a project has to be right in order to support the agile approach. Agile teams need local control to some extent, and they must have the opportunity to change the practices they perform during a project. The culture of the companies must also support negotiations, as this is an important part of the agile approach. The people or team members are important as they need to be trusted in their actions and they have more responsibility due to the more localized control in agile projects. Another aspect of the people is that agile projects need more competent people, as the size of these project teams are smaller (Cockburn, 2000). The smaller size of the teams is due to the last factor, communication, as rapid communication is necessary and larger teams make face-to-face communication more difficult. The bigger the project, the less agile they become. As rapid communication is necessary it is required that the team members are offered that opportunity, e.g. co-locating the team members facilitating face-to-face communication (Cohen et al., 2004). The two sets of factors have similarities and some differences. The size factor of B. Boehm and Turner (2003a) for example corresponds with the communication factor of Cohen et al. (2004), the criticality factor however is not found among the three factors of Cohen et al. (2004). Criticality refers to the consequences of a failure of the project, or to the loss resulting from a defect (B. Boehm & Turner, 2003a). Cohen et al. (2004) illustrate this factor with the difference in criticality between the development of the space shuttle and a toaster. As the first product fails it will cause loss of life, which is not the case with the second example. Cohen et al. (2004) however do not use the criticality factor, due to discussion among the users of agile methods on this factor. The rationale about criticality is that the use of a barely sufficient method in an agile project is incompatible with the high amount of reliability and safety requirements necessary for products with high potential loss of life. Many participants of the study of Cohen et al. (2004) stated however that the agile methods made it easier to address the factor of criticality, due to the participation of customers from the start of the project.

2.3.2 Difficulties implementing the agile approach

The studies of difficulties in implementing the agile approach in an organisation all focussed on different levels, components, or dimensions of the agile approach. Nerur et al. (2005) found challenges of implementing the agile approach divided in four different components: management and organisational, people, process and technology. Management and organisational challenges are, according to Nerur et al. (2005), the culture in the organisation, the role of the managers, the form of the organization, knowledge management and reward systems. The people difficulties encompass

teamwork, skill-level of the team members, and the relationship with the customer. The process difficulties include a more people-focussed approach, the acceptance of change during a process, and managing larger projects. A difficulty in the technology component is the abandoning of existing technology (Nerur et al., 2005). B. Boehm and Turner (2005) found difficulties in three areas – development process conflicts, business process conflicts, and people conflicts – they believed are important for the implementation of the agile approach. The development process conflicts involve the variety in products resulting from agile or traditional approaches, the difference in life cycles, the inappropriateness of legacy systems, and the different in requirements. The business process conflicts are about the skills of the team members, the measurement of progress of projects, and conflicts with standard ratings as ISO certificates. The people conflicts involve the role of managers, logistical problems, managing successful pilots, and resistance to change (B. Boehm & Turner, 2005). Lawrence and Yslas (2006) found similar difficulties in the implementation of the agile approach. These included resistance to change in the management, progress measurement affecting contracts, getting access to adequate members for the agile teams, and the different roles of managers (Lawrence & Yslas, 2006).

2.4 Influence on throughput time and quality performance of projects

The agile approach has emerged to develop new products faster, and to cope with the continues change in the environment of the product (B. Boehm & Turner, 2005). To successfully implement an agile approach in an organisation different aspects have to be taken into account. First of all the selection of a type of approach for product innovation projects is of importance as stated by multiple scholarly studies (B. Boehm & Turner, 2003a; Cockburn, 2000; Cohen et al., 2004; Vinekar et al., 2006). The selection of an approach should be based upon the characteristics of the project according to these scholars. These characteristics are: size (project and team), dynamism, personnel and culture. Criticality is left out of this set, due to the controversy about the importance of this factor. A different aspect is the challenges of implementing an agile approach in organisation. Nerur et al. (2005) found four components or categories: management and organisational, people, process and technology. B. Boehm and Turner (2005) and Lawrence and Yslas (2006) found similar difficulties on the implementation of the agile approach..

Chow and Cao (2008) reviewed the results of studies on both the factors of difficulty and success of the agile approach in software development projects, in order to find the critical success factors of agile projects. Chow and Cao (2008) combined all the factors of difficulty and success mentioned in the reviewed studies into 12 factors, which they sorted by type in five factor dimensions. These five factor dimensions are: organisational, people, process, technical and project. The 12 factors were tested on their positive impact on success of agile projects. The success of agile projects was measured in terms of four dimensions: quality, scope, time and cost. The success dimensions were defined as (Chow & Cao, 2008, p. 963): “Quality (delivering a good working product), Scope (meeting all requirements by the customer), Timeliness (delivering on time) and Cost (within estimated cost and effort)”. The 12 factors combined with the four success dimensions resulted in 48 hypotheses. With the use of a survey among 109 agile projects in over 25 countries, these hypotheses were tested and 10 out of the 48 hypotheses were supported by the gathered data. These 10 supported hypotheses represent 6 factors out of the 12 that were tested, representing four out of the five identified dimensions (See Table 1).

Factor dimension	Factor	Attributes of the factor	Supported success dimension
Technical	Delivery strategy	• Regular delivery of software • Delivering most important features first	• Scope, Timeliness, Cost
Technical	Agile software engineering techniques	• Well-defined coding standards up front • Pursuing simple design • Rigorous refactoring activities • Correct integration testing	• Quality, Scope
People	Team capability	• Team members with high competence and expertise • Team members with great motivation • Managers knowledgeable in agile • Managers who have adaptive management style • Appropriate technical training to team	• Timeliness, Cost
Process	Project management process	• Following agile-oriented requirements management process • Following agile-oriented project management process • Following agile-oriented configuration management process • Good progress tracking management • Strong communications focus with daily face-to-face meetings • Honouring regular working schedule	• Quality
Organisational	Team environment	• Collocation of the whole team • Coherent, self-organizing teamwork • Projects with small team • Projects with no multiple independent teams	• Quality
People	Customer involvement	• Good customer relationship • Strong customer commitment and presence • Customer having full authority	• Scope

Table 1 Supported factors and success dimensions (Chow & Cao, 2008)

When the factor dimensions and the corresponding attributes of the study of Chow and Cao (2008) are related to the four categories of Nerur et al. (2005), as Chow and Cao (2008) used their study to identify success factors. When the success dimensions of Chow and Cao (2008) are compared with the goal of improving the throughput time and quality performance of the capability development process without increasing the costs of these projects, similarities are seen between the dimensions quality, timeliness, scope and cost. In the context of the concepts throughput time and quality performance, the success dimensions of Chow and Cao (2008) improve and enrich the understanding of the data to be gathered during this research and how they influence the throughput time and quality performance of capability development projects. A little reminder, the Ministry of Defence stated the goal of

increasing the speed in which innovative concepts are converted into effective capabilities, whiles taking the financial situation of the organisation into account (Ministerie van Defensie, 2013).

When these categories and attributes are integrated the following table (See Table 2) arises, where the categories are assisted with the factor attributes and their relation to the supported success dimensions. Note that the description differs from the previous table. Both studies used different names for similar matters. The categories or factor dimensions are renamed to variables, the associated challenges or factors to these variables are renamed to attributes, and the descriptions of the successful factor attributes of Chow and Cao (2008) are replaced by characteristics.

Variables	Attributes	Characteristics	Success dimensions
Management and organisational	Organisational culture		
	Management style	• Managers who have adaptive management style	• Timeliness, Cost
	Organisational form	• Projects with small team • Projects with no multiple independent teams	• Quality • Quality
	Knowledge management		
People	Teamwork	• Collocation of the whole team • Coherent, self-organizing teamwork	• Quality • Quality
	Level of competence	• Team members with high competence and expertise • Managers knowledgeable in agile	• Timeliness, Cost • Timeliness, Cost
	Customer relationship	• Good customer relationship • Strong customer commitment and presence • Customer having full authority	• Scope • Scope • Scope
Process	Change in approach	• Good progress tracking management • Honouring regular working schedule • Delivering most important features first	• Quality • Quality • Scope, Timeliness, Cost
	Emphasis on adaptability	• Strong communications focus with daily face-to-face meetings • Correct integration testing • Regular delivery of software	• Quality • Quality, Scope • Scope, Timeliness, Cost
	Selection of methods	• Pursuing simple design	• Quality, Scope
Technology	Appropriateness of existing technology and tools	• Appropriate technical training to team	• Timeliness, Cost

Table 2: Integrated variables and attributes together with success dimensions

2.5 Conclusion

The theoretical framework started with an overview of the transformation of the product innovation process over the different generations. A transformation from a logical and linear process towards a chaotic and network oriented process can be observed. The models show an increasing degree of dependency on other stakeholders and increasingly complex products developed during the product innovation process. This transformation is observable in the capability development projects of the Ministry of Defence as well, resulting in more complex projects and affecting the duration and flexibility of these projects. The agile approach has emerged to develop new products faster, and to cope with the continues change in the environment of the product (B. Boehm & Turner, 2005). Because the agile approach shares the same object as CD&E and scientific studies have proven the contribution of agile to these goals, the literature on the agile approach is of importance for the goal of this study and therefore used in the theoretical framework of this study.

In the rest of this study, data is gathered based on these four variables (see Table 3), and their influence on the duration and flexibility of capability development projects of the Ministry of Defence with and without the use of CD&E. With the guidance of this theoretical framework for the collection of the data, this data will be more useful for the creation of recommendations on improving throughput time and quality performance of capability development projects of the Ministry of Defence.

Variables	**Attributes**
Management and organisational	Organisational culture
	Management style
	Organisational form
	Knowledge management
People	Teamwork
	Level of competence
	Customer relationship
Process	Change in approach
	Emphasis on adaptability
	Selection of methods
Technology	Appropriateness of existing technology and tools

Table 3: Overview variables and attributes

3. Methodology

In the introduction, the research strategy has already been discussed briefly, but in this chapter the methodological part of this research will be examined more thoroughly. This chapter will elaborate on the choice of research method, the operationalization is made, data collection and data analysis is discussed.

3.1 Conceptualization

The process of specifying what we mean is called conceptualization, this process is essential for performing a research. Without agreeing on the meaning of a concept, studying the subject and finding answers to a research question is impossible (Babbie, 2007). The unit of analysis in this research is the implementation of Concept, Development and Experimentation at the Ministry of Defence. The goal of CD&E is increasing the speed in which innovative concepts are transformed into effective military capabilities for the Dutch Military Forces. As discussed before this goal is explained via the concepts of throughput time and quality performance. Military capabilities consist of three components; the conceptual, physical and the mental component. Increasing military capabilities therefore does not only consider increasing the operational assets (physical component) of the Armed Forces but also their will (mental) and their ability (conceptual) to use the new capabilities (Koninklijke Landmacht, 2009). Note that not all military capabilities are developed through CD&E. The concept in which all the development of all the military capabilities is grouped are defined as the capability development projects of the Ministry of Defence.

3.2 Research method

To answer the central and research questions, information about the topics was to be collected. The method for collecting this information was chosen from a great variety. Each type of research method however has strengths and weaknesses. Therefore some methods more appropriate to collect data in some situations than others, and vice versa (Babbie, 2007). This research used a qualitative research strategy. This strategy was chosen, because the research questions require data about the experiences and expectations of stakeholders with CD&E in the current organisation. It is possible to quantify these experiences of the stakeholders, however this would cause the data to loose significant detail (Babbie, 2007). In order to find a deeper understanding of the experiences with CD&E that were gathered, the denser information occurring from a qualitative research strategy was necessary. A mixed research strategy, a combination of a qualitative and quantitative research strategy, was not applied, because this was complicated by the newness of CD&E at the Ministry of Defence and the other involved organisations (TNO and NATO). Only a small group of employees from these organisations had experienced CD&E and finding an adequate sample of employees in these different organisations was hard.

3.2.1 Data collection method

There is a great variety of qualitative data collection methods. In order to select the appropriate method, the unit of analysis had to be determined. The unit of analysis is the object that is being studied (Babbie, 2007; Van Aken, Berends, & Van der Bij, 2007). The goal of the research is to make recommendations on aligning the project management procedure of TNO with concept, development and experimentation and thereby improving the throughput time and quality performance of the capability development projects of the Ministry of Defence. The unit of analysis in this study is therefore the implementation of CD&E in the current capability development projects of the Ministry of Defence. Collecting qualitative data can be done in via different methods that are suitable with regards to this unit of analysis and the context of the research. Qualitative data in this research could be collected by interviews, focus groups, verbal protocols, using existing documents, observations, or

diaries(Van Aken et al., 2007). During this research, the qualitative interview was chosen as the data collection method. Interviews enabled the participants of the interview to reveal their reasons, thoughts and attitudes on the discussed topics with great detail (Babbie, 2007; Louise Barriball & While, 1994). The flexibility and good applicability of interviews ensured the feasibility of involving the selected participants, as the planning of the interviews could easily be adapted to the full agendas of the selected participants.

3.3 Selection of participants

The selection of the sample for a qualitative study differs from that of a quantitative study. Quantitative studies try to select a sample that is representative from the entire population. This is done so the results of the study from the sample can be generalized back to the entire population. Qualitative studies are likely to have smaller samples, and the participants are selected for their knowledge and competences to gain understanding of the problems that is examined. In accordance with the chosen research method Weiss (1995) identifies two categories of respondents for qualitative interviews. The first one is the informant, a respondent with specific knowledge or experienced in the subject under study. Together these informants form a panel of informants that can provide the necessary information to answer the research questions. The second category is the respondents that represents a population, together these respondents form a sample of respondents that represent the experiences or knowledge on the subject under study (Weiss, 1995). To select the participants for a qualitative research, there are different non-probability sampling strategies (Babbie, 2007; Marshall, 1996). This research used a combination of purposive or judgemental strategy and snowball strategy. Purposive or judgemental strategy is the selection of a sample or panel based on the knowledge of the respondents and their usefulness to the research (Babbie, 2007; Marshall, 1996). Weiss (1995) identified these respondents as informants. With the snowball strategy, participants of the research are asked to propose additional potential participants (Babbie, 2007). This last strategy was used when the data from the initial participants was not adequate to answer the research questions. The sample size was large enough when the data needed for the understanding and answering of the research questions was gained (Marshall, 1996; Weiss, 1995).To answer the research questions, data was gathered by interviewing participants that had experienced the use of CD&E in projects and those responsible for the implementation of CD&E at the Ministry of Defence (purposive or judgemental sampling). These participants were found at the Ministry of Defence, TNO and the NATO. Due to the focus on the collaboration between the Ministry of Defence and TNO, most participants were selected from these two organisations, but one participant of the NATO was added when the opportunity arose. Besides these three organisations, participants could also be found at the other independent research institutions (i.e. MARIN or NLR) and the defence industry.

3.4 Operationalization

The theoretical framework distinguished four important factors to consider when choosing an approach for a project. Furthermore four categories of implementation challenges for an agile approach in organisations have been identified in the literature. These factors and categories are defined as variables, using the definition of Babbie (2007). Variables are (Babbie, 2007, p. 14): “logical groupings of attributes”. Attributes are defined as: “characteristics of people or things” (Babbie, 2007, p. 15). These variables are not operationalised yet. Operationalization is defined as: “the development of specific research procedures (operations) that will result in empirical observations representing the concepts under study” (Babbie, 2007, p. 133). In this study the research operations is the interview protocol. These variables are converted to operational definitions to become measurable. See Table 4.

