Supporting company decision-making to transition from project to product platform

A case study to determine minimum product platform functionalities.

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TUDelft

Supporting company decision-making to transition from project to product platform

A case study to determine minimum product platform functionalities.

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Cover image of Bern Laninga, taken at Terhernster Puollen in Terherne in the summer of 2019.

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Executive summary

Several high-tech companies that develop creative new technological products fail to enter the market. For entering the market, some companies aim to use a transition from a customer engineering project to a so-called product platform. A product platform is a technological design that meets the needs of a core group of customers and can be modified by the addition and substitution of features. Scaling to a product platform enables a company to receive a higher profit margin on sold products then possible when performing projects. However, companies that seek to transition from a project to a product platform experience challenges in their decision-making of the functionalities of the product platform. So far, there is no literature on how companies should approach a transition from project to product platform.

Furthermore, this research tries to answer a scientific follow-up question of a literature review on technology-push (TP) and demand-pull (DP) mechanisms (Di Stefano et al., 2012, p. 1291): "How can firms capitalize both technology and demand in the process of innovation development and commercialization?" Successfully capturing both demand and state-of-the-art technology in the product platform could enable the company to let the technology diffuse into the market.

This research aims to help high-tech companies and contribute to scientific research. Therefore, this explorative research executes a single case study and delivers a framework to communicate the captured knowledge. The formal research objective is:

"Design a framework to support companies decide on the minimum functionalities for a product platform when the company wants to transition from project to product platform."

This research delivers a framework that helps companies decide on the minimum functionalities for the product platform. The framework structures the process and ensures that all employees can find a balance between knowledge of technology and knowledge of customers. The result can be a product platform that contains unique selling points and meets the shared actual needs of the customers of a so-called unique selling market (USM). In this way, a company can find a balance between TP and DP mechanisms, which enables the company to diffuse its technology into the market. Figure 1 visualizes the decision-making process.

The framework consists of three separate phases, and four events of which two are decision-moments. The blue lines represent a separate development process of a set of functionalities. Each phase represents a dynamic and iterative process. In phase 1, the company should focus on collecting both knowledge of technology and knowledge of customers. In phase 2, the split-off indicates the establishment of separate processes for both the project and the product platform preparation. Phase 2 starts if the company, as a company unity decides that there are sufficient organizational competences and collected knowledge. In phase 2, the collected knowledge is validated and complemented and helps the company to prepare the platform. Multiple preparations can coexist next to each other. Meanwhile, the development of the minimum viable product (MVP) for the project results in a launch. The launch proves the captured technology that can have an overlap with the technology that could be in the product platform. Therefore, the launch results in new knowledge that enables the company to validate its product platform preparation. After phase 3, decision moment 2 (DM2) defines the product platform by defining a USM, the end product, and the functionalities for the product platform.

This research was conducted through multi-method research. A single case study at a high-tech company developing an unmanned surface vessel (USV) enabled the research to *discover* and *define* the empirical problem. The literature study on TP and DP mechanisms *discovered* the applicability of the factors 'technology adaption and diffusion' and 'organizational competences'. Both provided input for a first framework design. Interviews validated the framework 1.0 and a set of functionalities were *developed* for the product platform of the USV, which enabled the *development* of framework 2.0. Finally, a workshop *delivered* the results of the interviews to the employees and validated framework 2.0.

The framework provides valuable knowledge to high-tech companies that want to transition from project to product platform. Implementing the decision-making process can enable the company to select the minimum functionalities that capture both technology and demand in the product platform. Framework 2.0 contributes to the scientific literature by elaborating on the discussion how companies can balance both TP

and DP mechanisms (Di Stefano et al., 2012; Lubik et al., 2013) by the use of existing literature (Ortt and Schoormans, 2004; Ortt et al., 2013; Moore, 2014; Lubik et al., 2013; Gawer, 2014).

Companies can use framework 2.0 as a guideline to organize their decision-making process. Besides, there are two case-specific practical recommendations. Firstly, this research showed the benefits of balancing both TP and DP orientations. It is recommended to the company of the USV case to actively experiment with early market research to shift from a TP orientation to a balance of TP and DP orientations. Secondly, the research showed that the employees on the USV project do not have a shared mindset on the transition from a project to a product platform. Although this research showed that company unity is required. Therefore, the company is recommended to organize DM1 as quickly as possible to establish a company unity on its transition.

Future research could focus on validating the framework. Also, follow-up research is required to execute more in-depth research on the effects of individual employees on the TP and DP orientation, and how leadership can influence the transition. Furthermore, follow-up research could focus on when a product platform is suitable for diffusing technology to the market.
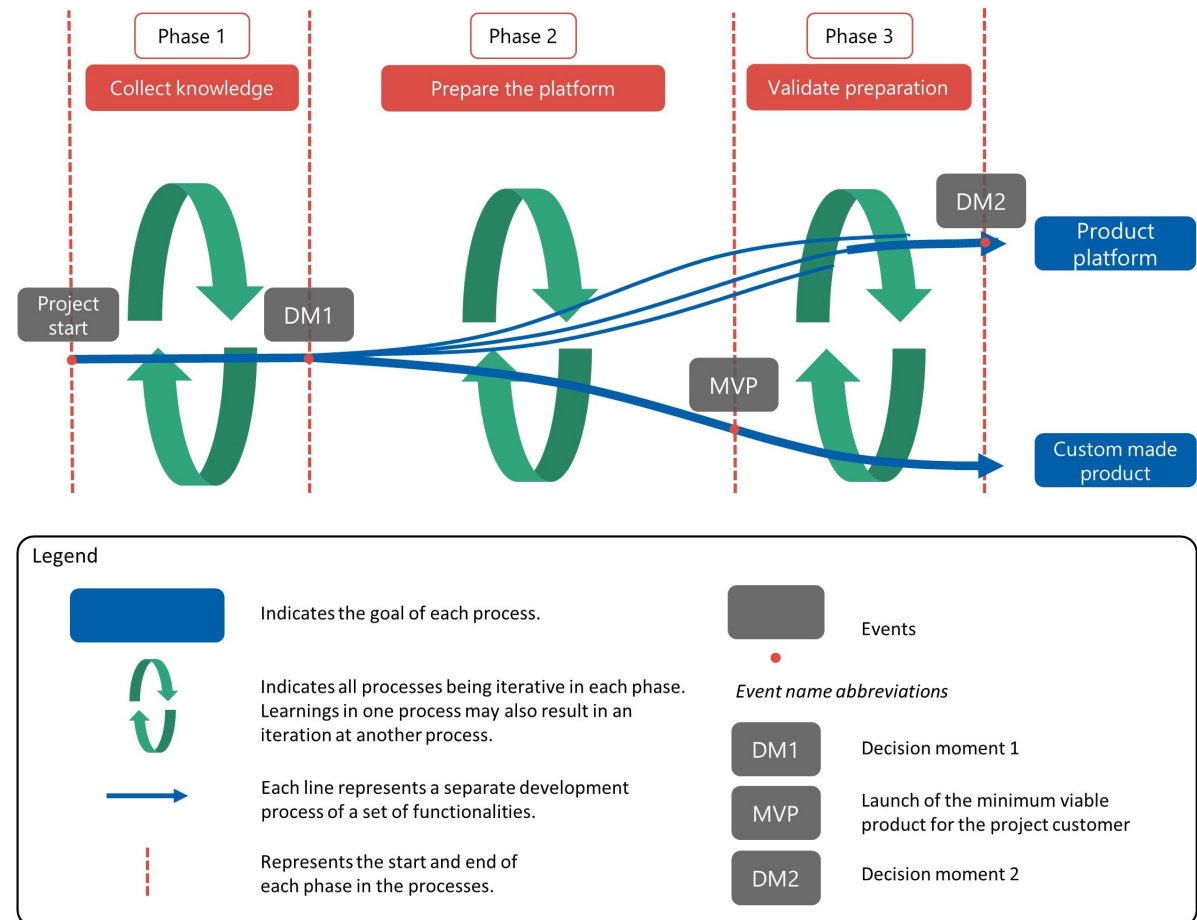

Figure 1: The decision-making process of the functionalities for the product platform in a transition from a project to a product platform as described in Framework 2.0.

Acknowledgements

The inspiration and experience I gained during my Bachelor's degree in mechanical engineering and my ancillary activities resulted in performing this research for my Master's degree in Management of Technology. An example of this is the frustration I saw on an exhibition floor where enthusiastic engineers presented their new inventions. They were proud of their invention, but at the same time, they struggled to get their products sold. My ambition arose to support developers in organizing their development process to meet the needs of the market. Besides, Demcon unmanned systems (DUS) faces the challenge of entering a new market through the development of a product platform of an unmanned surface vessel (USV). The USV is an interesting and complex technology with many required functionalities. Even extra exciting because of my affinity with water and technology. DUS offered me a unique position to investigate their challenges and the freedom to follow my ambition. The result is a study of about 6 months and the final report that lies in front of you.

The execution of my thesis project was a great adventure. Hopefully, my contribution supports DUS and similar companies to develop successful product platforms. Besides, I have developed a framework that is an addition to the existing literature. The framework offers a method to balance technology-push and demand-pull orientations and to use a transition from project to product platform to enter a new market with low risk. It was a real pleasure for me to contribute to scientific literature.

I would like to thank everyone who has enabled me to perform this research. First of all, I thank my teachers Roland Ortt and Mark de Bruijne for their enthusiasm for my topic and me as a person. They supported me through the process and helped me to deal with the complexity of this research. Roland Ortt taught me to slow down at the right moments, and in short moments he managed to help me a lot with the challenges that I encountered. These moments provided new insights and brought me even more motivation. Mark de Bruijne supported me in developing the report, both on structure level as well as textually he has taught me a lot. I am very grateful for the amount of attention both of you provided to me. Next, I want to thank Fedor Ester that supervised me on behalf of DUS. Fedor always tried to make time for me when I asked for it and he provided sharp feedback, which let me improve my work. Then, I like to express my gratefulness to my girlfriend, Susanne. She always supported me and always stood behind me. Besides, I want to thank my family that supported me at difficult moments but also celebrated the successes with me. I appreciate that I can always call them. Also, I want to thank my friends with whom I played sports, had fun, and relaxed, and who were also enthusiastic about discussing my research. At last, I want to thank all interviewees and people that helped me to organize the interviews.

I hope you can enjoy the reading of my thesis!

Bern Laninga
Delft, October 15th, 2019

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Abbreviations

DM Decision moment

DM1 Decision moment 1

DM2 Decision moment 2

DP Demand-pull

DUS Demcon unmanned systems

GPS Global positioning system

IP Intellectual property

MQ Main research question

MVP Minimum viable product

R&D Research and development

RO Research objective

SQ Sub research question

TP Technology-push

USV Unmanned surface vessel

Glossary

Actual needs Needs that solve the actual problem. (See subsection 4.5.2)

Assumed needs Estimations of the needs the customer has by the developer. (See subsection 4.5.2)

Company Refers to the high-tech developing company of the USV case. (See chapter 3 and 7)

Demand Pull "Demand-pull can be identified by a broader set of market features, including characteristics of the end market (particularly, the users) and the economy as a whole, that affects the performance of innovation." (Di Stefano et al., 2012)

Demand-pull orientation "Demand-pull oriented companies develop and produce products to address expressed market needs in specified, existing market segments" (Lubik et al., 2013, p. 13).

Demand-pull oriented companies "Companies that develop and produce products to address expressed market needs in specified, existing market segments" (Lubik et al., 2013, p. 13).

Functionality "Any or all of the operations performed by a piece of equipment or a software program" (Cambridge dictionary, a).

Industrial designer The technical function to determine the shape and function of the product, and collect and assemble parts of the products. (See subsection 3.3.3)

Knowledge of customers Knowledge of customers refers to the knowledge required to understand customer their actual needs, and be able to devide the market into segments. (See subsection 4.3.2)

Knowledge of technology "The knowledge of the technology refers to the knowledge required to develop, produce, replicate and control the technological principles in a product" (Ortt et al., 2013).

Market All established or potential market segments for a product or service. (See subsection 4.4.2)

Market segment "A set of actual or potential customers for a given set of products or services, who have a common set of needs or wants and who reference each other when making a buying decision" (Moore, 2014, p. 35).

Part "A separate piece of something, or a piece that combines with other pieces to form the whole of something" (Cambridge dictionary, b).

Project "Planned set of interrelated tasks to be executed over a fixed period and within certain cost and other limitations" (Business Dictionary, b).

Program "A plan of action aimed at accomplishing a clear business objective, with details on what work is to be done, by whom, when, and what means or resources will be used" (Business Dictionary, a).

Product platform A product platform is a technological design that meet the needs of a core group of customers and can be modified by the addition and substitution of features (Gawer, 2014).

Requirement "Something needed or necessary" (Cambridge dictionary, c).

Technology "The application of scientific knowledge for practical purposes, especially in industry" (Oxford dictionary). In this study 'functionalities' is used as level to refer to technology.

Technology Push "Technology-push perspective pinpointed the key role that science and technology play in developing technological innovations and adapting to the changing characteristics of the industry structure." (Di Stefano et al., 2012)

Technology-push orientation "Technology-push oriented companies are set up to commercialise a specific technology, drawing product ideas from an existing or developing technology" (Lubik et al., 2013, p. 13).

Technology-push oriented companies "Companies that are set up to commercialise a specific technology, drawing product ideas from an existing or developing technology" (Lubik et al., 2013, p. 13).

Unique selling market A market segment in which unique selling points of a developing company meet the actual needs of the customers from the market segment. (See subsection 7.2.4)

Unique selling proposition "The factor or consideration presented by a company as the reason that one product or service is different from and better than that of the competition" (Entrepreneur.com, 2013).

1

Introduction

1.1. Background

The background describes the motivation for this research, by describing the problems faced in a specific example, as well by problems described in the literature regarding new product development.

1.1.1. The development of an unmanned surface vessel

As a practical example, this research considers the following. A high-tech company (company) develops a new product for the market of surveys on water. Its business strategy is to gain entrance to a business-to-business market via client-driven development. One example is a project on the development of an unmanned surface vessel (USV) which is conducted together with a lead user. The company has the ambition to develop a marketable and customizable product based on the experience gained in the project. With this product, the company seeks to develop its technology to diffuse into the market. The company wants to use a product platform to scale their business. In other words, the company wants to transition from a customer project to the development of a so-called product platform. A product platform is a technological design that meets the needs of a core group of customers and can be modified by the addition and substitution of features (see chapter 4.5.2). Potential customers appear to have specific requirements regarding their application of the USV. Therefore, part of the end product must likely be customized for each customer. The development of a product platform suits the company because it enables the company to scale up the number of sales and the company can still use its project experiences for customizations. A higher profit might be the result of selling products instead of getting paid per hour only. However, what should be the functionalities for the product platform is crucial for successful market diffusion. Unnecessary functionalities make the product platform too expensive, and a lack of functionalities results in a platform with insufficient added value for potential customers. In this way, a wrong set of functionalities cost a lot of money since time and effort have been spent on their development (Lubik et al., 2013). Therefore, not knowing how to determine a successful set of functionalities for a product platform can be risky in today its fast-changing world.

From a market perspective, the example of the USV reveals that the technology is not yet diffused, but is in the market adaption phase (Ortt and Schoormans, 2004). Multiple niche markets for the technology might be distinguished. Some companies might have a need or even a necessity to deal with a specific problem they have, which could be fulfilled with the developed technological solution. Customers are sometimes capable of describing some functionalities to solve their problem. However, customers more than often do not understand their real problem and are therefore unable to specify their needs. This makes it difficult for a developer to choose a 'right' product platform and solve customers' actual problems. This lack of knowledge of customer's needs hampers the diffusion of new technology (Moore, 2014; Lubik et al., 2013).

Concluding, a successful transition from project to product platform has advantages for the company. However, both technology and demand must be captured in the product platform during the transition. Otherwise, time and money are lost. For this, a company must know how to choose the right functionalities for its product platform. The example shows that both the market perspective and the company perspective on the product platform must be considered to make the right choices for the product platform.

1.1.2. High-tech companies and their patterns

Some companies develop creative new technological products and fail to enter the market successfully (Lubik et al., 2013). A cause for this problem may be that the company did not succeed to capture both demand and technology in its innovation process (Choi, 2018). In other words, the company is unable to balance demand and technology (Di Stefano et al., 2012) during the transition from project to product platform.

For example, Google Glass products never entered the market after a seemingly successful internal project. After the technology was considered mature enough to enter the market, it was not clear for customers why the chosen functionalities should be useful for them (Altman, 2015). High-tech firms often focus on research and development, while the commercialization strategy is seen as a follow-up in their program (Wheeler and Shelley, 1987). In other words, companies often tend to be technology-push (TP) oriented and maybe have too little attention for a demand-pull (DP) orientation Lubik et al. (2013). Google may have developed a new technology, but they were not able to successfully sell the resulting products. Concluding, demand was not captured in the design of the product. The problem of capturing both demand and technology in the design of the process is often recommended for further research by literature about technology-push and demand-pull mechanisms (Ardilio and Seidenstricker, 2013; Di Stefano et al., 2012; Lubik et al., 2013; Kirchberger and Pohl, 2016).

1.1.3. Problem formulation
Several companies experience challenges in their decision-making of the functionalities for their product platform when they aim to use a transition from project to product platform to enter the market successfully.

1.2. Scientific background
Many perspectives and research fields can be taken into account for this research, like chapter 1.1.1 describes. However, there is a clear field of tension that runs through all levels of the problem. This is the field of tension between the market and the company. Both can influence the product platform by either a TP mechanism or a DP mechanism.