Attributes	Description	Operational definition
Organisational culture	Values, norms and assumptions. Influences decision making process, problem-solving strategies, innovative practices, information filtering, social negotiations, relationships and planning and control mechanisms (Nerur et al., 2005).	Is the organisational focussing on long Is there a small power distance in the o Is there a group culture within the orga
Management style	A traditional role of a manager was that of planner and controller. The agile manager changed into a facilitator that guides and coordinates the collaborative efforts of the stakeholders (Nerur et al., 2005).	Do project managers guide the team m Do project managers encourage collab
Organisational form	Different approaches require different forms of organisation. Traditional approaches benefit more from mechanistic forms (bureaucratic with high formalization) while agile approaches greater benefit from an organic (flexible and encouraging cooperative social action) form of organisation (Nerur et al., 2005).	Is the organisation organically (low fo organised? Are the projects organically (low form
Knowledge management	Traditional projects result in and require more explicit (documentation) knowledge management, while agile projects result and require more tacit (in the heads of team members) knowledge management (Nerur et al., 2005).	Do projects result in tacit knowledge? Are tacit results accepted as project res
Teamwork	Agile project teams are characterized by teamwork with heterogeneous teams encouraging interchangeable roles. Furthermore teamwork is characterized by informal communication and collaboration between the heterogeneous team members who value and trust each other. Instead of individual role assignment in homogeneous teams of traditional project teams (Nerur et al., 2005).	Are project teams established with het Are project teams characterized by inf collaboration on a daily base?
Level of competence	Level of competence with agile methods is important, as no evidence is available of successful agile teams lacking agile experience (Nerur et al., 2005)	How many agile projects did the team What percentage of members have CD
Customer relationship	Actively participating customers are essential. Customers are expected to be: collaborative, representative, authorized, committed and knowledgeable. Decisions are made with the customer instead of for the customer (Nerur et al., 2005).	Are customers actively involved on a c Are decisions based on pluralist-decisi
Change in approach	Traditional process: compliance-driven (Legislation and regulation) and activities- and measurement-based, aimed at providing assurance. Agile process: relies on speculation, or planning with understanding that everything is uncertain, to guide the rapid development of flexible and adaptive systems of high value. Process guided by product features. Assessing instead of measuring (Nerur et al., 2005).	Is the process and its progress guided b Does the process rely on speculations,
Emphasis on adaptability	Traditional projects use a life cycle model, agile projects instead use an evolutionary-delivery model which allows for feature based development. This model focusses on short, test driven, iterative development (Nerur et al., 2005).	Are projects using iterations, with a ce A potential product tested during proje
Selection of methods	Agile methods differ in terms of team size, code ownership, duration of cycles, emphasis of up or downstream activities, and mechanisms for rapid feedback and change (Nerur et al., 2005).	Is the choice for CD&E based on certa Is the choice for a certain scientific me of a project?
Appropriateness of existing technology and tools	Work procedures, tools and techniques altered for agile methods. These need to support rapid iterative development, and people need training to use them (Nerur et al., 2005).	Do the current procedures, tools and te development of CD&E projects?

Table 4: Description and operationization of attributes

3.4.1 Interview protocols

The design of an interview protocol depends on the representativeness of the respondents for the population. If they are representative for the population, than a standard interview protocol is appropriate. If they are not, or a panel of informants is used, the interview protocol has to be tailored for these respondents (Weiss, 1995). In this research a panel of informants was used of the employees that had the necessary knowledge, on the one hand employees of TNO and on the other the employees of the Ministry of Defence. Due to these differences in informants a standard interview protocol for all respondents was not appropriate. However the two groups of employees can be seen as two different populations, in which case for each population a standard interview protocol can be designed. The interview was semi-structured, which made deviating from the questions possible and gave the participants the possibility of introducing new issues and explore consistencies between participants (Louise Barriball & While, 1994). All interviews, used the categories and variables identified in the literature as a framework. An example of the interview protocol for TNO interviewees can be found in Appendix A:

3.5 Data collection

Prior to collection of the data through interviews, four informal conversations have taken place with TNO employees. These had the purpose of creating an understanding of the possible difficulties and ideas for research directions. During these conversations names of potential participants were suggested. Data collection involved, besides the analysis of documents, 12 interviews with different participants. The distribution of the participants was: five officers of the Ministry of Defence, six project managers of TNO and one civilian employee of the NATO. The interviews all lasted for one hour minimum, with some lasting for one and a half hour depending on the flexibility of the participant. All interviews were recorded, in agreement with the participants, with a voice recorded for easier consultation of the raw data of the interviews.

3.6 Data analysis

The data analysis started with the recording of the interviews with the CD&E stakeholders. These recorded interviews were transcribed entirely to provide the highest level of detail in the statements. After transcription, the texts were analysed with the help of Atlas TI (Qualitative data analysis software). With the use of the program, the wide variety of statements by the interviewees, were structured according to the operational definition and operationalization (See Table 4). The results of the interviews are displayed in chapter 6 and assisted by quotes from the interviews.

4. Product innovation at the Ministry of Defence

This chapter answers the first research question: What are the characteristics of the current project management procedure of TNO regarding the throughput time and quality performance of the capability development projects of the Ministry of Defence? The chapter discusses the current project management procedure of TNO and the equivalent at the Ministry of Defence.

4.1 TNO Project management procedure TNO

TNO is a project-driven organisation, all the research TNO carries out is done in projects. The project management procedure describes the course of the projects within TNO, from the start of developing a project until the project closure. TNO uses the project management procedure for all types of projects performed by the organisation (TNO, 2014). The procedure consists of three partial processes: Project development, project execution and project closure.

4.1.1 Project development process

The project development process consists of five phases; 1. introducing and deciding on the lead, 2. developing the opportunity, 3. offering the proposal, 4. reaching an agreement, and 5. the transfer to the project execution process. The process starts when a 'lead' identified, this can be done by a wide variety of employees for example: project leaders, market managers, account managers or business developers. The lead is then forwarded to the business line manager, by whom it is reviewed and decided if the lead should be developed further. If this I s the case the lead is further developed in resulting in a proposal in the tenor, time and money involved. Based on the proposal the business line manager determines the complexity of the project and thereby determines the level of the project leader. During phase 3, the offering of the proposal, the proposal is specified further. The managing director of expertise, director of research or the research manager appoints a proposal manager and an intended project leader. Together these design planning and staffing possibilities. Furthermore a risk analysis is done and the price of the project is coordinated with the business line manager. Then the proposal/bid is sent towards the customer, which is coordinated by the business line manager. If the customer accepts the bid, it is transferred to the project execution process. In this phase, the project leader is appointed. The project goals, human resources, planning inter alia are than specified by the project leader in coordination with the proposal manager, the business line manager and the research manager.

4.1.2 Project execution process

After the project development process, the project moves on to the project execution process. The components of the project execution process are a description of the project, planning the project and organising the project (TNO, 2013a). During this process, the project leader and the project team carry out the project within the boundaries of the contract that has been signed in the previous process. These boundaries are the timeline, budget and quality aspects. For more information see the heading Project plan. During this process the project leader reports the project progress to the customer and the research manager. Communications with the customer is based on the interval both actors agreed to. With the research manager communication are based on explicit documentation. In indication that is given for the interval of this reporting is four to six weeks. During the execution of the project, other employees of TNO reviews the project results compared to the agreed deliverables in the contract. If changes occur during the project impacting the content of the project, the intellectual property or the contract, the project leader and customer record the changes on the supervision of the business line manager. After the finishing of the project activities, the deliverables are transferred to the customer, the results shared with the research information support department for knowledge sharing.

Project plan

The description of the project contains the most important facts of the project, and is used as a project proposal in order to check the alignment of TNO and the client. The description contains a background of the relationship between TNO and the client, the problem statement, and the goal of the project. The problem statement also includes the request of the client and the direction of the possible solution the client demands. The scope of the project describes what TNO will be doing in the project. The scope tells the reader what will and what will not be a part of the project. These 'parts' will be expressed as products and services that TNO will provide. The end result of the products will be defined in terms of the form of the result (e.g. physical product, report of software), the time of delivering the product, and who should receive the products. The services are defined in similar terms. The terms are the type of services delivered, the duration of the services delivered and if there is any after sales service. The project approach is a global representation of the activities TNO will perform during the project. A few examples of these activities are the development of a model, organising workshops or executing a literature study. Within this project approach the usage of expertise, methods, techniques and resources are discussed as well. This subcomponent discusses the involvement of the client during the execution of the project. The contribution of the client in the project will be defined, in terms of the execution of activities, the client's expectation of the results and the time within the client executes the activities. The involvement of other stakeholders is described with the same terms as the involvement of the client. These other stakeholders can be equal parties, but subcontractors are possibility too. To deliver the project results in time and within the given budget, general conditions are arranged, risks identified and possible actions to control those risks. The general conditions are related to the budget, nature, size, quality and timeframe of the project. Risks identified especially apply to the clients. These could include dependence on activities of third parties and ambiguities in the contract specifications.

The planning of a project is made according to the work packages. Work packages are defined parts of the total project. The planning contains a short description of the work packages, the delivery dates of the packages, and go/no-go moments. The content of the work packages is described in this subcomponent. It describes who is responsible, which team members are involved, what the goal is, how the work packages is performed, what input is necessary, what results are expected, the location of the work, and the according of the result.

The composition of project team is an explicit statement of the members that will join the project team. It contains their competences, their department and their function in the project. The internal communication is explained as the communication channels of the project team with only the stakeholders. It contains a statement on the frequency, the format of reporting and the attending internal stakeholders. The external communication is similar, with the only difference that the stakeholders are external.

4.1.3 Project closure process

The project closure, consists of three phases; the checkout of contents, the evaluation and the after-sales services. During the project checkout of contents the project leader checks if all the activities are completed, hours are registered, costs are booked, invoices are sent and if all the incorrect costs are returned. In the evaluation phase, an internal evaluation of the project is conducted, extracting the lessons learned. Furthermore, the business line manager investigates the possibilities of follow-up projects. During the after-sales services the business line manager keeps communicating with the customer on the project results and the possibilities of follow-up projects.

4.2 Identifying the generation of the current procedure of TNO

The golden triangle in which the product innovation of the Ministry of Defence occurs is the level to which the innovation models are related, because this levels contains all the elements that are responsible for the product innovation. The TNO project management procedure for instance does not include the manufacturing, or marketing and sales of the finally developed product. If one wants to identify the model to which this product innovation system of the Ministry of Defence is related, one has to look at the entire system. By combining the different procedures of the golden triangle members, in this research especially the Ministry of Defence and TNO, this system can be observed and an appropriate innovation model can be identified.

Looking at the golden triangle one can observe the third generation or coupling model characteristics. In the two first phases the demands from the market and the available technologies are brought together and are integrated. This is done by the K&I department and the research institutes in the form of basic research. At TNO this research is done by targeted funding. After these phases the DMP is leading, with specific contributions of TNO and the defence industry. At TNO this research is done by additional funding. The emphasis of the collaboration between the Ministry of Defence and TNO apply especially to the first two stages of the coupling model. The defence industry is involved at later phases of the DMP. At the last two phases (C-D) of the DMP for example, a manufacturer is chosen for the prototype production or supplier of the end product. This shows sequential linear process of the current golden triangle collaboration.

The current project management procedure of TNO, as part of the product innovation process of the Ministry of Defence, fits the third innovation model. In the current product innovation process the processes are structured, mostly linear and separate phases are identified.

4.3 Influence on the throughput time and quality performance of projects

To answer parts of the first research question, this subchapter discusses the characteristics of the project management procedure of TNO in comparison with the identified attributes of the theoretical framework. Based on the gathered information from the documents on the TNO project management procedure, not all attributes of the theoretical framework are covered.

Attributes	**Characteristics TNO procedure**
Organisational culture	• Not covered by the documentation.
Management style	• It is noticed that during the different stages, important decisions are made based on collaboration between the team leader and higher management as the business line manager. The actors from the higher management vary continuously.
Organisational form	• The organisational form appears to be a mixture of the mechanistic and organic form. Some phases are clearly defined and formalized (e.g. content of the work packages) while other phases are less defined and offer flexibility for the project teams.
Knowledge management	• Knowledge sharing with the research manager is in the form of explicit documentation.
Teamwork	• The documentation does not include any information on the needed competencies in the project teams, except that they have to be documented in the project planning. The work packages are assigned to defined team members, again the composition of sub teams is left open. There is no emphasis

	on strong communications on a daily base. The intervals of communications are not formalized, and left open.
Level of competence	• Not covered by the documentation.
Customer relationship	• The documentation states changes to the project impacting the contract are made in collaboration with the customers and higher management. The participation of customers in the project is left open, same goas for the communication with the customer. This is tailored per project in consultation with the customer. The characteristics (e.g. authority) of the customer needed for projects is not discussed.
Change in approach	• Projects are guided by the time, budget and quality agreements stated in the contracts. There are no statements on delivering in order of importance.
Emphasis on adaptability	• Test-driven and iterative development of the deliverables is not discussed.
Selection of methods	• There is no mentioning of different types of project methods in the procedure, and the characters of projects appropriate for these project methods. Furthermore, there is no mentioning of different types of experiments and scientific methods.
Appropriateness of existing technology and tools	• Not covered by the documentation.

Table 5: Characteristics of TNO project management procedure

4.4 Ministry of Defence

A distinction can be made in the capability development process of the Ministry of Defence. The two distinguished elements are knowledge development and knowledge application. In its turn the knowledge development is divided into several components. The following discusses the distinguished elements and components in more detail and clarifies the position of CD&E.

4.5 Knowledge development

As explained above the knowledge development element of the capability development process of the Ministry of Defence can be divided in several components. These components act on different levels in the organisation. At a strategic level there are the Strategy, Knowledge & Innovation Agenda (SKIA), the Military Strategic Vision (MSV) and the Defence Industrial Strategy (DIS). The Military Strategic Vision is description on the development of the armed forces from an operational perspective. The vision spans a period of 15-20 years, and is updated every two years (Ministerie van Defensie, 2010). The Defence Industrial Strategy is a combined strategy of the Ministry of Defence and the Ministry of Economic Affairs. The goal of the strategy is enabling the Dutch Defence Industry and Research institutes to contribute the operational interests and needs of the armed forces, furthermore enabling them to compete on European and international markets (Ministerie van Defensie, 2007a).

The Strategy, Knowledge & Innovation Agenda (SKIA) is a policy document of the Dutch government about the future of the Dutch armed forces. The SKIA was designed because of the uncertain future and the ever changing environment. The goal of the strategy function is to make the right choices in the changeable environment. The knowledge and innovation parts are of value for the quality and the innovative character of the Dutch armed forces. Due to budget cuts the emphasis of the organisation will be on keeping effective, while reducing the overhead. In order to support this ambition, the government determined that the organisation needs to create a better environment for the emerging of new ideas, technology and processes. This SKIA is implemented for the period 2011-

2015. It supports the ambition by improving the strategy of the governance within the organisation, providing guidance to the knowledge development and stimulating the innovation of the organisation and the environment. (Ministerie van Defensie, 2008).

For this research, the Knowledge agenda and the Innovation agenda of the SKIA are most relevant. A broad knowledge base is important for the acquisition of military equipment and for the innovative capacity of the Ministry. The Dutch research institutions support the Ministry by being the smart customer, smart creator of requirements and smart developer. The importance of the Knowledge agenda is further increased by the increasingly complex weapon systems, as a result of technological advances (Ministerie van Defensie, 2008).

For the Ministry there has always been a need for the development of new scientific knowledge In the SKIA the Ministry there is a priority list of areas which are most important to them. These areas must meet the criteria of the Ministry before investments in these areas are considered. The knowledge must be relevant for the policy goals of the Ministry. The knowledge must stem from a specific knowledge need of the Ministry and there must be a potential application of the knowledge that lies ahead. The last criterion is that the Ministry has to be engaged in order for the knowledge to be viable. The following four areas are the Ministries priorities for the current SKIA: military action in complex and dynamic environments, new technologies for defence purposes, cyber defence and cyber operations, and the use of space for military purposes (Ministerie van Defensie, 2008).

These strategies discussed above result in the 'Aanwijzing Gereedstelling Commandant der Strijdkrachten' (AGCDS) and the Defence Knowledge and Innovation Plan (DKIP). The AGCDS is a document stating the assignments of the different military branches and their budget (Defensie Gezondheidszorg Organisatie, 2013). The DKIP is an annual document assigning the R&D budget to knowledge development projects, based on the knowledge priorities of the SKIA. The DKIP is (Rijksoverheid, 2013). This DKIP results in individual innovation plans for the military branches. As explained in the introduction, the Royal Netherlands Army is the first military branch introducing CD&E. A component of the Royal Netherlands Army innovation plan will be the CD&E plan, and consist of all CD&E activities. The DKIP furthermore sets the research programs, which are financed by the Ministry, of the research institutes (TNO, MARIN and NLR). In addition to these research institutes universities, other Ministries and international partners are involved in developing knowledge. The process of knowledge development is a linear process, with a market-pull strategy (Ministerie van Defensie, 2008)(See Figure 9**Error! Reference source not found.**).