1.2.1. TP versus DP
TP and DP concepts can be seen as different mechanisms. Which mechanism is better than the other to create an effective innovation is already many times discussed in literature (Schmookler, 1966; Mowery and Rosenberg, 1979; Van den Ende and Dolfsma, 2005; Di Stefano et al., 2012; Choi, 2018). The TP concept assumes a linear process from research and development towards a diffusion (Peters et al., 2012). DP as opposite can be described as market demand leads to technical change and steering research in other directions (Peters et al., 2012). For example, Apple has tried to push a PDA to the market. It could be seen as the first version of a phone or tablet with a touchscreen. Developed from a linear process after own research, which typically belongs to a TP mechanism (Peters et al., 2012). However, there was no demand for the product at that time. The technology was not matched with actual demand. Years later, phones with a touchscreen are successfully diffused. An example of a DP mechanism is the digital photo camera. Cameras available before the introduction of the digital camera all needed to change the film roll. This caused a demand for an alternative to this problem. Companies tried to solve this problem by developing a product that met the needs of customers (Ryan. V, 2013). TP and DP might be seen as opposites. However, according to Di Stefano et al. (2012), this must not be seen as a bifurcation between the two concepts. Demand and technology should be balanced instead of seen as opposites (Di Stefano et al., 2012). How this should be 'balanced' was not described by (Di Stefano et al., 2012).

1.2.2. Scientific starting-point
Work from Di Stefano et al. (2012) is the scientific starting point of this research. Literature from Di Stefano et al. (2012) reviews literature about both TP and DP mechanisms. According to Di Stefano et al. (2012), the mechanisms should not be seen as bifurcation but should be balanced to launch new products successfully (Di Stefano et al., 2012). Literature from (Di Stefano et al., 2012, p. 1290) questions how the process of innovation development can balance both TP and DP mechanisms. The field of tension of TP and DP mechanisms described by Di Stefano et al. (2012) and the background of the problem this research tries to answer are overlapping. The scientific research question articulated by Di Stefano et al. (2012) is the following (Di Stefano et al., 2012, p. 1291): *"How can firms capitalize both technology and demand in the process of innovation development and commercialization?"*

1.3. Research objective and questions

As a result of the practical and scientific background, this section describes the research objective and research questions.

1.3.1. Research objective

Research objective (RO):
Design a framework to support companies with its decision-making on the minimum functionalities for a product platform when the company wants to transition from project to product platform.

1.3.2. Research questions

Main research question (MQ):
Considering a high-tech company that wants to transition from a project to a product platform, how should this company determine the functionalities for the product platform?

Sub research questions (SQ):

1. *What should the company consider to determine functionalities for the product platform?*
2. *What should be the influence of the market on the functionalities for the product platform?*
3. *What should be functionalities of a product platform?*

Figure 1.1 visualizes the relation between all research questions. The TP and DP mechanisms are described by literature as bifurcating mechanisms. Figure 1 visualizes the influence of the developer and a market segment on the development of a product platform as opposite influences. In other words, Fig. 1.1 implicitly shows a field of tension. The company that decides over the product platform is also the developer. Although, it is called a developer to emphasize that the company could consider its influence on the product platform. Each SQ investigates part of the field of tension. The company wants to learn how to organize the decision-making process regarding the minimum functionalities for the product platform. Therefore, every SQ is also related to the decision-making process, which is included in the MQ. Literature from (Di Stefano et al., 2012, p. 1293) and (Lubik et al., 2013, p. 23) states that TP and DP mechanisms should be balanced. Figure 1.1 shows that the MQ is proposed in such a way it includes both the influence of the market and the developer. If a company understands its TP influence and the DP influence of the market segment, which refers to the customers of that market segment, on the product platform. Then the company is able to balance both TP and DP mechanisms for the derivation of the right minimum functionalities for the product platform.
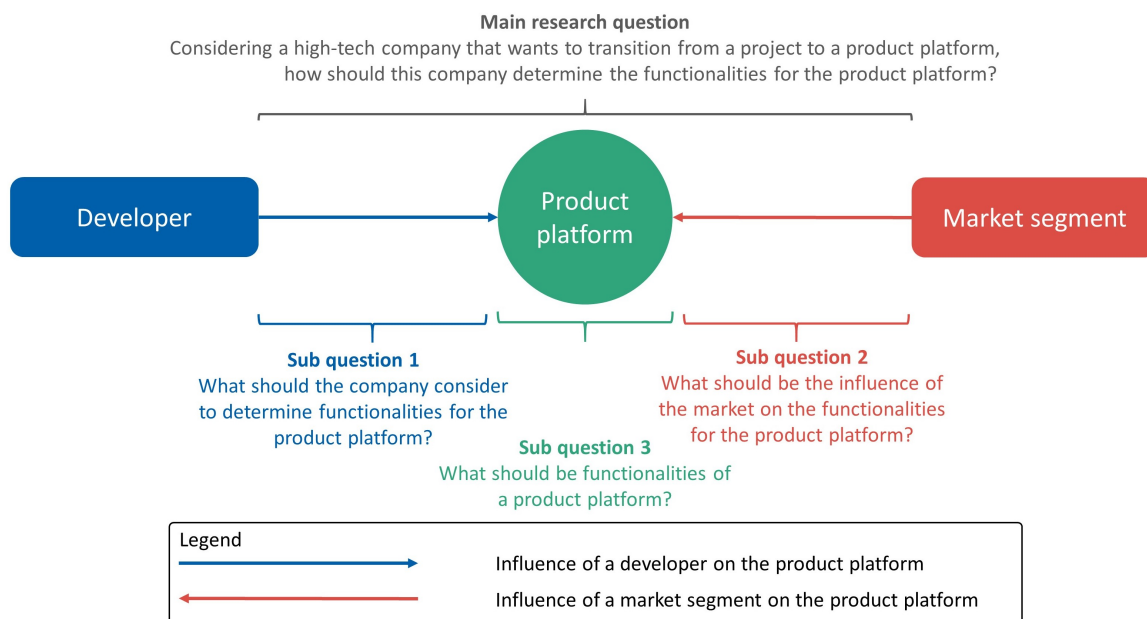
Figure 1.1: The coherence of the research questions and the tension between the market and the developing company

The MQ covers the entire problem described in subsection 1.1.3. SQ1 answers part of the MQ from the developer its perspective. Meaning, the answer of SQ1 contains 'what' elements the company should consider and explain 'why' and 'when' these elements should be considered. To be able to choose the right functionalities for the product platform, the influence of the market on the minimum functionalities for the product platform must be understood. Therefore, answering SQ2 is required. This also answers part of the MQ. Finally, answering SQ3 answers the last part of the MQ. What functionalities should and should not be included in the product platform supports the decision-making process of the transition from a project to a product platform. Answering the SQs delivers all parts required to answer the MQ.

1.4. Expected contributions

The expected contributions show what can be expected from this research. Subsection 9.2.1 describes the final contributions.

Scientific contributions

This research aims to provide a new perspective on dealing with TP and DP mechanisms in new product development. It elaborates on the discussion of TP and DP mechanisms by describing how companies can balance these mechanisms in the case they want to their innovation development process from project-based to the development of a product platform.

Practical contributions

The company described in subsection 1.1.1 can learn how they can decide on their selection of functionalities for a product platform. The framework can help these companies in organizing their transition from project to product platform. The framework could describe how companies can deal with the transition and what considerations they could make. A developer can interpret this knowledge and adjust their process so that the findings of this research provide a greater chance of a successful transition from project to product platform.

1.5. Chapter conclusion

The introduction of this research introduced the problem and described the research questions. In the next chapter, the research methodology is described, which shows the approach and methods used for this research.

Research methodology

2.1. Introduction

Explorative research is needed to answer the research questions because not much is known about the decision-making process of functionalities in the transition from a project to a product platform. Therefore, the research collects knowledge from practice and literature. After which, it captures the knowledge in a framework that transfers the knowledge to both practice and literature. Section 2.2 describes the approach for the framework design and section 2.3 describes the selected methods.

2.2. Research approach

Since the development of a framework has parallels with a design process and a design-science process (Hevner et al., 2004), literature has been used as inspiration for the selection of the methods (Hevner et al., 2004; Design Council, 2005). This section describes how literature inspired the selection of the methods. Section 2.3 explains the methods selection itself.

A developed double diamond research process, inspired by literature from Design Council (2005), enabled this research to select methods that are most suitable to reach the objective. Figure 2.1 shows that first a framework 1.0 is created. Validations of framework 1.0 enable this research to improve the framework. Several iterations result in the design of framework 2.0. The double diamond in Fig. 2.1 distinguishes four phases. The arrows indicate that each phase is an iterative process. The first phase *discovers* the problem, which is about "noticing new things and gathering insights" (Design Council, 2005). This research uses different research methods for the first phase. The second phase *defines* what matters most (Design Council, 2005). The third phase *develops* concepts for the solution. At last, phase 4 is *delivers* a solution.
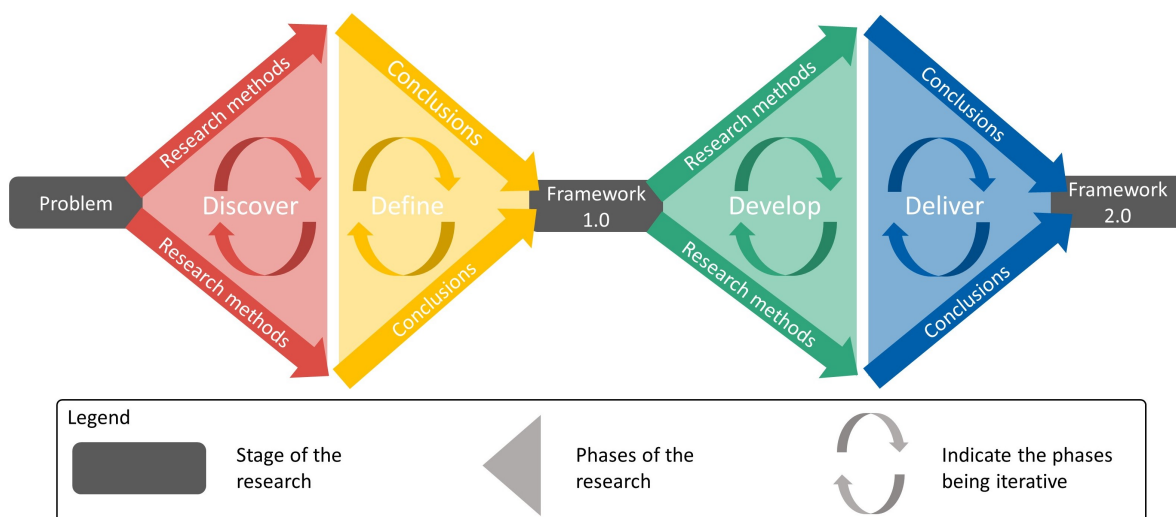
Figure 2.1: This figure visualizes the research approach, based on literature from Design Council (2005).

2.3. Research methods

This section describes the methodology for this research. Figure 2.2 shows a research flow diagram, which will be explained below. While Fig. 2.1 showed the inspiration for the selection of the methods, Fig. 2.2 shows the gridline for the research.
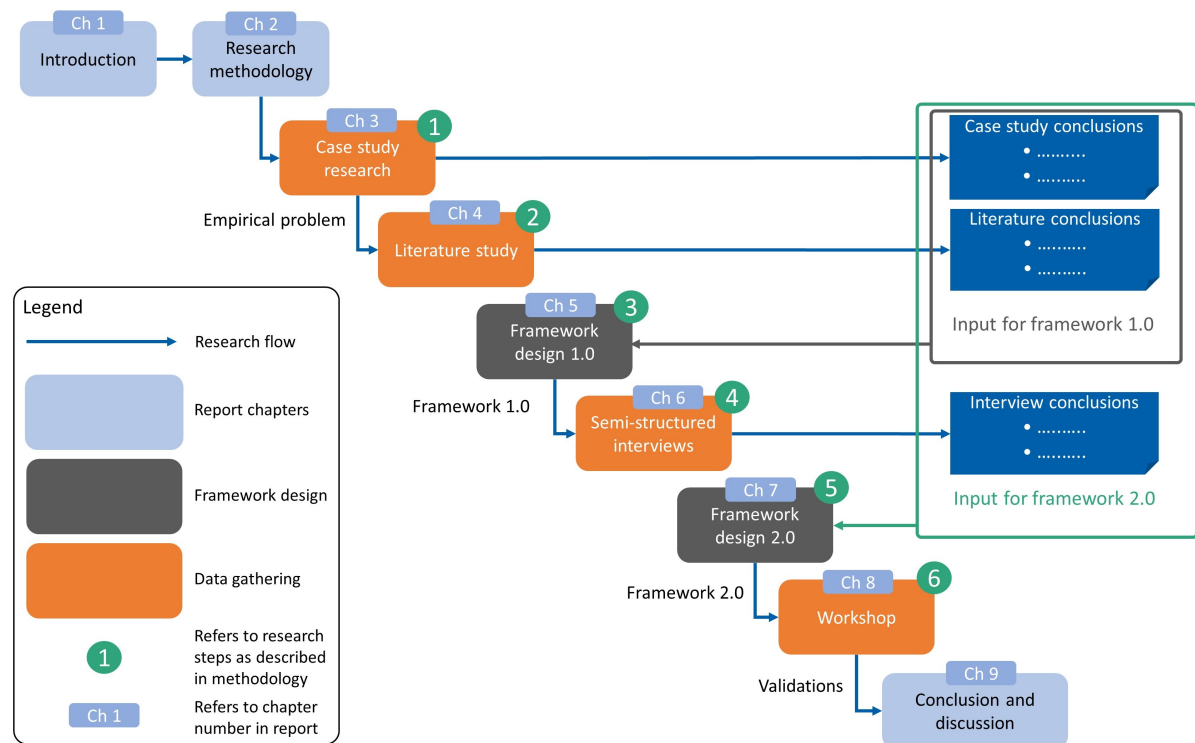
Figure 2.2: Research flow diagram, including research steps, research methods, chapter structure, and knowledge flow.

The research is explorative, which means the first step is to collect knowledge from practice and literature. In-depth research in a single case collects practical knowledge. In this way, the research *defines* the empirical problem. A single case study research (step 1, see subsection 2.3.1) *discovers* the problem from a company perspective. Defining an empirical problem is the goal of this research method. Being able to *define* the empirical problem is required input for the literature study. Furthermore, a literature study *discovers* existing literature (step 2, see subsection 2.3.2). The findings in the case study research and the literature study are used to derive an answer on the research questions; developing a framework (step 3, see subsection 2.3.3) *defines* the collected knowledge.

A framework captures and *defines* the knowledge and communicate these in an artefact that is suitable for both practitioners and researchers (Hevner et al., 2004). The figure shows that the conclusions from step 1 and 2 are used by step 3. Step 4 *develops* possible sets of functionalities by the use of semi-structured interviews. Semi-structured interviews are chosen as a method because this ensures the inclusion of additional knowledge from the practice of both the market perspective and the company perspective (see subsection 2.3.4). Semi-structured interviews enable the research to investigate the prefered sets of functionalities for the product platform from both the perspective of employees and customers (step 5, see subsection 2.3.5).

Furthermore, the interviews enable validation of framework 1.0. Due to additional knowledge of the interviews, framework 2.0 can be *delivered*. The figure shows that the redesign takes into account all conclusions from the case study research, the literature study and the interviews. At last, this research aims to validate the results internally. Therefore, step 6 validates the redesigned framework by the use of a workshop (step 6, see subsection 2.3.6). A workshop provides the opportunity to help the company by sharing the results, as well as to validate vital elements of framework 2.0.

Arrows in Fig. 2.2 represent the research flow. For example, the empirical problem is the research flow from step 1 to step 2 and the conclusions presented in the box 'input for framework 1.0' represent the flow towards research step 3. The different colours of the boxes show report chapters, data gathering and framework

design processes. All research steps correspond to chapters. For example, the approach of 'step 2: literature study' described in subsection 2.3.3 corresponds to the results described in chapter 4. The next subsections describe the application of each method as visualized in figure 2.2.

2.3.1. Step 1: Single case study

This study starts with a single case study. The case study research *discovers* and *defines* the empirical problem. Section 1.1.1 introduced the case already. In summary, the case study is about a company performing a customer project of the development of an unmanned surface vessel (USV) for a hydrographical application. A single case study enables in-depth research of the empirical problem (Hevner et al., 2004; Sekaran and Bougie, 2013). Knowing the practical difficulties experienced by companies enables this research to derive an answer that fits into practice.

The explanation of why a single case study is a suitable method can be scientifical. As is said by Sekaran and Bougie: "Inductive discovery via observation can pave the way for subsequent theory building and hypotheses testing" (Sekaran and Bougie, 2013). According to Yin (1994), direct observation and systematic interviewing are the two sources of evidence that let case study research differ from others. The case study research uses both of these methods. The research shares the results with each interviewee for validation. Each interviewee is asked to validate and complement the results. The execution of the single case study is called 'case study research'. The output of the case study research is the empirical problem and conclusions that could be used for the framework design. Section 3.1.2 describes how the case study research uses different methods.

Chapter 3 describes the case study research. These results are input for the framework design (step 3) as is also visualized in Fig. 2.2.