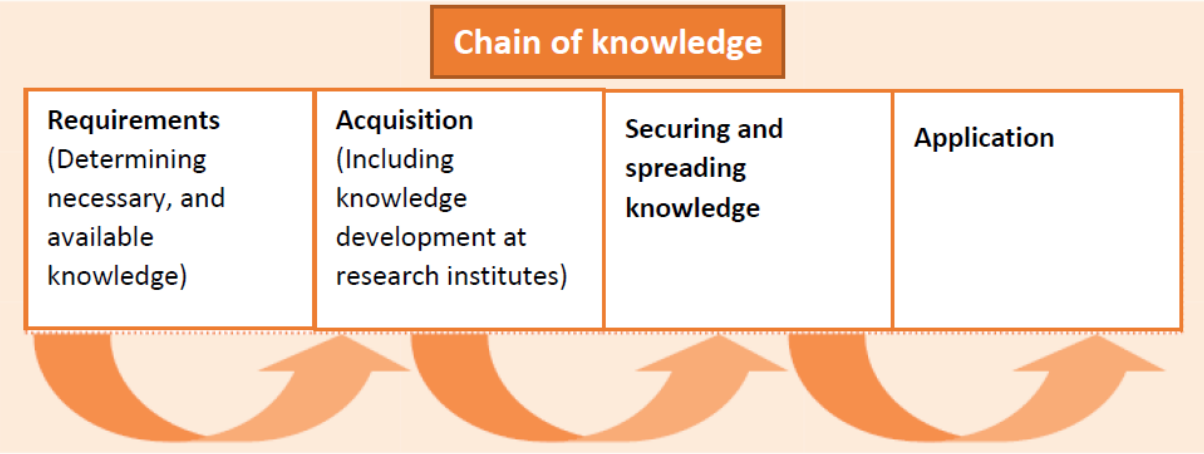


Figure 9: Knowledge development process (Ministerie van Defensie, 2008)

The innovation agenda of the Ministry is primarily intended to stimulate innovation at the Ministry. The organisation considers itself as quite innovative; the small size contributes to this innovativeness. The budget cuts, however, require the organisation to become more innovative to be able to perform the same operations. The innovation agenda provides innovation goals on areas in which the Ministry and the research institutes seek to innovate. The four innovation goals the Ministry has set are: acting in information driven-networks, effective influencing in military operations, an energy conscious army, and an innovative and flexible organisation.

4.6 Defence Materiel Process

The second distinguished element of the capability development process of the Ministry is knowledge application. The knowledge application is represented by the Defence Material Process (DMP), which is discussed hereafter. The investment in military material, information systems and real estate are complex. A variety of stakeholders are involved, projects often run for several years, the environment of such projects continues to evolve over these years and big sums of money are invested. The DMP was designed, with clearly defined procedures, to manage and control such complex investments with a minimum scope of € 5 million. These procedures made it also possible to inform the government with adequate, correct, complete and timely information. The DMP is divided into different phases. At the end of each phase, a DMP document is made in order to present the results and propose plans for the next phase. There are two types of DMP's, mandated and non-mandated projects. If a project is mandated the decision-making will be done by the civil-services. In non-mandated projects, decisions are made by the State Secretary of Defence. Projects with scopes between € 5- €100 million, are usually mandated. Projects with larger scopes than €100 million are not mandated (Ministerie van Defensie, 2007b).

The DMP is divided into four different phases. Setting the requirement (phase A), the preliminary study (phase B), the study (phase C), and preparing the procurement (phase D). For DMP projects with a scope of over € 250 million there is an ex post evaluation (phase E). Between the first four phases there is a distinction being made between setting the requirement (phase A) and the meeting the requirement (phase B-D). The phases of the DMP are executed sequentially, and the results of each phase are drawn up in a DMP document. When phase D is finished, the capability is implemented.

Setting the requirement – Phase A

Phase A is important and particularly decisive for the course of the DMP, by setting the requirement. The requirement that is needed to accomplish one of the objectives of the Ministry is derived from the policy and plans of the organisation. The Ministry uses the Policy, Planning and Budgeting Process (BPB-process). The BPB-process balances the investment in projects based on the ambitions of the Ministry and the available budget of the Ministry. Results of the BPB-process are included in the statement of requirements (A document). The choices made in setting the statement of requirements are supported by studies if possible. This phase should provide initial insights in the potential costs and effects of the projects. These insights can be gained from experiences from foreign and Dutch armed forces.

The preliminary study – Phase B

Phase B advances with results from Phase A. After the decision-making on Phase A, special instructions are established on the product, time, money and project organisation for the following phases. During phase B the requirement is translated into functional and, if possible, technical requirement that must be met with the DMP. Subsequently a market research is conducted and alternative products and risks are explored. The alternatives found will be compared and a selection is made and the most viable alternatives are selected ("long lists"). All the selected alternatives are

assessed for the functional and technical requirements and instructions mentioned above. This assessment can result in the adjustment of the requirement. Financial assessments of the lifecycle costs of all the alternatives are made, and the requirements of the upkeep are established in highlights. After the assessments the further and more detailed specification or the design of the product is started. At this point it is also considered if a study or development programme must be started, and if the Dutch defence industry could be involved. The Netherlands Defence Manufacturers Association (NIID) is concerned with a leading role on the last task.

The study – Phase C

During the C-phase the general requirements established in phase B are further differentiated and a short-list of the most appropriate alternatives is assessed on these requirements. At the end of the C phase a choice is made for the best alternative. Of-the-shelf products are considered at first, if those are not available, than it is considered to develop the product itself or let it be developed by others. Testing may or may not be included in the development options. After testing the chosen product for efficiency and legitimacy, occasionally a contract is signed for a development programme or the acquisition of prototypes for testing. In projects with scopes over € 100 million a cost-benefit analysis may first be performed.

Preparing the procurement – Phase D

In the D-phase the final decision for a product or supplier is made and is finalized by the signing of a contract. This is preceded by the request of bids from potential suppliers. After studying these bids, and possible negotiations with the chosen supplier, the contract is signed. Occasionally a social cost-benefit analysis is performed in projects with a scope of over €100 million.

Evaluation – Phase E

Every DMP project with a scope of €250 or larger has to undergo a DMP evaluation. Some financially smaller projects may as well undergo an evaluation. This can be triggered by the complexity of the project, the public or parliamentary interest or their relationships with other DMP projects. A DMP evaluation constitutes out of two parts: the evaluation of the project, which is started directly after the completion of the project, and an evaluation of the usage of the bought product. This is started after the product is in use for a while. The product evaluation is conducted by the members of the project team and is looking at the course of the project, while the usage evaluation is conducted by the end-users of the product.

The DMP is a time consuming process, which does not matter in projects with scopes of several years, but sometimes the material is required faster. Sometimes the normal DMP is too time consuming, and would the normal process take more time than the fast track procedures can be appointed.

4.6.1 Traditional approach at the Ministry of Defence

The product innovation process of the Ministry of Defence is discussed and similarities with the traditional approach are perceived. The assumption that everything is specifiable, predictable and can be achieved by extensive planning can be noticed in the product innovation process of the Ministry of Defence. The knowledge development process (Figure 9) and the DMP are divided in logical and sequential phases, that are created to be repetitive and easier to predict. The DMP is especially designed to manage and control complex investments with clearly defined procedures in continues evolving contexts (Ministerie van Defensie, 2007b). In this way, the outcomes of a phase are more predictable. The control can be seen in the documents that are drawn up after each phase and the possibility to present these to the government. The assumption of specifying and predicting can also be

found in the specification of the requirements, as this happens in the early start of the process, and opportunities to change the requirements are not available regardless of changes in the environment. The repetitive and predictive phases lead to specialisation of the employees, in an organization that is already characterized by functional specialisation. With the knowledge development process the customer, i.e. the Ministry of Defence, the first phase identifies the required knowledge and what knowledge is available already. The DMP derives its product to be developed from the statement of requirements made by the Ministry of Defence. In this way the customer is only indirectly involved in setting the requirements and specifications of the product to be developed.

4.7 Conclusion

This chapter set out to answer the first research question: *'What are the characteristics of the current project management procedure of TNO regarding the throughput time and quality performance of the capability development projects of the Ministry of Defence?'* In order to do so, the chapter discussed current project management procedure of TNO and the capability development process of the Ministry of Defence.

When discussing the current project management procedure of TNO with the help of the established theoretical framework, different interesting matters were found. Some attributes of the theoretical framework were discussed, to various degrees, in the procedure of TNO. Other attributes of the theoretical framework were not discussed at all in the procedure of TNO, or were not adjusted to benefits of CD&E. The most striking findings of these characteristics of the project management procedure of TNO belong to the attributes teamwork, customer relationship, level of competence, and the change in approach. The overall finding is a lack of mentioning different options in the procedure. CD&E or other types of approaches are not mentioned in the procedure, and therefore important considerations are not brought to the surface and are easily overlooked by the project manager. Both the teamwork and customer relationship lack an emphasis on daily face-to-face and informal communications. Customer involvement or the intervals between involvement of customer is left open, to be discussed with the customer. Regarding the goal of this study, Chow and Cao (2008) found these daily face-to-face meetings with customers or end-users to positively impact the ability of projects to meet all requirements of the customer. The lack of mentioning certain options on the other hand, offer flexibility for the future use of CD&E as a lot of these attributes are open for adaptations per project. For knowledge management attribute however exposes a requirement of knowledge sharing to be done by documented or explicit knowledge, which is the opposite of what is beneficial for agile approaches.

As seen, the current project management procedure is not adapted for the use of CD&E in its current form. The main problem is the lack of mentioning the different options that come with the use of different types of approaches. Overall the project management procedure of TNO provides a degree of flexibility and autonomy, which allows the project manager to make its own decisions. In the upcoming chapters CD&E and the experiences of TNO and the Ministry of Defence are the focus point of the discussion, and thereby contributing to the search for recommendations on aligning the current project management procedure of TNO with CD&E.

5. Concept Development and Experimentation

This chapter discusses Concept Development and Experimentation as designed by NATO, with the use of the theoretical framework of chapter 2. The detailed description of Concept Development and Experimentation provides the answer to the second research question: 'What are the characteristics of Concept Development and Experimentation regarding the throughput time and quality performance of capability development projects?'.

5.1 NATO: Initiator of CD&E

Concept Development & Experimentation (CD&E) is a method that was developed and adopted by the North Atlantic Treaty Organisation (NATO) in order to support NATO Transformation. NATO Transformation's goals are to deliver increased capabilities, better interoperability and standardization, and finally and most important a greater military effectiveness of the NATO (North Atlantic Treaty Organization, 2010). The definition NATO has given to CD&E is: "CD&E is one of the tools that drive NATO's transformation by enabling the structured development of creative and innovative ideas into viable solutions for capability development (North Atlantic Treaty Organization, 2009, p. 3; Weima & Van der Wiel, 2010, p. 7). The purpose of CD&E is to contribute to the continuous transformation of NATO, which will ensure that the organisation stays relevant in the security environment and that it keeps on performing its roles effectively. The method is aimed at the development innovative and novel solutions. Furthermore the process is organized in a repetitive way, which can lead to continues improvement of both the new and the existing solutions (North Atlantic Treaty Organization, 2010). The key elements of the transformation of NATO are conceptual and organisational intelligence and the development of powerful capabilities that are deployable, sustainable, interoperable and usable in future operations and missions (North Atlantic Treaty Organization, 2009). First the CD&E process is discussed, which can be seen as an overview of the organisation of CD&E at the overarching level of the NATO. After the discussion on the organisation of the CD&E process, CD&E is addressed.

The CD&E process at the level of the NATO consists of three elements (Figure 10): CD&E Project, CD&E Management and CD&E Engagement. This process encompasses CD&E in the development of all projects, the management of related activities and the engagement with nations and within NATO (North Atlantic Treaty Organization, 2010). All three elements of the CD&E process will be discussed, but the CD&E project will receive the most attention as this is the most important element for the implementation of CD&E in the product innovation process at the Ministry of Defence. CD&E management and CD&E engagement are only briefly discussed, as these elements mainly relate to the collaboration between NATO countries on NATO supervised projects.

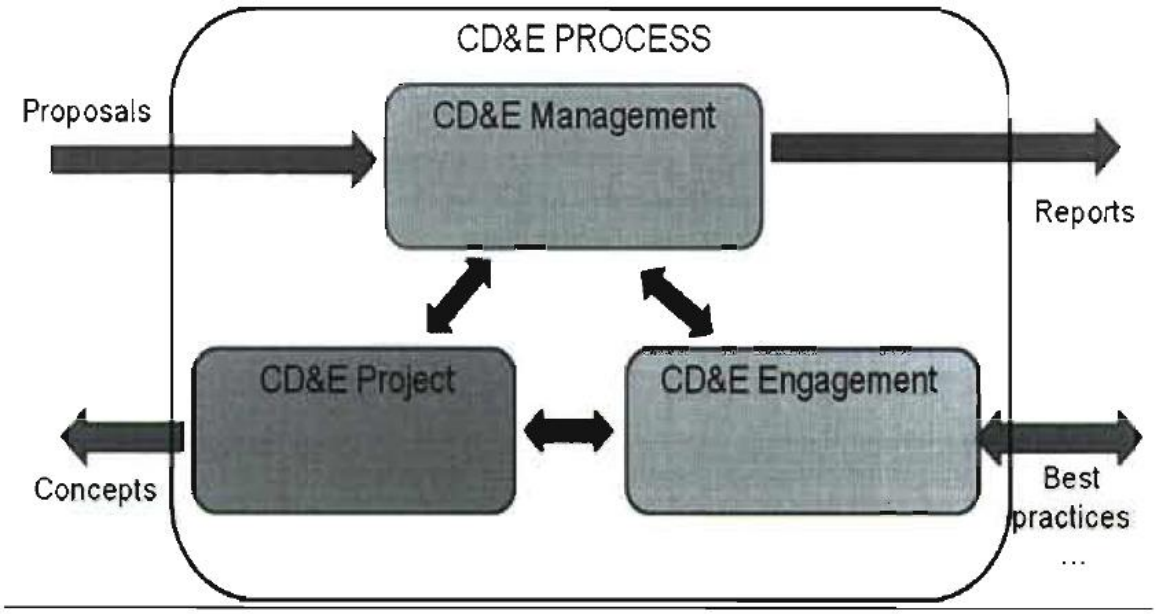


Figure 10: North Atlantic Treaty Organization (2010)

CD&E management

The CD&E management handles all the activities regarding CD&E proposals from the NATO or from associated nations. The management integrates all these proposals into the Comprehensive Campaign Plan (CCPlan) into the budgetary process of the NATO and all activities that come with launching and monitoring the CD&E projects. Some examples of such activities are: initiating projects, approving plans, allocating resources for CD&E projects, tracking CD&E projects, assuring quality and creating annual reports on all projects (North Atlantic Treaty Organization, 2010).

CD&E engagement

CD&E engagement constitutes of the distribution and sharing of the results, the spreading knowledge on CD&E methods, processes and projects to improve the exchange of best practices between NATO nations and partners(North Atlantic Treaty Organization, 2010).

CD&E Project

A CD&E project is the part of the process which is dedicated to developing a concept, experimenting with the concept, and analysing the concept in order to align it with the capability gaps. The choice for the initiation of a CD&E project is made with the help of a stakeholder's analysis, the identification of problems, and the first ideas thought of. This choice is made after the capability shortfall has been determined. After the initiation the concept development team is created, which consists of the right members in order to cover all the necessary competences that are needed to complete the project. Teams consist of concept developers, experimenters, analysts, modelling and simulation experts and specialists on the subject. The necessary competences may include: drafting documents, brainstorming, analysing, modelling and simulation or demonstrating prototypes. A CD&E project has a predetermined timeframe and resources, which are dedicated to finding solutions to particular shortfalls. During this timeframe the concept has to be developed and validated using CD&E. The process of a project using CD&E includes the following: a deep analysis of the problem and identification of potential concepts that solve the problem, the formulation of the concepts, the development of the concepts, analysing the abilities of the concepts, and experimentation to test and approve the suggested concepts. So a CD&E project is an iterative process that uses concept development, experimentation and analysis as its three main techniques. The strict usage of the three

techniques is the guarantee of an efficient method of analysing and assessing the quality of the conceptual outputs, furthermore knowledge and insights are gained on the consequences of the new concepts on for example employees, organisation, systems and processes (DOTMLPFI), their contribution to the transformational goals and their fit with the existing context before the actual implementation (North Atlantic Treaty Organization, 2010).

5.2 CD&E method and definitions

The primary purpose of CD&E is the contribution of solutions to capability shortfalls or gaps. The terms used in Concept Development & Experimentation are vulnerable for various interpretations, in order to prevent this risk, definitions of the NATO are used. After an explanation of the definitions the individual terms will be elaborated on. A Concept is a solution-oriented idea focussing on solving a capability shortfall (North Atlantic Treaty Organization, 2009). The exact definition of the NATO is: "a notion or statement of an idea, expressing how something might be done or accomplished, that may lead to an accepted procedure" (North Atlantic Treaty Organization, 2014, p. 71). Concept Development is the process towards identifying concepts that are a solution to capability shortfalls or gaps, and Experimentation is a process to discover information and test or validate a concept. A capability is the skill to perform a specific procedure or to accomplish a certain effect. Within the development of capabilities this definition always encompasses one or more elements of the Doctrine, Organisation, Training, Material, Leadership, Personnel, Facilities and Interoperability (DOTMLPFI) context (North Atlantic Treaty Organization, 2009).

Concepts

The definition of a concept given by the NATO is broad. A distinction can be made between strategic and operational concepts. Strategic concepts are addressed at a high political-military level. The concepts at this level contain a broad strategy on which military operations are based, and a vision for the mid to long term future. The operational concepts are more often, than Strategic concepts, the foundation of a CD&E project. Operational concepts are addressed to levels in which campaigns and joint operations are conducted, and are used in order to achieve strategic objectives in a theatre of operations (North Atlantic Treaty Organization, 2009). The operational concepts in their turn are divided into a hierarchy of three levels: a capstone concept, an operating concept and a functional concept. The hierarchy is established in order to describe the aim, scope and the content of the concept. The hierarchy is to create order among the different concepts. The capstone concept is an overarching concept for the development of a military organization in its entirety with broad descriptions of the requirements to meet the strategic objectives in a certain part of the theatre of operations. The operating concept is a concept description of a military function or type of operation and how a commander will execute these. It states the effects and capabilities required to achieve the desired result. The functional concept is a concept that characterizes a specific capability. The intention of this concept is to solve a explicit or practical capability problem, and to specify how this is done (North Atlantic Treaty Organization, 2009).

Concept development

The role of Concept Development is to find suitable solutions to capability shortfalls or gaps. New shortfalls or gaps can occur due to changes in the macro-environment or changes in the DOTMLPFI context. New objectives in existing situations are also a possible cause of shortfalls or gaps, which can be dealt with by new concepts. New concepts may also be developed to suggest a superior solution to the concepts currently used. These improved concepts might arise from advancements in the macro-environment such as technological improvements or by concepts that are no longer in use. Concept development provides a framework in which a new solution might be developed, and the iterative nature of CD&E aims at gaining the best solutions by allowing these concepts to be fully analysed and

investigated taking all the ancillary matters, for example DOTMLPFI (North Atlantic Treaty Organization, 2009).

Experimentation

For the determining the ability of a concept to achieve the objectives it was designed for, experimentation is used. The results of an experiment show the concept developers if the concept can be expected to be a solution to the capability shortfall or gap, or if parts of the concept are adequately contributing to solving the shortfall or gap. Experimentation therefore reduces the uncertainty on the success rate of a concept, provides practical insights that cannot be found by only studying and analysing concepts, and keeping concepts as simple as possible by removing things that do not add value (North Atlantic Treaty Organization, 2009). There are three types of experiments that can occur during a CD&E project: discovery, hypothesis testing and validation experiments. The discovery experiments are used to observe innovative concepts, which for example use new technology. The hypothesis testing experiment improves the knowledge of the concept by proving or disproving a hypothesis or to find the limiting conditions. The last experiment is the validation experiment. The results of this experiment are hard evidence that a new concept is an improvement of the current concept or a completely new and effectively working capability (North Atlantic Treaty Organization, 2009).

Principles

In the CD&E policy of the NATO, six relevant principles are noted (North Atlantic Treaty Organization, 2009).

a. Innovation: CD&E is seen as an important component in developing capabilities, as an innovative and flexible way of providing new solutions to capability shortfalls.
b. Resource efficiency: CD&E contributes to finding the best solutions to a capability shortfall with the given scarce resources available, changes in the environment and technological advances. This is achieved by the flexible, result-oriented approach, reducing unpredictability, and decisions made with the support of experiments.
c. Linkage other processes: The CD&E process includes many different aspects, and must therefore be strongly linked to other processes. E.g. the NATO Defence Planning Process (NDPP) or the Comprehensive Campaign Plan (CCP) overarching all CD&E projects supervised by the NATO.
d. Transparency: Involvement of all stakeholders is crucial with CD&E. This includes all the different bodies and agencies within the NATO, but the European Union and companies as well. Transparency between these stakeholders will establish trust between them and that is an important factor for the other principles to be effective.
e. Coordination and integration: the cooperative nature of CD&E improves the unity of the NATO members, by interchanging employees, agencies and partners. Integrating all these resources that contribute to developing new capabilities results in synergy effects of which all NATO members' benefit.
f. Flexibility and balance: CD&E enables the NATO to quickly react to urgent capability shortfalls, while balancing these efforts with long term projects.

The Ministry of Defence

Capability shortfalls and gaps are determined by the NATO Defence Planning Process (NDPP) which will be transformed into a Minimum Capability Requirements (MCR) (North Atlantic Treaty Organization, 2010). Within the Ministry of Defence comparable processes are installed. As discussed in phase A of the DMP, the BPB process determines the capabilities needed to meet the ambitions of

the Ministry of Defence, taking the budget into account. These necessary capabilities are listed in the statement of requirements (A document). CD&E at the Ministry of Defence will be implemented primarily to the benefit of the Dutch capability development projects, which are carried out independently of the NATO CD&E process.

5.3 Influence on throughput time and quality performance of projects

To answer parts of the second research question, this subchapter discusses the characteristics of the CD&E documentation by NATO in comparison with the identified attributes of the theoretical framework. Based on the gathered information from the documents on CD&E, not all attributes of the theoretical framework are covered.

Attributes	**Characteristics (Success dimensions)**
Organisational culture	• Not discussed in the documentation.
Management style	• Not discussed in the documentation.
Organisational form	• The documentation states CD&E is a flexible way of providing solutions to capability shortfalls.
Knowledge management	• Combination of explicit and tacit knowledge. CD&E relies heavy on competences of team members and the experimentation performed provides tacit knowledge as well. While on the other hand CD&E management creates yearly reports on all the CD&E projects and CD&E engagement spreads the knowledge between NATO nations and partners on methods, processes and projects.
Teamwork	• Emphasis on heterogeneous teams, including all the competences required. Furthermore, CD&E is focussed on cooperation between the members, by interchanging employees. Involving all stakeholders in a transparent way is done to create trust between the team members.
Level of competence	• Not discussed in the documentation.
Customer relationship	• Involving customers is essential for both Concept Development as Experimentation. Active participation and the characteristics of customers in the project teams are not mentioned in the documentation.
Change in approach	• CD&E is a result-oriented approach, assuming changing circumstances and adding only the functions that add value.
Emphasis on adaptability	• CD&E emphasis test driven and iterative development of concepts.
Selection of methods	• The documentation contains no clear explanation of the selection of CD&E for projects. Three types of experiments are identified within CD&E; discovery, hypothesis testing, or validation experiments.
Appropriateness of existing technology and tools	• The documentation does not mention specific tools or technologies required for CD&E.

Table 6: Characteristics of CD&E

5.4 Conclusion

This chapter found an answer to the second research question: *'What are the characteristics of Concept Development and Experimentation regarding the throughput time and quality performance of capability development projects?'* During the chapter Concept Development and Experimentation was discussed and confronted with the theoretical framework of chapter 2.

Due to the resemblance of CD&E and the agile approach, it is expected that the characteristics of CD&E contribute to the throughput time and quality performance of capability development projects of the Ministry of Defence. During the confrontation of the NATO documents on CD&E and the attributes of the theoretical framework certain matters are noticed. First, certain attributes are not discussed in the NATO documentation of CD&E. These attributes are the organisational culture, the management style, the level of competence of team members and the appropriateness of existing technology and tools. The level of competence of team members and project managers is directly related to improving the timeliness of projects and their ability to remain within the estimated costs (Chow & Cao, 2008). When looking at the attributes that are being discussed in the documentation of the NATO, it appears most characteristics of CD&E are in line with the attributes of the theoretical framework.

"In theory, theory and practice are the same. In practice they are not", attributed to Albert Einstein. Because theory and practice often differ, chapter 6 discusses the experiences of CD&E stakeholders from TNO and the Ministry of Defence with the approach.

6. Experienced and expected differences and problems of alignment with CD&E

The results of the interviews are discussed in this chapter for each of the variables of the theoretical framework. As explained in chapter 3, the design of the interviews is based on the theoretical framework. The experienced differences in conventional and CD&E projects and the challenges in these categories and variables are explained and the third research question is answered. This research question is: 'What are the experiences and expectations of stakeholders with Concept, Development and Experimentation, regarding the throughput time and quality performance of capability development projects?'

D	The Ministry of Defence participants
T	TNO participants
N	NATO participant
(D3/5)	3 out of 5 participants of the Ministry of Defence indicated this.

Table 7: Description of additional information in next tables

6.1 General

The general category discussed the definition, the goal, the place in the process and effects of CD&E on duration and flexibility of capability development projects based on their experiences and expectations. The definition of CD&E was consistent among the interviewees from the Ministry of Defence and TNO. The NATO participant explained the definition of CD&E rather different, on a more abstract level as the NATO does not acquire the products themselves. They deliver agreed upon, standardized and tested concepts on a lower concept maturity level. The responsibility for the more mature concept levels and the implementation lies with the NATO members themselves. The question on the goal of CD&E displayed a scattered image in which several interviewees said something about improving the quality of end-results of capability development projects, e.g. *'improving the applicability of the concepts in the organisation'* or *'combining all views from stakeholders, to improve the justification of needs statements'*. A completely different statement was: *'The expectation of CD&E is to speed up the responsiveness of projects at the Ministry of Defence. At least during the development of needs statement, and hopefully during the fulfilment of these needs as well*'. The positioning of CD&E in the product innovation processes of the Ministry of Defence resulted in contradictory statements between officers of the Ministry of Defence and project managers of TNO. Most officers explained: *'the positioning of CD&E is before the start of the DMP'* while most TNO employees state that: *'CD&E should be used from the occurring of the idea or concept until the implementation of the product'.* When asked for their experiences with the effect of CD&E on both the duration of projects as the flexibility of projects, all interviewees based their answers on expectations of the effects of CD&E. Their expectations on the duration are divided into several statements with an overall thought that CD&E won't speed up the entire product innovation process. A group of both officers and TNO project managers stated their expectations on the effects on duration: *'stating the needs can be done faster, but acquiring the product cannot be done faster due to all legislation and regulations'*, and *'Projects won't be faster, but more thorough as a result of the testing of concepts in an operational*

Most officers explained: *'the positioning of CD&E is before the start of the DMP'* while most TNO employees state that: *'CD&E should be used from the occurring of the idea or concept until the implementation of the product'.*

setting'. The expectations on the flexibility were less clear. Some interviewees thought the flexibility of projects improved, others expected no change or at least no significant change.

What is CD&E?	Definition for the time being in the functional concept: an instrument to develop concepts in areas of material, personnel and training and validates these concepts by means of experiments in a methodologically justified way und the supervision of professionals. The results of the experiments provide iterative improvements. CD&E will be used in order to optimize the operational deployment of the armed forces (D1/5). CD is about identifying a problem and finding possible solutions. E is about validating the concepts with experiments in creative and realistic environments (D1/5). CD&E is about coming up with new ideas/concepts together with end-users and stakeholders and to test these with experiments before you implement them in to the organization (D3/5, T6/6).
Goal CD&E	(1/5) Expectations of CD&E in the functional concept is speeding up the responsiveness, at least during the development of the needs statement, but hopefully during the fulfilment of these needs as well. Furthermore the improvement of the relationship with the golden triangle to ensure the help of the industrial partners and knowledge institutes during the development and fulfilment of needs (D2). (1/5, 1/6) Testing the applicability of new ideas/concepts in the organization of the Ministry of Defence (D7, T12). (1/6) Combining different views of the stakeholders (T6). (1/6) Increasing the quality of knowledge for the customer (T9) (1/6) Better justifying the statement of needs (T10).
Place CD&E in innovation process	(1/5) CD&E results in requirements that can be used in the D-document of the DMP (D1). (3/5/1/6) The place of CD&E is before the start of a DMP, resulting in a validated concept that can be used in the DMP (D2:D3;D8;T6). E.g. This debate is caused by the responsibilities of the CLAS and the DMO, as CLAS is not responsible for the acquisition of material (D2). (2/5/4/6) CD&E should be used in the entire innovation process (D1;D7;T6;T9;T10;T12). E.g. CD&E is used from the occurring of a concept until the implementation of the products. Thus CD&E is used in the DMP as well (D7).
Effect on duration and flexibility	(3/5/2/6) Stating the needs can be done faster with the use of CD&E, acquiring the product cannot be done faster, due to all the legislation and regulation (D2:D3;D7;T5;T10). (1/5/3/6)Projects won't be faster, but more thorough as a result of the testing of concepts in an operational setting (D8;T6;T9;T12). (1/5;1/6) Flexibility of projects is greater due to CD&E (D8;T12). (1/6) Flexibility won't be improved significantly (T9)

	All above are opinions and expectations. Real prove for these expectations is missing. There is no track record. CD&E has to be at least as effective, cheaper and faster than the conventional project for it to succeed. Proving this is difficult, how to specifically define conventional and CD&E projects, how to make a good comparison. On the other hand, the advantages of CD&E are experienced by the users, creating support, faster decision making, costs reductions for products resulting from CD&E projects.

Table 8: Experienced differences conventional and CD&E projects (Category: general)

6.2 Management and organisation

6.2.1 Organisational culture

During the management and organisation category the differences the topics discussed are the organisational culture, the management style, the organisational form, and knowledge management. Differences in organisational culture between conventional projects and the current CD&E projects did not result in consistent experiences in the populations from both the Ministry of Defence and TNO. An interesting challenge reported by the Defence personnel and the NATO interviewee was the lack of creative skills for idea and concept generations among the end-users, complicated by operating routine. During the early phases of CD&E a more creative approach is used, which is more challenging with stakeholders not used or trained for this approach. An officer had a striking example: *'a colonel was asked what a development team could do for him on improving his command and control. The colonel explained he had a tent and a flip over, what more can I wish for? When demonstrated a range of possible concepts like live UAV images and better radios, the colonel could not see the opportunities arising from these new concepts. Only after being demonstrated the actual application of concepts the colonel 'woke up' and started contributing to the development of a new command post with the use of such concepts'.*

'A colonel was asked what a development team could do for him on improving his command and control. The colonel explained he had a tent and a flip over, what more can I wish for?'