2.3.2. Step 2: Literature study

The second step for the research to explore and *discover* the current knowledge base includes a literature study. After an in-depth single case study research, it is required to explore literature about the empirical problem that is found. For this literature study literature from (Di Stefano et al., 2012) will be used as a starting point for the literature study (see subsection 1.2).

The empirical problem is about the decision-making process of a company, which can be seen as a micro level of the problem. However, to properly implement this decision-making process, higher levels of the problem must also be understood. The multiple levels make it complex literature research. To capture the complexity of this research, three levels of literature research are required. The macro level contains the market perspective of new technology adoption and diffusion. The meso level contains the company perspective of new technology adoption and diffusion. At last, the micro level contains the perspective of organizational competences and the decision-making processes of companies regarding the transition from project to product platform. Conclusions of the theoretical framework ensure the knowledge can be used to be *defined* in framework 1.0.

Subsection 4.1 elaborates the explanation of the multi-level literature research. The other part of chapter 4 describes the results of the literature framework. The theoretical framework is used as input for the framework design (step 3) as is also visualized in Fig. 2.2.

2.3.3. Step 3: Framework design

The gathered knowledge from the case study analysis and the literature study should be *defined* in an artefact. A framework is chosen to enable the research to develop procedures and guidelines and communicate these in an artefact that is suitable for both practitioners and researchers (Hevner et al., 2004). The framework structures the decision-making process.

Figure 2.3 shows that both step 1 and step 2 are input for the framework. The figure shows that both the case study research and the literature study result in conclusions. Framework design 1.0 uses these conclusions as input.
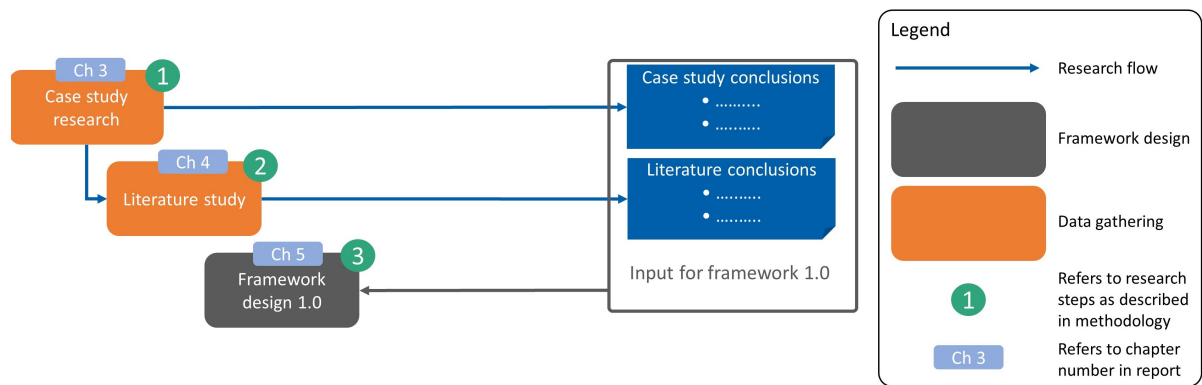
Figure 2.3: A visualization of the inclusion of the input for the framework design.

2.3.4. Step 4: Semi-structured interviews

To improve framework 1.0, validation and complementing knowledge is required. This knowledge should include both the company and the market perspective. Therefore, the case study of step 2 can also be used to gather the knowledge used for the improvement of framework 1.0. The selected research method to validate and complement framework 1.0 is semi-structured interviews.

The semi-structured interviews have two goals. Firstly, the interviews should validate the knowledge captured in framework 1.0. Interviewees are asked to validate and evaluate framework 1.0. Secondly, the interviews should complement with additional knowledge. The complementation of additional knowledge via the interviews is an extension of the case study research described in chapter 3. The semi-structured interviews focus on the decision-making process of the minimum functionalities for the product platform; each interviewee is asked to derive a set of functionalities for the product platform. Observation of these selection processes and the analysis of the results enable this research to *develop* the set of minimum functionalities for the product platform in the case study. Interviews with a small number of employees of the company that develops the USV to collect tacit knowledge. Interviews with a small number of (potential) customers to collect knowledge of the market perspective.

A list of conclusions from all interviews summarizes the data. These conclusions are input for framework 2.0. The conclusions of the interviews also result in an iteration of the use of the theoretical framework. Several aspects mentioned in literature gain more attention because the interviews are mentioning the aspect too. This research flow is visualized in Fig. 2.2.

2.3.5. Step 5: Framework redesign

Data from the semi-structured interviews are used to redesign the framework, see Fig. 2.2. Framework 2.0 *delivers* the findings to both practitioners and researchers. This iteration improves the first framework by the inclusion of tacit knowledge from both the company and the market perspective. The knowledge and insights from the interviews may ensure that the framework not only needs to be supplemented but also needs to be adjusted. In addition to the knowledge gathered from the interviews, the framework can also include supplementary knowledge from case study research and the literature study. Figure 2.4 visualizes the input for the redesign. The figure shows that both the case study research, the literature study, and the interviews result in conclusions. Framework design 2.0 uses these conclusions as input.
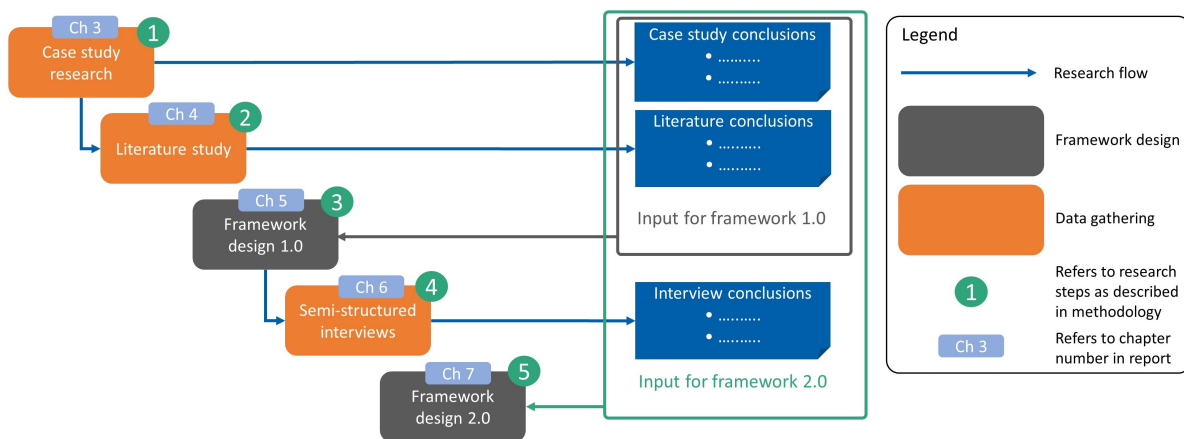
Figure 2.4: A visualization of the inclusion of the input for the framework redesign.

2.3.6. Step 6: Workshop

The results of the interview, which is the *development* of the set of functionalities, should be *delivered* with the company. Besides that, framework 2.0 should be evaluated to increase the validity of the framework and determine future research. Therefore, this research selected a workshop as a research method. The workshop shares the results with the employees and validates the most significant changes between framework 1.0 and the redesigned framework. Furthermore, the participants are asked to recommend future research. A short survey collects the results of the validation and recommendations.

2.4. Chapter conclusion

The research methodology enables the execution of the first research method. The next chapter describes the results of this method; the case study research.

3

Case study research

3.1. Introduction

The case study research aims to *discover* the difficulties for the company in a case study, and *defines* the empirical problem. This research considers a company that develops an unmanned surface vessel in a customer engineering project, and it has the ambition to transition to a product platform. The case and the research fit together, because the company wants to use the product platform to enter a new market. However, the company experiences challenges regarding its decision-making of functionalities for the product platform. Therefore, *discovering* the empirical problem with this case provides knowledge to reach the research objective. This introduction describes the approach and structure of the case study research.

3.1.1. Objectives

This subsection describes the formal objectives of the case study research:

Objective 1: *Derive the empirical problem for the company of the USV case.*
Objective 2: *Derive input for the framework design.*

3.1.2. Methods

Multiple methods collect various types of evidence for case study research. This subsection describes the methods and corresponding results. The case study research uses direct observation, analysis of documents and interviews as methods. The unit of analysis is the unmanned surface vessel (USV) project, including all people that are involved in the project, the co-developing lead user, and other potential customers. Direct observations aim to capture striking things, interviews and document analysis provide in-depth results. All pieces of evidence together are used to make the analysis. The interview preparation for each interview is a goal and a set of questions, which results in semi-structured interviews (Sekaran and Bougie, 2013). This research captures the knowledge by the use of paper notations and voice records. The summarized interview results are shared and validated by the interviewees. The used data collection and reduction methodology are inspired by literature from Sekaran and Bougie (2013). Also, this research uses documents to provide in-depth information.