6.2.2 Management style

The understanding of differences in management style and skills of the project manager between conventional and CD&E projects has been observed as a main theme at five TNO and one NATO participant. The higher uncertainty and complexity of CD&E projects prevents project managers to control their projects based on previously agreed processes and plans. *'Guiding the project and their members in the right direction is an important skill necessary for CD&E projects'* and *'in order to keep the team members on track, the project manager has to have more in depth knowledge on the subjects'.* Guiding and multi-disciplinary project managers are the main differences identified among the TNO and NATO employees. At interviewees of the Ministry of Defence a lower perceived need for a different type of management style and associated skills was observed between the management of conventional projects and CD&E projects. One officer stated: *'The style of command used at the Ministry of Defence is based on assignment oriented commands. The commander indicated what and why he wants something done and the operator determines how the assignment is to be performed and*

'Guiding the project and their members in the right direction is an important skill necessary for CD&E projects'

I expect the style of command used at the Ministry of Defence to be of positive influence on the CD&E projects'. Dealing with uncertainty and fast changing environment is skill officers are selected on and therefor possess to deal with dangerous situations in an operational setting. Someone from TNO said: *'the officers of the Ministry of Defence are far better trained and selected to handle changing conditions and be able to quickly adapt to new situations, these are good skills for CD&E project'.*

6.2.3 Organisational form

The topic of operational form resulted in one main theme for all participants, the separation of the product innovation processes in two parts both at TNO and the Ministry of Defence. The two parts have different organisational forms and different persons controlling them. The knowledge development and 'R&D' are more organically organised, while the knowledge application and DMP are more mechanistically of form. The view the participants had on the place of CD&E in those two similar parts of the Ministry of Defence and TNO is contradictory. The interviewees from the Ministry of Defence placed CD&E before the start of the DMP, while the TNO interviewees see a role for CD&E in the entire product innovation process. However the experienced challenges between these groups had all to do with the mechanistically parts of the product innovation processes. An officer stated: '*We as the Ministry of Defence spend 33 million euros a year on knowledge development at TNO mainly. If we want to use this developed knowledge, we cannot do this for free due to the separation between knowledge development and application. In our own DMP we don't have a broad budget to buy additional services from TNO, so these costs are directly influencing the amount of products we can acquire at the end of a DMP'.* Another challenge is the political-decision making being interwoven with DMP, causing problems with converting for example interesting IT concept into effective capabilities due to duration of these projects, implementing the actual capability while they are still effective and not yet superseded by new technology. E.g.: *'The budgetary rules due to political involvement require planning ahead for many years. For IT concepts you can't predict what product you want to buy in a few years, as the changes in new IT technologies are rapid. Furthermore the political decision-making takes a lot of time, again a problem with rapid changing technology'*. TNO This contradiction also results in different challenges experienced from these separated parts. The Ministry of Defence employees report a lack of, or a lack in, flexible financial funds in their DMP. Several officers stated: *'all cost we make during a DMP have a direct negative effect on the amount of products or capabilities we can acquire at the end of the acquiring process'*. The TNO employees report issues on the different controlling mechanisms and people responsible. Several TNO employees stated: '*Knowledge development controls by general and broad terms, while knowledge application controls by more specific terms that have a higher certainty. Both parts are controlled and decided by different entities with different funding as well, resulting in controllers and decision-makers not being involved during the entire CD&E project'* and *'if one starts a CD&E at the beginning of a DMP the decision to acquire a product or capability is made before the effectivity of the concept is tested or the motives to buy the concept are completely clear', 'during knowledge development projects the responsibility for the following knowledge application project is unclear, resulting in knowledge development projects that come to nothing*. Some things are done to meet this higher need for certainty. Several interviewees stated: '*the higher certainty requests can be met by dividing the projects into smaller subprojects or work packages to improve the certainty of the end results. Manageability of the entire project however will turn into a bigger challenge'.*

'*We as the Ministry of Defence spend 33 million euros a year on knowledge development at TNO mainly. If we want to use this developed knowledge, we cannot do this for free due to the separation between knowledge development and application'*

6.2.4 Knowledge management

Differences for knowledge management between conventional and CD&E projects are experienced by most interviewees, and brings advantages and challenges. A more tacit type of knowledge is experienced as the results of CD&E projects but also as the requirements of CD&E projects, CD&E focusses less on the documentation of knowledge. Most interviewees experiences advantages in the more tacit type of knowledge resulting from the CD&E projects. These come mostly in the form of experiencing the concepts in an operational setting, and these experiences are better in making an impression and therefore create a support base. A few TNO employees mentioned: *'the explicit results of conventional projects, mostly in the form of documents, are hardly read by anyone and end up in the drawer most of the times. On the contrary, the tacit knowledge produced with CD&E, is buzzing through the Ministry of Defence. Sometimes project results pop up in different parts of the Ministry of Defence where you would never expect it'* or *'experiencing something yourself is a different form of learning with respect to a researcher or expert telling you something'*. A challenge of tacit knowledge as experienced by the participants is the higher dependency on team members, SME's and end-users in CD&E projects. The knowledge of these people is essential, if this is missed during CD&E projects the end results might not be viable and effective, which is an important part of the CD&E goal. A few examples of the necessity of expertise and knowledge: *'if the end-users at some point during the project fail to contribute, the project will be halted'* and *'if the expertise to use a suit of simulation models developed specially for one project is not embedded in the organisation, than this expertise will slowly evaporate, and make those models useless'.* Dealing with scarce knowledge and embed this knowledge, that is stored inside the heads of stakeholders is therefore an important challenge. This challenge is even bigger in the organisation of the Ministry of Defence were the officers rotate jobs every 3 years.

'On the contrary, the tacit knowledge produced with CD&E, is buzzing through the Ministry of Defence. Sometimes project results pop up in different parts of the Ministry of Defence where you would never expect it'

'if the end-users at some point during the project fail to contribute, the project will be halted'

	Conventional	Current CD&E	Ideal CD&E
Organisational culture	TNO culture is appropriate for conventional projects (T2/6)	Current: TNO culture is appropriate for CD&E (T2/6). Challenges: End-users lack skills for idea and concept generation skills (D2/5, N).	Ideal: A more entrepreneurial culture might improve CD&E projects both at TNO as the Ministry of Defence (T1/6)
Management style	General TNO project managers; can be deployed in any project (T3/6). Ministry of Defence us an assignment based type of	Current: Different type of leader and skills required (T5/6, N) Challenges: Dealing with uncertainty. Networking; all opinions have to be heard.	Ideal: Providing guidance, democratic, and encouraging collaboration, multi-disciplinary (D2/5, T5/6, N).

	command. Top down (D1/5)		
Organisational form	Conventional TNO innovation process separated in knowledge development and knowledge application at TNO, with different organisational forms (D2/5, T4/6). Innovation process Ministry of Defence separated in two parts 'R&D' and DMP. DMP is organised mechanistically (D3/5, T1/6).	Current: CD&E projects overlap entire innovation process (D1/5, T4/6). CD&E is placed before the start of DMP (D4/5, T1/6). Challenges: Actually implementing solutions (D2/5) Separation knowledge development and application (D2/5, T4/6). Flexibility involving team members (D2/5, T1/6).	Ideal: One innovation process for CD&E projects organised organically both at TNO and Ministry of Defence (D3/5, T4/6, N). No or less political influence/control in the DMP (D3/5).
Knowledge management	Conventional projects resulted in documented (explicit) results (T3/6)	Current: CD&E results in mostly tacit knowledge. (D2/5, T5/6, N). Challenge: Higher dependency on SME's (D2/5, T4/6). Preserving tacit knowledge is harder (D1/5, N). Finding tacit knowledge is harder (D1/5).	Ideal: Flexibility in SME's. Important SME's should have substitutes (T3/6). Liaison officers (D4/5). Improvements in tacit knowledge management (T2/6, N)

Table 9: Experienced differences conventional and CD&E projects (Category: management and organisation)

6.3 People

6.3.1 Teamwork

The topics discussed in the category people are teamwork, level of competence and customer relationship. Interviewees experienced the need of a bigger diversity of expertise in the project teams for CD&E projects and involving them when necessary. This was shared among most of the interviewees belonging to all the different organisations. The bigger diversity of expertise led to several challenges. *'The need for a higher variety of expertise from different persons leads to a higher variety in interests', 'mixing different expertise makes communication between these people harder'*. Flexibility in involving team members with certain expertise when it is required is experienced as a challenge. An officer stated *'involving TNO expertise is slow as the process to arrange the contracts is taking weeks'*, most TNO interviewees stated *'a lack of time for some important SME's prevents them from joining a project'*, a different challenge experienced is involving the industrial partners. Project managers of TNO and several officers

'Mixing different expertise makes communication between these people harder'

experienced: *'involving industrial partners in the lower concept maturity levels of CD&E projects is difficult due to rules on public procurement'*, while another TNO project manager experienced: *'industrial partners to be hesitant to join CD&E projects'*. All employees of TNO experienced communication to be essential during CD&E projects and more important with respect to conventional projects, both internal as external communication. As one TNO project manager stated: *'The only thing we can do to involve the end-user or SME's in projects, is to explain them why it is a good idea for them to be involved. We can't force them'*, a different example from an interviewee: *'in order to keep all the different stakeholders involved, these stakeholders need to understand each other. This is more of a challenge with such a variety of expertise'.*

6.3.2 Level of competence

The subject on the level of competence of employees of the organisations with CD&E resulted in consistent answers from both the Ministry of Defence and TNO, there is a lack of familiarity with CD&E among all the organisations directly involved, let alone the industrial partners. Several interviewees experienced the job rotation of military personnel at the Ministry of Defence contributing to this problem, as some stated: *'after working together with a certain officer for a few years on a CD&E project, the officer got rotated and the replacement had no experience with CD&E and was reluctant to using it. Getting this officer to invest time, money and effort of his troops in a CD&E project is a lot harder if he is not knowledgeable with CD&E '*. A project manager of TNO mentioned a vicious circle regarding the level of CD&E competence: *'if people are not knowledgeable with CD&E and did not experience it, people are reluctant to start a CD&E project. But if you never start experiencing a CD&E project you will never gain a certain level of competence with CD&E'.*

'if people are not knowledgeable with CD&E and did not experience it, people are reluctant to start a CD&E project. But if you never start experiencing a CD&E project you will never gain a certain level of competence with CD&E'

6.3.3 Customer relationship

'Involving the end-users is essential for CD&E projects' is mentioned by most of the interviewees, which is a major difference compared to conventional projects in which end-users were usually not involved. The advantage of involving end-users is mainly considered the creation of a support base among the end-users, *'as the end-users are involved the concepts are developed in capabilities they consider effective. This creates a support base as the end-users experience they can rely on the new equipment. If equipment is not trustworthy, the end-users don't want to have it'.* Involving the end-users is experienced to be difficult for TNO project managers and one officer. As they stated: *'involving the end-users is hard due to the budget cuts of the last decades. Their workload is high and participating has to compete directly with training exercises and deployments'.*

'Involving the end-users is essential for CD&E projects'

Teamwork	Communication less important with respect to CD&E (T2/6).	Current: Heterogeneous teams (D4/5, T6/6, N). Communications essential in CD&E projects (T6/6, N).	Ideal: Heterogeneous teams consisting of a dedicated core team and flexible involvement of

		Challenge: Collaboration between expertises (T6/6). Wide variety of projects for team members (T1/6) Involving team members (D1/5, T5/6, N). Involvement of industrial partners early during a CD&E (D2/5)	required expertise's (framework contracts) (D1/5, T4/6) Co-located teams to improve communications and speed up projects (T3/6).
Level of competence		Current: Lot of stakeholders are not familiar with CD&E (D4/5, T5/6, N). Challenge: CD&E ability of stakeholders not sufficient at the moment (D4/5, T5/6, N). Job rotation officers D1/5, T2/6, N).	Ideal: Most stakeholders having at least some level of CD&E ability, with a few CD&E experts guiding project (D1/5, T3/6). Creating possibilities for CD&E knowledge sharing among TNO and the Ministry of Defence (D1/5, T3/6)
Customer relationship	Conventional projects do not actively involve end-users (D2/5, T4/6, N).	Current: End-users need to be involved and are essential in a CD&E (D1/5, T4/6, N). Involving end-users creates a support-base (D3/5, T5/6) Challenge: Involving end-users difficult (N1/5, T4/6, N).	Ideal: End-user always actively involved, and leading in decision-making creating a support-base (D3/5, T2/6). Dedicated CD&E battalion is being established (D2/5, T1/6).

Table 10: Experienced differences conventional and CD&E projects (Category: people)

6.4 Process

6.4.1 Change in approach

The process of CD&E projects differs substantially from the conventional projects. The differentiation can be noted in the way projects are guided. *'Conventional projects are guided by a plan, which is set before the start of the project. In this plan activities are divided into small bite-sized pieces and manageable pieces. This was possible because identifying stakeholders and possibilities for the project was easier with respect to the higher complexity of CD&E projects'.* The CD&E projects plans have a higher tolerance for uncertainty and speculation. Several interviewees mentioned: *'the planning has a higher uncertainty, as you can hardly predict the outcomes of experiments', 'Stakeholders,*

specific problems and possible solutions are not identified before the start of the projects, they are added during the project'. The differences in the accepting change and uncertainty in the projects causes challenges for the CD&E projects with the current forms of the DMP and Knowledge application processes. Several project managers of TNO stated: *'a planning with such uncertainties incorporated in it, causes problems for the controllers. They control the projects by looking at measurable like costs and hours invested, but you don't know these figures at the start of a project'*. During the conversations on the approach and the planning the subject turned to the concept maturity levels and a problem of alignment emerged. TNO uses the concept maturity levels 1-6. An officer mentioned however: *'we will use CML1-4, while TNO uses CML 1-6. CML1 is an initial concept, CML2 is an agreed concept (detailed and validated), CML3 is testing a concept in a creative environment and CML4 testing, in practice, resulting in a conclusion for implementing the concept yes/or no'.*

6.4.2 Emphasis on adaptability

The interviews resulted in clear differences between CD&E projects and the conventional projects on the subject of emphasis on adaptability. Several officers stated: *'I never experienced or heard that concepts were tested using experiments. New material was purchased as a standalone article, and was never tested in an operational setting'*. For CD&E contrasting answered were given. An officer for example: *'During our project we used iteration. First a concept was tested in the White-lab, a laboratorial setting. After this they were tested in the Green-lab, a controlled experiment outside the laboratory, and the final experiment was done in a training exercise of a unit. Per iteration the experiments got more realistic'.* Several interviewees stated: *'CD&E requires you to test the concept in an operational setting, and look at the effects. If the results are not acceptable or desirable than one has to change the concept and test it again'*. One officer mentioned that he experienced difficulties in considering a concept ready for implementation, as there is always something to improve. A difficulty experienced by several interviewees was the challenge of arranging experiments and iterations in the higher concept maturity levels. An interviewee stated: *'As the level of concept maturity gets higher, it gets more expensive to design and build the environments to test the concepts. The higher specificity prevents models and experiments to be re-used'.* Another interviewee stated: *'the higher the level of concept maturity, the harder it is to do experiments and plan iterations. As the higher concept maturity levels use existing training exercises of units, the experiments are dependent on them and most of these exercises do not give the CD&E experiments the highest priority'.*

'I never experienced or heard that concepts were tested using experiments. New material was purchased as a standalone article, and was never tested in an operational setting'

6.4.3 Selection of methods

The questions on the selection of methods give some important information on the subject. It shows most interviewees have knowledge on the existence of multiple methods that can be used during CD&E projects and the insight that CD&E is not appropriate for all capability development projects. On the other hand, most interviewees acknowledge the fact that selection criteria for the different type of methods are missing as well as criteria for selecting CD&E for appropriate projects. As one officer mentioned: *'for all I know, there are no criteria at the Ministry of Defence for choosing CD&E for a project'.* TNO project managers stated: *'The selection of CD&E for*

'The selection of CD&E for a project depends on the person that the project is assigned to and his/her familiarity with CD&E'

a project depends on the person that the project is assigned to and his/her familiarity with CD&E' or *'some people also choose the methods based on their familiarity with a certain type, for example simulation, while in some cases CDAGs for example are easier and cheaper to perform'.*

Change in approach	Conventional projects are guided by a plan based on activities and measurements, and thereby providing certainty (D1/5, T4/6, N).	Current: CD&E projects are both guided by CMLs based on speculation (D3/5, T5/6) and project plans based on activities and measurements (D2/5, T3/6). Challenges: DMP and knowledge application not guided by speculation (D2/5, T3/6). Different CMLs at TNO and the Ministry of Defence (D1/5).	Ideal: Innovation processes of Ministry of Defence and TNO for CD&E projects entirely guided by the same CMLs (D1/5, T2/6). More flexible and simple DMP for CD&E projects (D2/5, T1/6).
Emphasis on adaptability	Conventional projects are not tested in operational and iterative settings (D2/5).	Current: CD&E projects are tested in operational and iterative settings with the customer involved (D3/5, T4/6). Challenge: Considering a concept finished (D1/5). Experiments and fast Iterations are difficult to arrange higher CMLs (D1/5, T2/6).	Ideal: Implementing products in iterations in order to become more flexible (D7). (CD&E uses flexible test-driven iterations guided by CMLs, throughout the entire innovation process.)
Selection of methods	Lacking of experiments and scientific methods from different fields of expertise performed in projects gave no need for selection criteria.	Current: Scala of different experiments and scientific methods are available to be used in CD&E projects (D1/5, T3/6). Not all selections are based on project characteristics. Same applies for the selection of appropriate projects for CD&E. Therefore selection mainly based on familiarity of employees with CD&E and not on characteristics (D1/5, T5/6).	Ideal: Selection of appropriate projects for CD&E, experiments and scientific methods are based on the characteristics of projects (D4/5, T5/6). Ministry of Defence supported in the selection by TNO due to their experience with CD&E (D1/5, T1/6).

		Challenge: Selection criteria are missing both for experiments and methods, as for appropriateness of projects for CD&E (D1/5, T5/6).	

Table 11: Experienced differences conventional and CD&E projects (Category: process)

6.5 Technology

6.5.1 Appropriateness of existing technology and tools

The question on the differences in technology for conventional and CD&E projects did not result in challenges directly linked to the appropriateness of technology. For both the conventional as the CD&E projects the current technology is appropriate. Several TNO project managers reported a difference in the dependency on technology and tools for conventional and CD&E projects. The CD&E projects are more dependent on the technology and tools. The CD&E projects need more technology and tools for testing and experimenting. Some tools and technology may not exist yet, and for some projects new models for simulations have to be designed and developed. Without them a concept can't be tested, but it also more expensive to build them. For the lower concept maturity levels, these models for example are easier to re-use. For the more mature concept levels, it is harder to re-use the models as they are designed for more specific tests. The same applies to experiments designed for a certain type of concept, these are hard to re-use, and thereby making the projects more expensive to execute.

Appropriateness of existing technology and tools	Less technology and tools dependent (T2/6).	Current: Higher technology and tools dependency (T2/6). Simulation rooms and models are available or can be created. Awareness of different qualities of scientific methods is present. Challenge: collection point for all the different methods, experiments and their advantages/disadvantages is missing (T1/6). Re-using tools and technology designed for higher CML's is difficult (T2/6).	Ideal: Development of tools or guidelines for the use and selection of scientific methods (D3/5, T1/6) . Development of tools for selection of appropriate projects for CD&E based on characteristics of the projects (D1/5, T2/6). Ministry of Defence would like to have self-administered CD&E tools, which they can use in their projects. Self-administered because they assume TNO is lacking CD&E experts to support all their CD&E projects in the future (D3/5).

Table 12: Experienced differences conventional and CD&E projects (Category: technology)

6.6 Conclusion

The experienced differences and challenges of the interviewees have been discussed in this chapter. Per category the conclusions will be elaborated on in the following part, and an overall challenge identified. Thereby the chapter answers the research question: *'What are the experiences and expectations of stakeholders with Concept, Development and Experimentation, regarding the throughput time and quality performance of capability development projects?'* But first the findings for the general category is discussed. TNO and the Ministry of Defence are aligned on what CD&E is. If one compares the goal of the Ministry of Defence with CD&E, to the goal the interviewees had in mind one can easily see a big gap. Most interviewees stated goals regarding the quality of the end-results of projects. An interesting differences between TNO and the Ministry of Defence was seen at their placement of CD&E in the innovation process. The officers placed CD&E before the DMP and knowledge application. TNO project managers however, placed CD&E in the entire process. Most believed that CD&E should be used until the implementation of the product or material and therefore during the DMP as well. In terms of effect on duration the interviewees were fairly united, that CD&E won't shorten the duration of projects. The expectations on the effects on the flexibility of projects were divided, some expected improvements and some did not.

6.6.1 Management and organisational

In conclusion to the management and organisational category the following interesting problems and challenges were found. A lack of creative and entrepreneurial competences was experienced by officers and the NATO interviewee. Due to the active involvement of the end-users lacking these competences this made the creation of ideas and concepts harder. According to the TNO and NATO interviewees project managers should be guiding the projects in the right direction, due to the higher (but accepted) uncertainty and change. Project managers need to be more multi-disciplinary to guide these projects with the input of the team members. This is a bottom-up approach. The style of management used at the Ministry of Defence is a top-down approach were the manager or leader assigns the commands to the operators, and they perform the required actions. The main challenges to do with the organisation form had to do with the mechanistically organised parts of both TNO and the Ministry of Defence. The more organic organised parts did not result in challenges. Most interviewees experienced advantages and challenges with the differences in type of knowledge resulting from conventional and CD&E projects. The documentation of tacit knowledge is a challenge and CD&E projects focus less on documenting knowledge. The dependency on the knowledge of team members is higher and preserving their knowledge for continuity in a project is a challenge.

6.6.2 People

The category people resulted in several differences and challenges. The interviewees experienced a need for more diversity in members of CD&E project teams. The diversity can come from different expertise and involving team members when needed. The higher need for diversity caused several challenges. With the variety of team members rising, the number of different interests rises as well. This causes communication between team members to be more challenging. Involving team members was experienced as a challenge as well. The current level of competence and familiarity with CD&E is experienced as too low, both at the Ministry of Defence and TNO. The involvement of end-users creates a support base for the product in development. The higher dependency on the involvement of end-users is challenged by the high workload of these end-users. Due to this workload end-users are hard to involve, and thereby compromising the effectiveness of CD&E.

6.6.3 Process

Guidance of CD&E projects is different from the conventional projects, as these were guided by plans. The higher uncertainty accompanied with CD&E projects, necessitates other means of guidance. This

is met by using concept maturity levels as guidance, but still challenges are experienced that have to do with guidance by plans in the DMP and knowledge application parts of the process. An important note is the differences in CMLs between TNO and the Ministry of Defence. A difference in adaptability comes from the iterations and testing concepts in an operational setting performed during a CD&E. Challenges experienced with these changes were considering a product finished and the increasing difficulty of arranging experiments and iterations at higher CMLs. The advantages and disadvantages of CD&E and the variety of scientific methods are recognized by most interviewees. But these characteristics are not used (structurally) for the selection of CD&E and choosing appropriate scientific methods, selection criteria are missing. Furthermore, people are used to a certain type of method and therefore use this more often, and take other methods less in consideration.

6.6.4 Technology

The interviewees experienced that CD&E projects have a higher dependency on tools and technology specially designed for the project. The interviewees experienced the technological possibilities as appropriate for CD&E. During concepts that fall within the higher maturity levels re-using these tools and technology becomes harder and therefore CD&E projects tend to be more expensive to perform. Furthermore they experience the lack of tools for selecting methods for CD&E.

6.6.5 Concluding the chapter

Per category the conclusions have been discussed. This final part of the chapter is intended to elaborate on the overall problem. The elaboration will better focus the effort on finding a solution to the experienced challenges of the interviewees. During the discussion of the different categories the recurring themes were the challenges resulting from the higher dependency and the higher integration needed between the involved organisations, for a proper execution of CD&E. The dependency was found in the involvement of end-users, dependency on a variety of knowledge and expertise, dependency on team members' level of competence with CD&E, dependency of other parties, such as controllers. The higher dependency between the various organisations involved, results in a large amount of the challenges mentioned in this chapter.

7. Finding the solution to the overall challenge

In the previous chapter the results of the interviews are discussed. The interviewees experienced and expected a variety of differences between conventional and CD&E projects. These differences caused challenges as both organisations are still arranged for conventional projects and therefore adapted to the characteristics of these projects. As concluded in the previous chapter most challenges resulted from the higher dependency between the involved organisations. During the interviews, the interviewees also brought possible solutions into the conversation. Together with the results of chapter 4 and 5, these results answer the research question: '*What problems of aligning the current project management procedure arise with the implementation of Concept Development and Experimentation, regarding the throughput time and quality performance of capability development projects?' In the remainder part of the chapter possible solutions for these problems of alignment are discussed. Thereby answering the research question: 'What solutions can be identified to solve the problems of alignment?' An important note at the start of this chapter is the change in structure, from the attributes found in the literature to the use of levels indicating the level at which a provided solution has an impact. The solutions are divided in three levels in order to allow the solutions to be bundled more specifically and to create a clear overview of the impact levels for the reader. These categories are organisation, process and project.*

7.1 Organisation

On an organisational level different problems of alignment were found in the literature, the project management procedure of TNO, the CD&E documents of the NATO and the experiences of the interviewees. These belonged to the attributes: organisational form, knowledge management, level of competence and customer relationship. Especially the experiences of the interviews showed problems of dependencies emerging through the use of CD&E. Malone and Crowston (1994) found communication to be an important aspect of coping with dependencies among stakeholders during a process. Johansson and Persson (2009) found face-to-face communication increases the acceptability of uncertainty, as it improves trust and relationships among stakeholders. The agile approach has proven to improve communication between stakeholders (Johansson & Persson, 2009; Petersen & Wohlin, 2010; Pikkarainen, Haikara, Salo, Abrahamsson, & Still, 2008), Malone and Crowston (1994) found communication to be an important aspect of coping with dependencies among stakeholders during a process. The dependencies are: task-resource, producer-consumer, task-subtask, and feature-requirement dependencies (Malone & Crowston, 1994). The task-resource dependency is defined as the dependency resulting from allocating resources to particular tasks constantly. The actors in this dependency are the management and project team members responsible for allocating resources. (Pikkarainen et al., 2008). The producer-consumer dependency results from pursuing compatibility between the requirements of the consumer and the output of the producer. The actors involved are the customers and the project team members (Pikkarainen et al., 2008). The task-subtask dependency is a result of dividing all tasks in smaller tasks that can be distributed among the employees involved. The goal of the original task, must be achieved with the subtasks as well and thereby creating a dependency. The actors involved are the customers, management and project team members (Pikkarainen et al., 2008). The last dependency identified as the dependency between features and requirements. The dependency is the result of difficulties with the interaction between different features and requirements of systems. Especially for large systems it is hard for all features and requirements to collaborate with each other. The actors involved with this dependency are the customers, management, project team members and support staff. The support staff for example ensures the quality of the end product (Pikkarainen et al., 2008).

Several officers experienced liaisons: *'at the moment we have a TNO employee in or department, whenever I have something TNO related, I just walk by and get my answer. It speeds up and simplifies communication between the organisations'*.

In order for both TNO and the Ministry of Defence to better cope with the dependencies created with CD&E, the communication between both organisations has to improve. This can be achieved by a variety of solutions. The most radical solution for improving the communication between the two organizations is by removing the separation of the two organizations. Merging the two organizations will literally remove the walls between the current collaboration. Within NATO the strategic partnership between the Ministry of Defence and the independent research institutes (i.e. TNO) is quite unique. Most associated Ministries of Defence conduct their own R&D. Less radical solutions are available as well. Officers of the Ministry of Defence were positive on the use of liaison officers in order to enhance the communication between the organisations.

A lack of CD&E competence of the employees of both TNO and the Ministry of Defence was another problem for both organisations. The cause can probably be found in the newness of CD&E for both organizations. In order to improve the level of competence of employees with CD&E a set of possibilities were described by the interviewees. The functional concept that is written at the Ministry of Defence may improve the level of their employees. A TNO project manager came up with the idea of more structured knowledge sharing on CD&E, in a way the big consultancy firms do once a week. They share knowledge, methods, and challenges, discuss projects and do peer reviews. This structured knowledge sharing could be done at the project management guild of TNO, as this guild also exchanges best practices, methods and techniques on project management. At the Ministry of Defence, they started yearly exercises (e.g. Purple Nectar) in which CD&E activities are performed. These exercises are also seized as an opportunity to share knowledge on CD&E and present the results of such projects. Pikkarainen et al. (2008) found reflection workshops being an efficient manner of implementing and improving agile practices. Employees with a high level of agile competence positively impact the delivery of projects on time and within the estimated budget and efforts (Chow & Cao, 2008). Combining it with the goal of improving the communication between TNO and the Ministry of Defence, this structured manner of sharing CD&E knowledge could also be done in cooperation with the Ministry of Defence.

Related to these reflection workshops improving information sharing and communication, the information sharing between related project teams should be discussed on an organisation level as well. When project become larger than a single cross-functional team can manage, projects should be scaled up with additional teams. These teams of teams should have regular and structural meetings in order to coordinate the entire project (Cohen et al., 2004). If knowledge is not properly shared among the variety of cross functional teams, the communication between these teams will suffer. Especially communicating technical dependencies and the ability of creating a planning for the variety of teams (Sekitoleko et al., 2014). In order to improve knowledge sharing between cross functional teams Sekitoleko et al. (2014) suggest some recommendations based on their research. The first recommendation is to minimize the dependencies between the tasks of teams. Open space meetings with the involved teams is another recommendation. These meetings have the goal to discuss technology, challenges experienced and progress made by the teams. Furthermore a scrum of scrums can be applied (Sekitoleko et al., 2014). Scrum is an agile method, in which iterations (sprints) last for one to four weeks. During these sprints, the project team has short daily meetings with a maximum of 15 minutes (Schwaber, 1997). During a scrum of scrum, the project managers of the different teams meet on a regular basis. Encouraging communication, cooperation and cross-fertilization and thereby

decreasing the dependencies between the teams (Sutherland, Viktorov, Blount, & Puntikov, 2007). Furthermore such teams of teams can be supported by a team responsible for the architecture and standardization in the project (Cohen et al., 2004).

Another challenge experienced by the interviewees was the involvement of SME's and end-users. Certain SME's lack time, while CD&E projects are dependent on them. If these SME's are not part of the small cross functional team, involving them should be possible in a flexible manner. Officers from the Ministry of Defence stated the time consuming process of involving TNO employees as challenge due to the high formalised process taking weeks. Neglecting the challenge of flexible involving SME's will negatively impact the quality, timeliness and costs of the projects (Chow & Cao, 2008). Lowering the dependencies on these SME's could be done by creating substitutes and a higher level of interchangeable roles. Some employees of TNO noted the option of creating more 'expertise trains' or knowledge duo's, were senior SME's educate junior employees of TNO on their expertise and thereby lowering the dependency on the senior SME's. Each senior SME with important knowledge should have a protégé. The same challenge was found for the involvement of end-users. Due to the many years of budgets cuts the workload of the end-users is high. The activity of being involved in CD&E projects therefore directly competes with activities such as operational training. This challenge of involving end-users is an important problem of alignment, as the involvement of end-users is essential for the success of projects as stated by CD&E documents and the interviewees and was found to positively impacting the throughput time of projects (Chow & Cao, 2008). At the Royal Netherlands Army a CD&E battalion is being established, which should provide a solution for this problem of involving end-users. This battalion should be able to deliver at least one company for a CD&E project or experiment at any time.

7.2 Process

Due to the holistic character of CD&E the solutions found on the organizational level tend to be closely related to the process level, but non related solutions have surfaced as well. The problems and solutions on this level belong to the attributes: organisational form, customer relationship, change in approach, and the selection of methods. The process levels covers both the current capability development process of the Ministry of Defence (including TNO procedure) and the CD&E process as designed by NATO.

The first solution is connected to the separation between knowledge development and knowledge application at TNO and the Ministry of Defence. Both parts are organized differently and controlled by different entities. For a more ideal form of the process for CD&E projects the interviewees are in favour of removing the separation between the two parts that exist at the moment both at the Ministry of Defence and TNO. This new process should be organised organically with more emphasis on flexibility in time and money, less rules to take into account, and less control. By removing the separation projects will encounter less barriers until the final implementation of the capability. Furthermore, creating one process enables cross functional teams to commit to projects from the emergence of an idea to the implementation of the capability. Thereby retaining important tacit knowledge which is the most important outcome during the entire duration of the project, and is often (partially) lost during transition from knowledge development into knowledge application, as stated by the interviewees. Assigning a single cross functional team for the duration of a project will contribute to the support base and motivation among the team members and thereby positively impacting the timeliness and costs of the project (Chow & Cao, 2008).

The current procedure of TNO and the equivalent of the Ministry of Defence are mostly guided by time, budget and quality. The literature of the theoretical framework and the interviewees are unified

in their preference of process guidance by product features for an agile approach as CD&E. Such a form of guidance was developed at TNO, the Concept Maturity Levels (CML) (See Figure 11). The CML's indicate the maturity of the product or capability during the entire process from idea to the implemented capability (Meessen & van der Wiel, 2014).