Figure 3.1 shows the data triangulation of the case study research. The figure shows a list of methods together with the corresponding pieces of evidence. For example, 'direct observation' resulted in 'piece of evidence 1'.

Method		Result
Direct observation	→	Piece of evidence 1
Semi-structured interview	→	Piece of evidence 2
Semi-structured interview	→	Piece of evidence 3
Analysis of documentation	→	Piece of evidence 4
Unstructured interview	→	Piece of evidence 5
Semi-structured interview	→	Piece of evidence 6
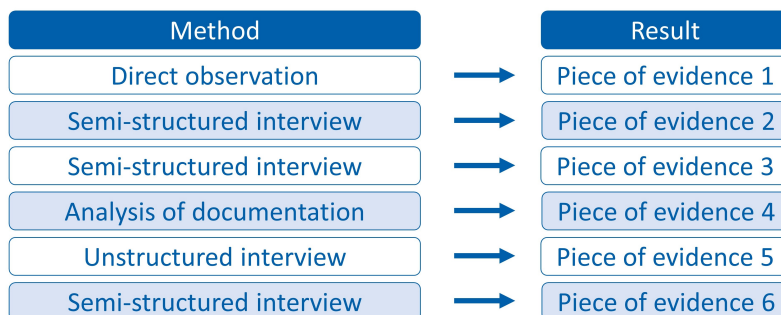
Figure 3.1: Data triangulation of the case study research. The methods that are used are connected with the result.

3.1.3. Structure
Section 3.2 describes the analysis. The analysis provides the context for the case study, after which the results show what details could be input for the framework. Section 3.3 presents the results. Afterwards, 'reduced results' help to deduce the results to conclusions. The research uses the conclusions of platform 3.4 as input for the framework design. Appendix I describes the discussion of the case study research results.

3.2. Case study analysis
The analysis provides the context of the case study. Subsection 3.2.1 describes the company characteristics describe. Then, platform 3.2.2 describes the technology and platform 3.2.3 describes the company its aimed transition to a product platform.

3.2.1. Company characteristics
The company developing the USV project is a 100% subsidiary of a large high-tech engineering group in the Netherlands. The subsidiary company established around two years ago. The core employees of a high tech start-up were taken over by the group. At the moment, around 10 employees are working for the subsidiary company. The team is a small and flexible project team. The subsidiary company is subject of this study, so this research refers to the subsidiary company with the use of the word 'company.' This research refers to the parental company as 'group.'

This high-tech engineering group facilitates client-driven technology development. The business strategy of the company and the vision of the group are aligned, which resulted in the execution of client-driven engineering development projects. However, the company has the ambition to transition from a project to a so-called product platform (see 3.3.2). In its opinion, this strategy results in a win-win for the customer and themselves.

3.2.2. Unmanned surface vessels
In the global market of USVs, there are not yet products diffused into the market. However, the company identified demand for boats between 1.5 and 6 meters that can carry all instruments wanted by the customer and can be transported by car and trailer (see subsection 3.3.5).

From a company perspective, the project is an opportunity to develop and push their products. The project is heading to design a minimum viable product (MVP) for the project customer. However, the company wants to develop a product platform that includes functionalities that enable the company to diffuse its technology in the market.

The company hopes to have entered a market segment by starting a project with a lead user in a niche market for the use of USVs. This niche market is the market for USVs for inland water surfaces in the Netherlands. The potential size of the market is not known. Business-to-business development of advanced equipment like USVs likely requires customizations. The company has in mind that a product platform is standardized for the first 80%. The last 20% is customized for each customer. The company considers a product platform that includes the required technology of the end product to stay ahead of the competition.

3.2.3. Transition from a project to a product platform
Currently, client-driven development is the business strategy of the company. A project is performed together with a lead user. The project has multiple phases. Phase 1 is the development of an MVP for the customer. The company decides on the functionalities in consultation with the customer. The pool of engineers and the managers co-decide about the choices for the development of the product. Phase 2 includes the development of additional functionalities that are needed by the customer. The company aims to learn enough about technology in the project to be able to use this in a transition to a product platform. However, their primary focus is to deliver the project on time. The company does not know how to organize this transition process.

Scaling to a product platform is the ambition of the company because selling products can generate a higher profit than possibile with selling projects. Other options would be to execute multiple custom made projects or to develop a standardized product. Figure 3.2 shows the three alternative business strategies if the company wants to use their experiences of client-driven development projects for scaling. If the company would have several parallel custom-made projects, the company the profit margin on sold projects would not increase that much. Thus, the company does not receive the prefered scaling benefits with scaling to multiple projects. The expected numbers in the business-to-business market of USVs are currently not that large that a fully standardized product seems a logical choice. Also, scaling to a business-model of developing

standardizes product could be riskier, because of a much greater change for the organization. The expected order of magnitude by the company for the coming years is around five to ten USVs for the inland water surface market in the Netherlands. Potential customers seem to have different specific functionalities for the end product. A fully standardized product would not suit this situation. Furthermore, the project experience proves that the company is good at customizations. Its strategy is to use this as a competitive advantage in a product platform. In conclusion, this research considers that a product platform is a suitable strategy for the company, judging on its current business strategy. Subsection 9.2.3 reflects on this consideration focus on product platforms.
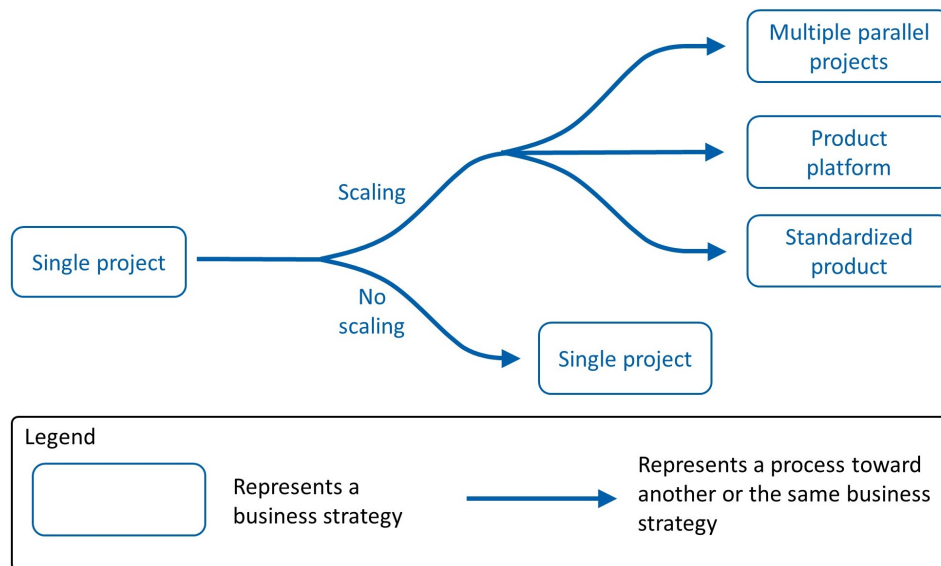
Figure 3.2: Three scaling alternatives of business strategies from client-driven development to another.

3.2.4. Empirical problem statement
The analysis of the case study results in the following problem statement:

The company's main challenge is to determine the right set of functionalities for the product platform for a successful market diffusion.

3.3. Case study results
The gathered data is called 'evidence' Hevner et al. (2004). Each piece lists the characteristics of the evidence.

3.3.1. Piece of evidence 1: Direct observation at test location
The research methods used for this piece of evidence is direct observation. Employees tested the USV on small water next to their office in Delft. Furthermore, short questions validated the observations.

Summary of the gathered information
The test was about the vessels its ability to autonomously sail a pre-specified route. A conversation among two engineers started about a certain functionality of the USV. Afterwards, the following question was asked to one of the engineers: "Why is this boat using only GPS to determine its current position." As observed and validated through the answer of the employee, it turned out that some design choices for a project have an opposite impact of what the engineers would like to design. They prefer to design a product suitable for more applications, but the project boundaries are limiting them. The engineer describes this below.

"The project is now in phase 1, in which the functionalities are mainly based on what the customer needs. In phase 2 of the project, the idea is both to start a product platform and to execute the next iteration to the MVP developed in phase 1. Costs and time are limits. The customer asks, we develop. If those limits were not present, the company could develop a higher quality product with better standards and more suitable for cus-

tomizations. In phase 2, the customer requires a design with GPS denying technologies. However, GPS is chosen together with the customer for now, because it creates an MVP for them."

Reduced results of piece of evidence 1

- The company facilitates client-driven technology development.
- Functionalities of the MVP are chosen in consultation with the customer of the project.
- The employees want to include other functionalities than the project customers wants.
- The project has multiple phases, of which the launch of an MVP ends the first phase.

3.3.2. Piece of evidence 2: Semi-structured interview with manager
This semi-structured interview aimed to get in-depth information of the company.