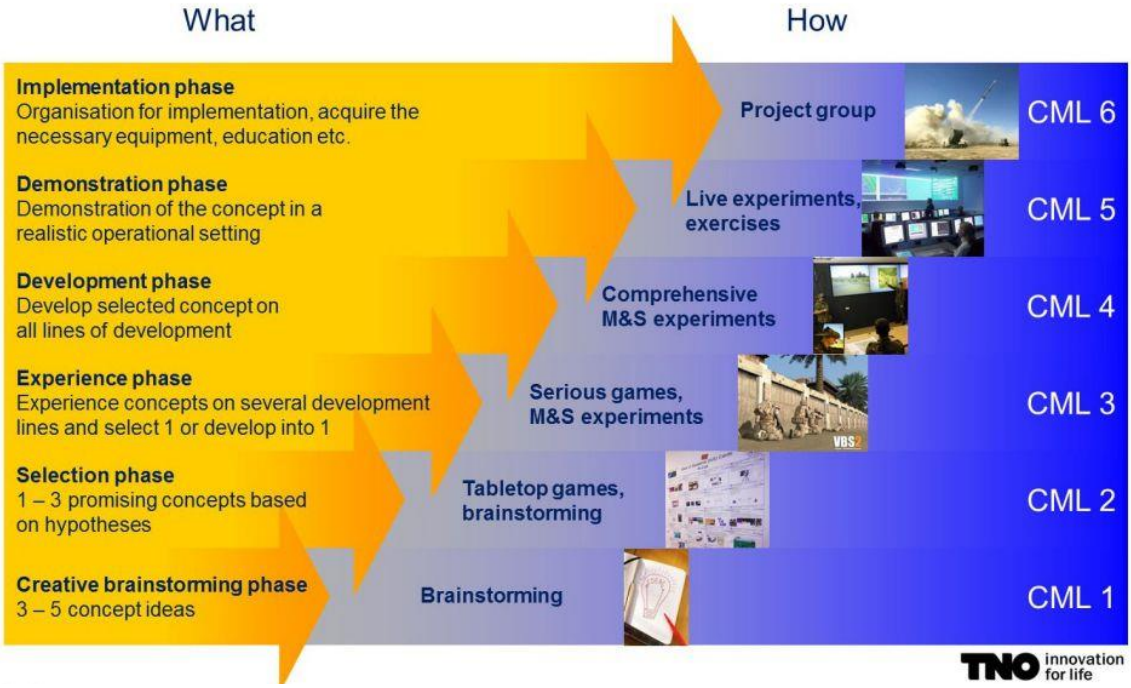


Figure 11:(Meessen & van der Wiel, 2014)

During the interviews and in the CD&E documentation of NATO or the project management procedure no clear answer or criteria were found for the selection of project approaches. The interviewees did agree CD&E is not appropriate for every project. For the selection criteria most interviewees argued that the selection of CD&E should be based on the characteristics of the projects. These characteristics should be the complexity, risk, and their relation to the operational context (DOTMPFLI). The project management procedure of TNO should therefore be expanded with an overview of different project approaches and the appropriate characteristics in order to suggest or indicate the multiple potential options a project manager is able to choose.

An important missing element of the project management procedure of TNO is the emphasis on involving the customer or end-user actively during the project. Their involvement is left open and self-determined by the project manager. Whereas both literature and the interviewees agree on the essentiality of involving the customer of end-user during the project. It positively impacts the project awareness of the customer, meeting the requirements of the customer, and helps overcome the producer-consumer dependency(Chow & Cao, 2008; Pikkarainen et al., 2008). If CD&E is chosen as a project approach, the involvement of customers or end-users should be made evident and obligatory.

For the selection of scientific methods to be used in the CD&E projects, these should as well be selected based on certain criteria instead of personal preference. A frequently heard requirements that the method should be selected on the financial load the method addresses to the organisation, concept should be validated with as little resources as possible. Selection of appropriate projects is missing (CD&E documents and procedure).

7.3 Project

Finally, solutions for problems at the project level are discussed. Most solutions discussed on organisational and process level are closely related to the solutions on the project level. The solutions belong to the following attributes: management style, teamwork, level of competence, customer relationship, change in approach, emphasis on adaptability and the selection of methods.

As discussed above, the project teams of CD&E projects have a higher variety of expertise and backgrounds among the members. The right mix of required expertise positively impacts the timeless and cost management in agile projects teams (Chow & Cao, 2008). It is important to create cross-functional teams that include all the competences for the development of the concepts and the execution of the experiments. During the interviews the design of the current teams was discussed and a lot of functions or roles were present during projects including the customers or end-users. Some, however, were not or hardly involved, such as decision makers from the DMO, representatives from the industry or CD&E specialists. One has to keep in mind, the larger the team, the more difficult it is to stay agile as a team (Cockburn & Highsmith, 2001). Keeping the teams as small has several advantages. The need for a higher variety of team members from different organisations, backgrounds and expertise in CD&E projects causes challenges in communication between those members as a result of different interests. Furthermore to keep the costs on human resources within limits, stakeholders are not involved for the entirety of the project and involved in a flexible manner. However in order to allow for a durable progression of the project, a solution was brought in by several interviewees and agile literature. By installing core members whom are involved during the entire duration of the project inside the cross-functional team, specific knowledge and rationale for certain choices made in the past, continues to remain in the project, while SME and other team members rotate based on the required expertise. Several studies found agile teams to consist of around ten members (Cockburn & Highsmith, 2001; Cohen et al., 2004; Dybå & Dingsøyr, 2008; Sekitoleko et al., 2014). In these teams, members might have several roles in order to maintain all competences (Sekitoleko et al., 2014).

In order to improve the communication among these teams certain agile practices could be performed. Communication between team members should be easy to perform, both formal and informal (Plowman, 1994). Pikkarainen et al. (2008) identified several agile practices having a positive impact on informal and formal communication and thereby on the dependencies among stakeholders, both internal and external. The practices identified are: open office space, daily meetings, story/task board, iteration planning, reflection workshops, pair programming and continues integration (Pikkarainen et al., 2008). Using an open office space positively impacts the internal communication of a project team by facilitating face-to-face communication and thereby reducing the need for written communication. The improved communication was found more capable of facilitating task-subtask dependencies (Pikkarainen et al., 2008). Practising daily meetings and a story/task board, were found to enhance the awareness of project managers, team members and customers on project status. Both practices enhanced the facilitating of task-subtask and task-resource dependencies (Pikkarainen et al., 2008). Iteration planning was also found to improve the communication and made sure all stakeholders involved were aware of the plans and goal for the next iteration. There by facilitating the task-resource, producer-consumer and feature-and-requirements dependencies (Pikkarainen et al., 2008).

These agile practices positively impact the dependencies, require the team members to be co-located to a certain extent. Co-locating is found to be increasing the productivity, timeliness of development teams and higher satisfaction among all stakeholders (Teasley, Covi, Krishnan, & Olson, 2002). Furthermore it facilitates interactive communication and thereby improving learning, clarifying- and solving-problems (Cohen et al., 2004; Teasley et al., 2002). Cockburn (2000) stated the importance of

face-to-face communication in agile project teams, as this is the most effective way of communicating. This was supported by the study of Plowman (1994) which recognised speech communication as more desirable compared to written communication. Co-locating of project teams was mentioned by several interviewees as a possible solution, as it speeds up and simplifies communication between employees of the different organisations. In the current capability development process the project teams are often not co-located and working together on a daily base. As some interviewees stated, employees of TNO have a large variety of projects during a year. These projects are spread out over the year in a parallel manner. This makes focussing on a project hard, as employees are working on multiple projects during the week. In addition, it takes projects longer to be completed as employees are not working full-time on the project. Performing the projects in scrum like manner would solve both of these issues. Instead of spreading out the activities of employees for a project over an entire year, focus these activities by finishing one or two projects in a sprint before starting with the following projects. This can help with decreasing the work in progress and thereby the throughput time of the capability development process.

A new approach like CD&E has potential consequences for the appropriate style of management that should be applied during projects. The agile literature identified a shift from a command and control type of management towards a leadership and collaboration type (Nerur et al., 2005). The interviewees described an ideal picture of a CD&E project managers as well. According to the interviewees the ideal project managers should provide guidance, is multi-disciplinary, encourage collaboration between team members, and has a democratic style of decision-making. He or she should ensure the input of all members being taken into account.

The involvement of customers or end-users during the projects come from their interest in the end capability of the CD&E product, as this should allow them to perform better or allow them to do new things. The interviewees stated the active involvement of end-users is essential for CD&E projects, in addition the literature found evidence for the positive impact on meeting all requirements of the end-user and managing the costs of the project. The emphasis on involving the end-user is missing in the current project management procedure of TNO. It should be clear as well that product features should be guided by the end-user, in a way that new features are only added if it enhances the capabilities for the end-user. As discussed on the organisational level, the establishment of the CD&E battalion should positively impact the challenge of involving the end-users in projects and allow for a better ability to cope with the higher dependency on end-users during a CD&E project.

Selection of appropriate scientific methods and experiments for CD&E projects are missing in the current project management procedure of TNO and the CD&E documentation of NATO as well. The selection of scientific methods to be used in the CD&E projects, these should as well be selected based on certain criteria instead of personal preference. A frequently heard requirements from the interviewees was that the method should be selected on the financial load the method addresses to the organisation, concept should be validated with as little resources as possible. With the use of the reflection workshops as discussed on the organisation level, these criteria can be discussed and tools can be created to be used for determining methods and experiments during CD&E projects. These reflection workshop can be performed in an internal setting with the project management guild of TNO or in collaboration with the Ministry of Defence. In addition to the possibilities of improving the selection of methods and experiments, several officers stated they needed self-administered tools for CD&E projects. They thought TNO would lack the manpower to support all the projects of the Ministry and this would be a way to ease this pressure on TNO.

7.4 Conclusion

In the previous chapter the problems of alignment were discussed and a vast variety of solutions were presented and discussed. The goal of this chapter was finding answers to the following research questions: '*What problems of aligning the current project management procedure arise with the implementation of Concept Development and Experimentation, regarding the throughput time and quality performance of capability development projects?' and 'What solutions can be identified to solve the problems of alignment?'*

Due to the holistic characteristics of CD&E the problems of alignment and potential solutions that were found are often connected to three categories introduced in this chapter. This was experienced in the research of Sekitoleko et al. (2014) as well. They found relationships between the challenges with the agile approach. Improving one challenge will make other challenges to become less problematic (Sekitoleko et al., 2014). Addressing a challenge in the organisational level might also improve challenges at for example the project level.

Some solutions discussed in this chapter are rather radical, not directly applicable, or not immediately preferred. The next chapter discusses the best solutions and turns them in to the recommendations answering the central research question of this master thesis.

8. Conclusion, discussion and future research

This chapter concludes the research. First the most appropriate solution found during this research are highlighted, after which the final recommendations are explained and the central research question is answered. The central research questions is: 'What should TNO modify optimally to align their current project management procedure with concept, development and experimentation, contributing to the throughput time and quality performance of the capability development projects of the Ministry of Defence, without increasing the costs of these projects?' With the practical implications of the research covered, the focus shifts to the theoretical contributions of this study. Following the theoretical part of this chapter, the limitations of this research and consequently possibilities for further research are discussed and summarized.

8.1 Conclusion

The research started with examining the current project management procedure of TNO in chapter 4, seen in the context of the theoretical framework. Based on this examining of the current project management procedure, the theoretical framework provided insights on some well-established parts of the procedure, some parts in need of improvement and other important practices or characteristics not mentioned at all. In the previous chapter problems of alignment and the potential solution are discussed. These are categorized in three levels; organisational, process and project. The most achievable solutions for these levels, positively impacting the throughput time and quality performance of the capability development process of the Ministry of Defence are discussed and become the recommendations that answer the central research question.

8.1.1 Organisational

The advantages of CD&E for TNO are clear and as well as the ability of TNO to deliver a vast variety of expertise for CD&E projects. It is clear CD&E is a great opportunity for TNO as a research institute, as the organisations possesses unique abilities. The first recommendation on an (inter-) organisational level is the improvement of CD&E knowledge throughout TNO and the Ministry of Defence. Organising reflection workshops in cooperation with the Ministry of Defence improves the implementation of CD&E throughout the organisations and positively impacts the spreading of CD&E knowledge. The deployment of reflection workshops can be broadened in a later stage with the Defence industry and other related organisations. TNO can adopt a leading role in these reflection workshops, as obtained a lot of expertise on CD&E and therefore a head start over other organisations.

Furthermore, knowledge sharing between teams of teams is of major importance, as the teams are set up to operate as independent as possible. Dependency between different teams on a large project cannot be excluded, all teams strive for the same goal with their different tasks (as demonstrated with the task-subtask dependency). Structured meetings on large project specific topics between these teams improve communication, and thereby improve the ability of these teams to cope with the task-subtask dependencies among teams. Initially this recommendation apply to TNO, as most of the research is done by them. Obviously, the same applies to the Ministry of Defence if multiple dependent teams occur.

A last recommendation on an organisational level is the improvement of the ability of TNO and the Ministry of Defence to cope with the dependency on SME's. This is not an ability that can be improved on a short term, but with the introduction of CD&E, the dependency on SME's rises. Both organisations are advised to identify the expertise most demanded and to educate substitutes in order to create flexibility for the project teams to involve experts on certain matters during their project. Due to the high dependencies on experts, projects stall if these SME's cannot be involved on a flexible base. The recommendations is of great importance for both TNO and the Ministry of Defence.

What should be improved	Recommendation	Positive impact	Advised introduction (Responsibility)
CD&E knowledge	Inter-organisational reflection workshops	Improves implantation and spreading of CD&E knowledge.	Immediately (TNO and the Ministry of Defence)
Knowledge sharing among teams	Structured meetings between project teams	Improves communication and coping with task-subtask dependency	Immediately (TNO)
Availability of SME's.	Identify expertise most demanded Educate substitute SME's.	Ability to cope with SME dependency	Within two years (TNO and the Ministry of Defence)

Table 13: Recommendations organisational level

8.1.2 Process

The first recommendation on the process level is related to the guidance of the capability development process. Both at TNO as the Ministry of Defence guidance or progress tracking is done on the base of time, budget and quality. Therefore the recommendation applies to both organisations. Agile approaches benefit from process guidance by prioritized value adding product-features. Guidance by product-features positively impacts the quality of the end-result, and the prioritized adding of product-features with value for the end-users positively impacts the timeliness, the ability of meeting end-users requirements and cost management of the projects (Chow & Cao, 2008). TNO developed the CML system in recent years, which is a good utility for process guidance of CD&E projects.

A recommendation for the long term, is removing the separation between knowledge management and knowledge application at both TNO and the Ministry of Defence. CD&E projects benefit from organically organized process. The separation heightens the formalization for the entire process and acts against rather than on behalf of the agile CD&E projects. The process is controlled by entities not participating in the projects and thereby missing important tacit knowledge gained during the projects. Merging the entire process positively impacts these issues as it allows for one project team and one controlling entity to be involved in the entire process, greatly improving the project status awareness and project specific knowledge of the stakeholders. Designing such a new process could be a topic of the inter-organisational reflection workshops discussed organisational level recommendations.

A last recommendation on the process level is the development of a tool for the selection of appropriate projects for the CD&E approach. As in the previous recommendations this should be done with a support-base among a large extend of CD&E stakeholders and could therefore be a topic on an inter-organisational reflection workshop as well. According to the interviewees of this research the characteristics should be the complexity, risk, and their relation to the operational context (DOTMPFLI). Literature adds dynamism and communication to those characteristics, were communication is the ability of the stakeholders to create strong focus on communication. When stakeholders do not have the ability to be co-located, CD&E is not the best choice of approach for the project.

What should be improved	Recommendation	Positive impact	Advised introduction (Responsibility)
Guidance by product-features	Using CML's as process guidance. Prioritized value-adding	Quality Timeliness, Scope and Cost	Immediately Immediately (TNO and the Ministry of

	product-features during process		Defence)
Lowering formalization during capability development process	Removing separation between knowledge development and application. Involvement single project team and controlling entity during the entire process.	Organically organised process Project status awareness and project specific knowledge of stakeholders	Within two years (TNO and the Ministry of Defence)
Selection of projects appropriate for CD&E	Development of selection tool for CD&E projects.		Within one year (TNO)

Table 14: Recommendations process level

8.1.3 Project

The first recommendation on the project level is on the importance of end-user involvement. The interviewees stated the importance of actively involving the end-users as well. Without active involvement of stakeholders a CD&E project cannot be properly performed. The active involvement of end-users positively impacts the projects meeting the requirements as set by the customer or end-user and it enables project teams to better cope with the producer-consumer dependency during the duration of a project. Dybå and Dingsøyr (2008) found the value of the product in development to improve as the result of being exposed to the customer using the agile approach, due to the customer being directly involved. This, in combination with constant feedback from the customer, improves the customers' satisfaction on projects using the agile approach in comparison to traditional approaches. It also increased the satisfaction of the company with their customers, so the relationship between company and customer increased in both ways (Dybå & Dingsøyr, 2008). Therefore the project management procedure should emphasise the active involvement of end-users in CD&E projects by adding end-users to the project team. The involvement of end-users in the current project management procedure is self-determined by the project manager, in consultation with the end-user. This is of importance for TNO, but for the Ministry of Defence as well as the success of the projects depends on the availability of end-users.

An important recommendation for the project level is the set-up of the teams and the teamwork. CD&E projects are best performed by cross functional teams that have the right expertise for the project. A core team should be established of stakeholders possessing all necessary competences and expertise for the entire duration of the project. In addition SME's are involved in a flexible manner whenever their expertise is required. Such cross-functional teams have a positive impact on the ability of projects to meet the requirements of the customer, the timeliness of the project, and the ability to finish the project within the estimated costs (Chow & Cao, 2008). In addition to the set-up of the team, the CD&E teams are highly focussed on communication, preferably face-to-face communication. This is enabled by co-locating team members, use open office spaces for the teams and practice short daily meetings. This positively impacts the quality of the end result of the project (Chow & Cao, 2008), improves internal communication (Pikkarainen et al., 2008), increasing project status awareness of team members, and thereby enables project teams to better cope with the task-subtask dependency (Malone & Crowston, 1994). This recommendation applies to the Ministry of Defence as well, as the end-users are part of the project team.

Assigning TNO project managers for CD&E projects is recommended to be done based on the following characteristics. Managers are knowledgeable in the CD&E approach, encourage

collaboration between team members, provides guidance and use a democratic style of decision-making involving all project members. The CD&E competence of project managers was found to positively impact the timeliness of projects and their ability to be finished within the estimated costs (Chow & Cao, 2008).

One last recommendation for CD&E projects is the instalment of a clear iterative planning during the duration of the projects. Regularly delivering results contributes to the ability of projects to meet the requirements of the customer, the ability to finish the project in time and finishing the project within the estimated costs (Chow & Cao, 2008). As the executor of the project this recommendation applies to TNO.

What should be improved	**Recommendation**	**Positive impact**	**Advised introduction** (Responsibility)
Emphasis on end-user involvement	Daily involvement end-users and strong commitment. Full-authority of end-user.	Project status awareness and Scope. Scope	Immediately (TNO and the Ministry of Defence)
Cross-functional teams	Establishment core team, with flexible involvement SME's.	Scope, timeliness, cost	Immediately (TNO and the Ministry of Defence)
Communication project teams	Co-locating team members. Use open office spaces Practice short daily meetings	Quality Internal communication and task-subtask dependencies Project status awareness	Beginning with new project and within half a year (TNO and the Ministry of Defence)
Alignment project managers with CD&E	Managers knowledgeable in CD&E.	Timeliness, cost	Beginning with new projects (TNO)
Use of iterations	Iterative planning, regular delivery of results.	Scope, timeliness, and cost	Beginning with new projects (TNO)

Table 15: Recommendations project level

8.2 Practical contribution

The practical contributions of this study are clear. The study provides an improved understanding of the challenges the implementation of an agile approach in governmental and semi-governmental organisations causes and the benefits it produces for these organisations and the affiliated society. In this study the focus was on the organisations TNO and the Royal Netherlands Army as a branch of the Ministry of Defence. But these results and recommendations are valuable for the other two independent research institutes (MARIN and NLR) and the other branches of the Ministry of Defence (the Royal Netherlands Navy and the Royal Netherlands Air Force). The results of the interviews showed the consensus among the interviewees on the positive effect of CD&E on the quality performance of the end result. The agile approach theory supports this view and in addition found the agile approach contributing to the throughput time and the improvement of costs management of development projects. It is frequently reported in daily newspapers that governmental projects are completed overtime, over budget and with the quality of the end-result not meeting the expectations. And in this context this study gives a clear insight in the potential of the agile approach. Additional to the improved understanding of the potential the agile approach offers governmental and semi-governmental, this study explored the use of the agile approach outside of a software development context and provides the understanding that the agile approach is easily deployable in and valuable for development projects of physical products. In many cases the interviewees stated the use of CD&E favourable as it increased the quality performance of the end-result.

The findings of this study emphasize the essentiality of the active involvement of the end-users in agile projects. This contributes to the understanding of organisations wishing to set up agile projects that all stakeholder organisations in such a project should agree upon the responsibility of the end-user to actively engage in such projects and the investment this requires from the organisations. In comparison with other approaches this is a turnaround in the prevailing assumptions of success factors for development projects. The empirical evidence furthermore suggest the characteristics on which project teams in these organisations in a military context should choose CD&E as an approach for the projects. These characteristics were the complexity of projects, the risks and the relation of the projects with the operational context of military organisation (DOTMPFLI). These characteristics are strengthen and compliment the current characteristics used in the literature and an important practical contribution for considering CD&E as an appropriate approach for projects.

Finally, the findings of this study reveal the exceptional position of independent research institutes as TNO regarding the agile approach. This exceptional position works in two directions. First, TNO is in possession of an exceptionally broad knowledge base, and involving TNO in CD&E projects can contribute to minimizing the amount of stakeholders involved. Due to the dependencies created with CD&E it is beneficial to involve as little stakeholder organisations in CD&E projects as possible, as a higher number of stakeholder organisation increase the challenges in communication between stakeholders. The same applies to knowledge on CD&E. TNO is able to obtain a leading role and become the expert organisation on CD&E knowledge required for CD&E projects of the Ministry of Defence or other users of CD&E. The other way around, CD&E provides the opportunity for TNO to establish itself as a knowledge agent in CD&E projects of the Ministry of Defence, other members of the NATO. If TNO lacks the knowledge required for a project, their network of partner organisations is likely able to cover the knowledge. TNO's network as a knowledge agent in such a CD&E projects contributes to the ability of the project to obtain the required knowledge. Lastly, these practical contributions resulting from a broad knowledge base might encourage the Ministry of Defence to perform more of their research internally and thereby obtain more knowledge and expertise themselves.

8.3 Theoretical contribution

The results of this research have led to multiple theoretical contributions. First of all, a contribution of this research to the agile approach theory is the shift from a narrow focus on software development organisations to a broader deployment of the approach. The agile approach can be used properly for product development projects outside the field of software-development. This research explored and gathered empirical data on the experienced challenges emerging from the implementation of the agile approach in the capability development projects of the Ministry of Defence and therefore outside of the software specific context. These findings are of importance for the research on product development and innovation management in such organisations as it offers an alternative for the stage-gate model and viewing development projects in activities and task instead of a more chaotic projects driven by the features of the end-result.

A different contribution is the implementation of CD&E at TNO and the Ministry of Defence, which can be considered as an agile approach being implemented in a broader perspective. Because the study is performed in a governmental and a semi-governmental organisation, the study is of major impact on the existing agile approach theories. As these focus only on the use of the agile approach in commercial enterprises, and this study points out the opportunities for the agile approach in the public sector. Therefore this research contributes to the expansion of the research field in a potential and promising sector, as the empirical data collected during the research indicate the potential of the agile approach in large governmental and semi-governmental organisations for improving the throughput time and quality performance of large and complicated projects. Therefore it gives all researchers a new perspective and application of the agile approach for research on innovation in public sectors.

Furthermore the empirical data gathered through the use of qualitative interviews found the heightened dependency on various factors created with an agile approach, and thereby confirms the existing assumptions in the agile approach literature (Pikkarainen et al., 2008). The interviewees clearly stated the dependency of CD&E projects on the active involvement of end-users and customers as an essential factor for the success of these projects. Other dependency factors of major importance to the success of CD&E projects were found to be the dependency on a variety of knowledge and subject matter experts and the level of competence of stakeholders with CD&E. Unfamiliarity with CD&E was found to complicate the execution of CD&E projects, and the dependency of a variety of knowledge and expertise during projects increases difficulties in communication between team members. These findings are in line with previous research.

This study revealed a variety of conditions, on which interviewees reached consensus, on which projects should be assessed on in order to select CD&E as an appropriate approach. These conditions were the complexity, risk and their relations with the operational context (DOTMPFLI). These conditions are corresponding with the factors described in the literature as well. These conditions are the size of the project and project team, the criticality, the dynamism, the personnel and the culture. Therefore the results of this study strengthen the current assumptions and understanding of the agile approach theory on the selection of appropriate projects.

8.4 Discussion of limitations and future research

This research resulted in recommendations for TNO and the Ministry of Defence in order solve the experienced problems of alignment caused by the implementation of CD&E. In order to create these recommendations, potential solutions were gathered with the help of agile approach literature and the expectations of CD&E stakeholders from both organisations, which did not yet explore a context similar to the context of this research. Assurance of the ability of the recommendations to solve the problems of alignment are therefore limited. This limitation provides great opportunity for future research, to measure the impact of the recommendations in a longitudinal study among a single organisation. Both TNO and the Ministry of Defence should gather performance data on these projects and study CD&E and its performance over the coming years. For both organisations this can be a major advantage in gaining understanding knowledge on CD&E. In addition to the practical contributions such a future research can yield, it would be an interesting contribution to the agile approach theory, as most studies conducted on the agile approach is conducted among a group of organisation and took place after the implementation of the approach was finished and not during.

This brings another limitation of the research to attention. No quantitative data was or is being gathered for the conventional projects and the current CD&E project. Therefore this research was limited to the use of qualitative data gathered from experienced CD&E stakeholders. It should be clear that gathering data on specific key performance indicators for these different types of project approaches could prove to be of great value for evaluating the functioning of different project approaches used at TNO and the Ministry of Defence. A starting point for gathering of quantitative data on the different types of projects can be the characteristics presented in the literature, size project and project team, and dynamism. Supplemented with the goals of the Ministry of Defence with CD&E, throughput time, quality performance and as boundary condition the costs of the project.

The limited amount of experienced CD&E stakeholders due to the newness of the CD&E approach is another limitation of this research that should be addressed. A bigger group of experienced CD&E stakeholders could have enabled the possibility of using quantitative methods, and thereby increase the generalizability of the research. This is a possibility for research in the future. Another possibility for improving this research and therefor for future research is the use of focus groups, composed of employees of both TNO and the Ministry of Defence. During focus group meetings topics importance to both organisations could be addressed. An example is a discussion in a focus group on scientific methods, this would allow the researcher to identify the scientific methods used for experimentation and more importantly the scientific methods lacking during experimentation. Such a research could be done or started together with the recommendation of introducing inter-organisational reflection workshops on CD&E in order to improve the implementation of CD&E and the spreading of CD&E knowledge in both organisations. A last practical limitation of the research was the focus on the cooperation between TNO and the Ministry of Defence, which left other stake holding organisations (Defence industry) out of consideration. As the defence industry is an important partner in the golden triangle, future research of TNO or the Ministry of Defence on CD&E should also take them in consideration. For the NATO a similar opportunity is applicable.

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Appendix

Appendix A:

Interview TNO

Doel van het gesprek

- Achterhalen van verschillen en veranderingen tussen conventionele innovatie projecten en innovatie projecten met CD&E.
- Achterhalen ervaringen en verwachtingen TNO projectleiders of ervaringsdeskundigen met CD&E in projecten.
- Achterhalen mogelijke uitdagingen die ontstaan bij projecten met gebruik van CD&E, en de mogelijke oplossingen die projectleiders hiervoor in gedachten hebben.
- Achterhalen van de verwachting van TNO met betrekking tot CD&E.

Introductie

- Mijzelf introduceren
- Doel onderzoek: Het doen van aanbevelingen voor het afstemmen van de huidige project management procedure van TNO met CD&E, en daarmee bijdragen aan het versnellen en flexibeler maken van de product innovatie projecten van het Ministerie van Defensie.
- Doel interview
    - Zie boven
- Er wordt niet gevraagd naar inhoudelijke informatie van projecten, vanwege vertrouwelijkheid. Concrete voorbeelden zijn gewenst, maar mogen generiek gemaakt worden als men anders geen antwoord kan geven.
- Introductie interviewee
    - Functie
    - Rol in conventionele en CD&E projecten
    - Aantal projecten met CD&E uitgevoerd

()= Geheugensteuntjes voor interviewer

Algemeen over CD&E

1. Wat verstaat u onder CD&E?
2. Wat is het doel van CD&E?
3. Kunt u iets vertellen over het verschil tussen normale en CD&E projecten?
4. Waar ziet u een rol weggelegd voor CD&E in het gehele innovatie proces? (Kennisopbouw en/of verwerving, K&I of DMP)(Additioneel of doelfinanciering).
5. Kunt u iets vertellen over uw ervaring met CD&E en hoe u denkt dat CD&E de snelheid en flexibiliteit van innovatie projecten van TNO beïnvloed?
6. Hebt u tot nu toe al problemen of uitdagingen ondervonden bij het gebruik van CD&E? (Icm met Defensie, TNO of de industrie).

Management and organization (Conventionele projecten → Adhoc CD&E projecten → ideale situatie CD&E projecten)

7. Kunt u iets vertellen over de huidige cultuur binnen conventionele innovatie projecten bij TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Waarden, normen, en uitganspunten) (Hiërarchie, onzekerheidsvermijding, kort/lange termijn)
8. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
9. Kunt u iets vertellen over de stijl van leidinggeven die er wordt gehanteerd bij conventionele innovatie projecten van TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Leidinggeven en faciliteren voor de teamleden)
10. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
11. Kunt u iets vertellen over de organisatorische vorm van conventionele innovatie projecten bij TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (organisch/mechanisch) (**Complexiteit**: horizontale differentiatie, **formalisatie**: regels, procedures, taakomschrijvingen, en **centralisatie:** besluitvorming met lagere rangen) (Terecht/onterecht tegengehouden of vertraagde projecten)
12. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
13. Kunt u iets vertellen over het beheer van kennis en informatie bij conventionele innovatie projecten van TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Moet alles gedocumenteerd worden?)
14. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
15. Hebt u wel eens ervaren dat CD&E projecten worden tegen gehouden? (Gebeurd dit terecht of onterecht?)

People (Conventionele projecten → Adhoc CD&E projecten → ideale situatie CD&E projecten)

16. Kunt u iets vertellen over de manier waarop conventionele innovatie project teams van TNO werken, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Samenwerking, face-2-face communicatie, pluriforme besluitvorming)
17. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
18. Kunt u iets vertellen over de achtergronden die teamleden van conventionele innovatie projecten van TNO hebben, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Bedenker idee aanwezig, motivatie van teamleden om deel te nemen)
19. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
20. Kunt u iets vertellen over de samenwerking van de gouden driehoek bij conventionele innovatie projecten van TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Actieve betrokkenheid, besluitvorming, bevoegdheden, goed ingelicht)(rol onderzoeksinstellingen/industrie)
21. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
22. Kunt u iets vertellen over samenwerking met de eindgebruikers bij conventionele innovatie projecten van TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Actieve betrokkenheid, besluitvorming, bevoegdheden, goed ingelicht)
23. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?

Process (Conventionele projecten → Adhoc CD&E projecten → ideale situatie CD&E projecten)

24. Kunt u iets vertellen over de benodigde middelen voor conventionele innovatie projecten, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Middelen: geld, tijd, mensen, materiaal)
25. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
26. Kunt u iets vertellen over de aanpak van conventionele innovatie projecten van TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Baseren keuze CD&E ipv

conventioneel? Aanpassen aanpak aan beschikbare middelen? Grootte, Dynamiek, Personeel, Cultuur)

27. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
28. Kunt u iets vertellen over de opzet van de project planning van conventionele innovatie projecten bij TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Baseren planning op schatting, rekening houden met aanpassing tijdens het project, clusteren van projecturen of uitspreiden over een jaar)
29. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?
30. Kunt u iets vertellen over hoe de keuze voor validatie methodieken bij conventionele innovatie projecten van TNO worden gemaakt, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Wordt er een bewuste keuze gemaakt voor methodieken? En waar wordt dat op gebaseerd?)
31. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?

Technical (Conventionele projecten → Adhoc CD&E projecten → ideale situatie CD&E projecten)

32. Kunt u iets vertellen over het gebruik van onderzoeksmiddelen in conventionele innovatie projecten van TNO, en of dat verschilt van de tot nu toe uitgevoerde CD&E projecten? (Zijn de beschikbare onderzoeksmiddelen beschikbaar en toereikend) (Laboratoria, simulatie ruimtes)(Heeft Defensie er weet van wat hier mogelijk is?)
33. Hoe denkt u dat de ideale situatie er uit zal zien voor CD&E projecten?

Afsluiting

34. Hebt u contrasterende voorbeelden van CD&E en conventionele innovatie projecten? (Duur, vertraging die het heeft opgelopen, grote verandering tijdens het project, productfouten na de aanschaf).
35. Verwacht u zelf nog andere belangrijke uitdagingen/problemen/randvoorwaarden voor de implementatie van CD&E, die niet tijdens dit gesprek naar voren zijn gekomen?
    Weet u in het kader van mijn onderzoek nog/interessante personen binnen de TNOorganisatie die ik zou kunnen interviewen?

Uitleggen wat er gebeurd met dit interview en de resultaten daarvan. Verwerkte resultaten van dit interview zullen gedeeld worden, als de persoon dit op prijs stelt.

Hartelijk dank voor uw tijd.