Summary of the gathered information
The company, which is the owner of the case is 100% subsidiary company of the group. Opposite of most high tech start-up or firms, the group has a different strategy in coping with risks in the R&D process. Their core business strategy is client-driven technology development. This strategy means that they get paid per hour, which do not need upfront investments. The company promises to deliver the agreed functionalities to the customer within those hours, but they are not bothered by disappointing sales. In addition to the core business, the manager spoke out the ambition to be able to transition products developed in a project to a product platform.

The manager summarized the background of the project. First, conversations with a potential customer in the market of dredging equipment started. The customer came up with a problem description. Their main problem can is that they are not able to efficiently identify dredging depts at building sites. A regular boat was not efficient because these building sites in which the problem occurred contain horizontal beams. The original boat operated by two people was not able to sail underneath it, it required lifting over each of the beams. The company was challenged to help them. In this way, a project started to develop a vessel that can sail autonomously underneath the beams and can measure water depths. Tthe project consists of three phases. The first phase includes the development of an MVP. The second phase is a follow-up, which enables the inclusion of additional functionalities. For example, in the MVP, the vessel will have a GPS to determine its position, but in phase 2 requires GPS denied situational awareness, which means that the USV can use other methods than using GPS to determine its position. This additional functionality is needed to sail underneath the beams as described in the previous paragraph. Phase three is yet undefined. However, the main difference in the product might be the ability to drive on public routes.

The company also has its (research and development) R&D roadmap. This roadmap includes the development of creating a digital world in which unmanned systems can move autonomously.

Client-driven development has advantages and disadvantages. An advantage is that the engineering goal is quite clear; this is considered to be a unique approach to deal with engineering perfectionism. Engineers want to develop the best product possible, but the customers set time and cost limits. Another advantage is that the development of the project results in knowledge that the company can use for other projects or products. A disadvantage can be the hampering of its product development because all personnel is required to develop the MVP for the project. The manager argues the following about this:

"First you need to be relevant; there must be a market for your product. However, we are paid per hour when we are developing the MVP, so there is a real risk if there is no other market for the product. A disadvantage of this strategy is that the first market introduction takes longer because the requirements of the project customer limit freedom in the design process."

The company uses this the client-driven development strategy to gain enough knowledge of the product and the market to launch a new product to a new market. The goal is to develop a product that is good enough for diffusing the market of USVs. How the company is going to do this is unclear yet.

Halfway the interview, the following question has been asked: "From your perspective, which factors influence the decisions regarding functionalities?" During the interview, a discussion of 'levels' in factors started. Two major levels of functionality decisions can be distinguished, according to the interviewer:

"I see a first level called 'system functionalities', which are: Standardization, flexibility, costs, safety, usability, employability, and robustness. From my perspective, these factors are guidelines within which we must design, but ultimately we still have to determine specific functionalities together with the customer. Thus, the second

level is the set of functionalities that make sure that system functionality comes out well. For example, an aluminium hull and protected rotors and a waterproof upperside ensure the vessel will be robust."

Reduced results of piece of evidence 2

- Client-driven technology development is the core business strategy of the company, and they have the ambition to transition to product platform if the technology is relevant enough.
- The company uses an R&D roadmap to capture knowledge that can be used in multiple projects.
- Standardization, flexibility, costs, safety, usability, employability, and robustness, were mentioned as system functionalities.
- Success factors of commercialization are according to the manager: competitive environment, the added value of the product, partner (choice) and market maturity.

3.3.3. Piece of evidence 3: Semi-structured interview with industrial designer
This semi-structured interview was held with an 'industrial designer'. The glossary contains a definition of an industrial designer.

Summary of the gathered information
The first question for the interviewee was: "How do you experience the difficulties related to the development of the product platform?" The interviewee answered that the difficulty is to select the right functionalities for the product platform. This was apparent from the following questions that are raised by the interviewee:

"Which technological features should be included to go to the market successfully? Moreover, is the MVP of the project successful for market diffusion?"

Therefore, the question has been asked to the interviewee what he thinks that relational factors are. He responded that it depends on what the market wants and what competitors are doing. Also, it depends on how mature the market is and on what the company is capable of. The interviewer raised the next question: "What are the factors that influence commercialization?" The interviewee responded that identification of market maturity is one of the most important factors.

The interview moved to how the company makes decisions on functionalities in the project. The answer provided information about the customer project background and the company its strategy:

"Via conversations we tried to identify and specify the problem of the customer. The problem leads to a proposal, which estimates pain points that must be solved. These estimates are concepts of functionalities that add value for the customer. Together with the customer is decided which functionalities match their budget and adds the required value."

The interviewee answered that the company uses the 'V-model' (Clark, 2009). It helps the company to iterate on their design choices within the project:

"First an entire concept is presented, on which together we agreed on a certain price. We then develop the system requirements and eventually design each component. The same as the figure shows with the arrow going to right below. In this way, we bring more detail into the original concept and validate every design choice with the customer. If it was not right, then we have to make an iteration. Our process means that the customer asks something, we estimate what the required solution is. Interesting about these estimates is that the customer or the market does not yet know what they want. However, they already might know that they have some problems, but are unable to define specific requirements for the solution."

After explaining the development process, the interviewee has been asked whether he is seeing this as a technology-push (TP) or demand-pull (DP) mechanism. From a company perspective, this project is a way to push technology. However, it can also be seen as a DP because the company was asked by a market party to come up with a solution, as described by the quotes below:

"That the customer has a certain demand can perhaps be a DP mechanism, but that we think he needs our product is certainly a TP. The functionalities that the company chooses can be seen as a push, and the market needs to determine the 'pull.'"

At last, the following questions has been asked: "why do you want to transition from project to product?" The described his answer by the following:

"Doing a project like the company is doing now with the USV, is low risk but time-consuming. From my experi-

ence, other start-ups tend to have high upfront investment costs. The company can spread the risk by developing for a customer and have their R&D roadmap. It can also be interpreted as learning part of the market needs because of a close partnership. However, the question can be raised if this customer is an accurate reflection of the market as a whole. We are bound to that because it is who pays, who determines."

The company assumes that the learning part decreases when executing projects only, resulting in the risk that competitors could be faster in their development cycles. Scaling the project to a product level is therefore seen as the method to become the leader in the market and scaling can result in more profitability. The idea is to gain knowledge during the project and use it to make a product. The company hopes that by this, the product is successful. The interviewee explained that the company does not know how it should transition from project to product platform, which was apparent from the following raised questions by the interviewee:

"When is the right moment to transition the project to a product? It depends on the added value and competitiveness. Do you want an MVP to be launched, to be the first on the market? Alternatively, is it better to wait, learn in the project and then to market a product with more or better functionalities? Scaling is the goal to create more profitability, which raises questions for us. How do we estimate the market as well as possible? How do we choose the right set of functionalities? When is the time to transition? Which commercialization strategy do we choose?"

Reduced results of piece of evidence 3

- Factors influencing functionality decisions: Firm capabilities, market needs, competition, and market maturity.
- Validating concepts with the project customer shows their iterative nature of the design process in projects.
- The industrial designer questions what features should be included in a product platform.

3.3.4. Piece of evidence 4: Document regarding competitive environment

In appendix A a document lists website links from worldwide manufacturers of USVs. This document describes the market research done so far by the developer. It is relevant for this research because it provides insights into the market potentials, potential competitive parties and current products. This information can be used to determine the development of USVs from a market perspective. An analysis of all of the websites resulted in the following results.

Results of piece of evidence 4

- None of the available products is widely diffused to the market.
- Multiple products are smaller than 1.5 meters and are too small to carry all instruments wanted by the customer.
- None of the available competitive vessels has the right size regarding the customer requirements, none of the small USVs could handle a multi-beam sensor that is somethimes required. Others are to big to transport by car and trailer. Meaning that there is a gap in the market for USVs that are big enough to carry all instruments needed by the customers and small enough to transport by car and trailer.
- Few competitors are focused on the Dutch market. Therefore, a potential niche market for USVs is inland water surfaces in the Netherlands.

3.3.5. Piece of evidence 5: Unstructured interview with manager

A short conversation started in response to the document about the competitive environment. The questions were raised: "Which functionalities were appreciated by the market of the already launched products?" The following summarizes the answer:

"The launched products are not widely diffused to the market. Some market companies are using one or another product, but do not match their actual needs. The small boats are unable to carry enough weight and are still too heavy to handle by one person. Therefore, the idea is to focus on the inland water market and to come up with an autonomous boat. If the company succeeds in developing a product for the inland water market in the Netherlands in the project, this can be used as validation to expand to other markets."

Reduced results of piece of evidence 5

- A potential niche market for the USV is: the inland water surface market of the Netherlands for USVs that can carry enough instruments and can be transported by car and trailer.

3.3.6. Piece of evidence 6: Semi-structured interview with manager

This semi-structured interview has been held at the office of the company. The goal was to create an understanding of the current approach for the company its transition from project to product platform.

Summary of the gathered information

The interview started with the introduction of the goal and the findings until now. The first question of the interview was: "Why do you want to transition from project to product?" The interviewee answered that project development is paid by hours, and scalable products are paid by items sold. Which was assisted by the following quote:

"A higher profit can be achieved because selling products can have a better margin than getting paid per hour. Therefore, scaling is commercially interesting for our company."

The second question was: "How can the upcoming process of transitioning from project to product be described?" It triggered a description of how the transition process from project to product platform was linked to the current phases of the project. A figure of his description helps to capture the knowledge that can be used as input for a framework design. Therefore, figure 3.3 visualizes the description of his current ideas of the transiition, which was described by the interviewee as:

"There are three phases in the project. The first phase is about the development of an MVP for the customer. Phase 2 adds features and functionalities that are required by the customer, and phase three is not yet defined. The goal of the transition is to develop a scalable product in parallel, and somewhere there can be a process in which the company starts this parallel phase. How should we organize this transition process?"
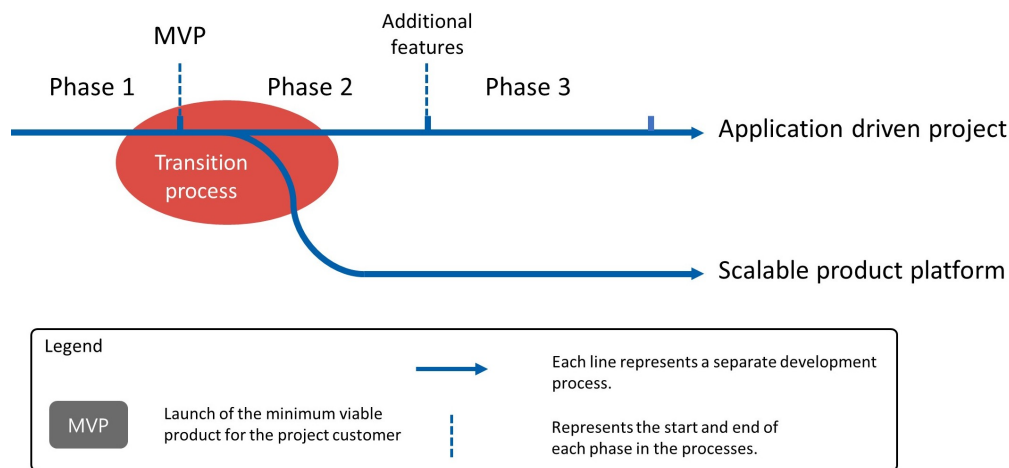
Figure 3.3: Digital sketch of the transition from project to product platform according to the company.

The following question was: "How does the company identify market needs?" The manager answered this question while drawing the relationship between these parties, Fig. 3.4 shows a digital version of the drawing. The citation below describes this figure.
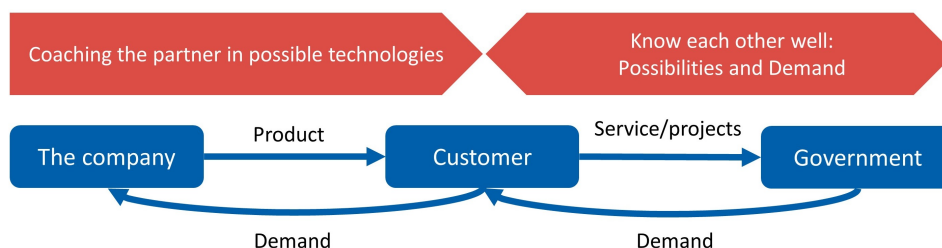
Figure 3.4: Relationships between the company, the customer and the customer its main contractor

"We see the customer project as market demand. The company takes the factors of standardization and flexibility of the design into account to keep 'scalability' possible. The market needs depend on the relationship

between the customer and the government, and the product that the company delivers will be used to service the responsibility of the government to maintain the waterways. In the Netherlands, this is done by the organization called 'Rijkswaterstaat'."

The next question was: "What could be the size of the first market segment?" This question was hard to answer for the interviewee. It became clear that the specific market segment was not yet defined. The question resulted in the opinion of the manager about customization within a market segment.

"In business to business markets products are often customized. We see a scalable product platform as products that are for 80% standardized. The last 20% could be customized in coöperation with the customer. Key will be to capitalize on essential technologies in the 80% to stay ahead of the competition."

The last question was: "Who are the decision-makers within the company?" The interviewee answered this by the help of a sketch of the organizational structure. Figure 3.5 shows the digital version of the sketch. The main decisions for functionalities are made by the manager and lead engineer in consultation with the customer. The pool of engineers thinks along and decides with the realization of the functionalities.
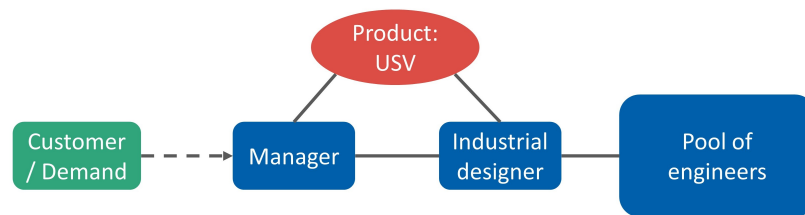
Figure 3.5: Organizational chart visualized by the company

The manager concluded that the company's main challenge is to determine the right set of functionalities for the product platform for a successful market diffusion. For example, the manager stated:

"How should we organize this transition and what would be included in the product platform?"

Reduced results of piece of evidence 6

- The company aims to transition from project to product platform because instead of getting paid per hour can getting paid per items sold result in a higher turnover.
- According to the manager, a product platform consists of 80% of the functionalities of the end product, due to the required customizations in business-to-business markets.
- The company's main challenge is to determine the right set of functionalities for the product platform for a successful market diffusion.

3.4. Chapter conclusion

The case study research *discovered* and *defined* the empirical problem. The analysis of the case study research contributes to this research in two ways. First, it contributes by exploring the difficulties the company is experiencing. Secondly, it contributes to the applicability of this research to practice. The framework should be in line with the problems as experienced in practice, which is enabled by the in-depth research of a single case study. The next paragraph continues with *discovering* knowledge by the literature study.

Furthermore, this paragraph lists conclusions that can be used as input for the design of framework 1.0 and framework 2.0 in chapters 5 and 7. Appendix I contains several discussion points of the case study research.

- The company aims to transition from project to product platform because instead of getting paid per hour can, a profit margin per sold product can result in a higher profit (See reduced results in subsection 3.3.6).
- A potential niche market to focus on is the inland water market of the Netherlands. For this market should USVs be able to carry enough instruments, and be small enough to transport by car and trailer (See reduced results in subsection 3.3.4 and 3.3.5).
- The company's main challenge is to determine the right set of functionalities for the product platform for a successful market diffusion (See reduced results in subsection 3.3.3 and 3.3.6).

4

Theoretical framework

4.1. Introduction

The theoretical framework aims to *discover* and *define* the required literature to design framework 1.0 and 2.0. as described in chapter 2. This introduction describes the scope, the choice for multi-level research and the structure of the theoretical framework.

4.1.1. Scope

The subject of this research is complex because there are multiple levels. Various research fields might contain relevant knowledge for this study. Chapter 1 introduces the research field of technology-push (TP) and demand-pull (DP) mechanisms. The perspective of the research field of TP and DP mechanisms is chosen because it matches characterizations and the problem described in the case study research in chapter 4.2. The choice for TP and DP will be explained in chapter 4.2.1. The research field of TP and DP is captured by describing the five factors mentioned by Di Stefano et al. (2012). Two of the five factors are researched more extensively (see subsection 4.2.7). This scope helps to answer the research question within the time limit of this research and to capture all knowledge required. Different perspectives, to be defined as levels, are chosen to grasp the complexity of the problem.

4.1.2. Multi-level research

Multi-level research is required to capture the complexity of this research. The company of the case study (referred to as 'the company' in this chapter) experiences difficulties in their decision-making process. However, higher levels are related to this decision-making process. For example, if a company seems to be doing well at its decision-making process on a micro level. It may be that, at a macro-level, the market is not yet ready for technology diffusion. Furthermore, figure 1.1 visualized that a company could consider both a company perspective and a market perspective on the selection of functionalities for the product platform in its decision-making process. Three levels of literature research are required to capture the complexity of this research with the help of factors described by Di Stefano et al. (2012). The macro-level contains the market perspective on new technology adoption and diffusion. The meso level contains the company perspective on new technology adoption and diffusion. At last, the micro-level contains organizational competences and the decision-making processes of companies regarding the transition from project to product platform. Figure 4.1 visualizes the three levels of literature research for this research.

Concluding, all levels are required for a successful decision-making process of the functionalities for the product platform. Therefore, this research researches all these levels. This distinction determines the structure of the theoretical framework, figure 4.2 shows this structure.
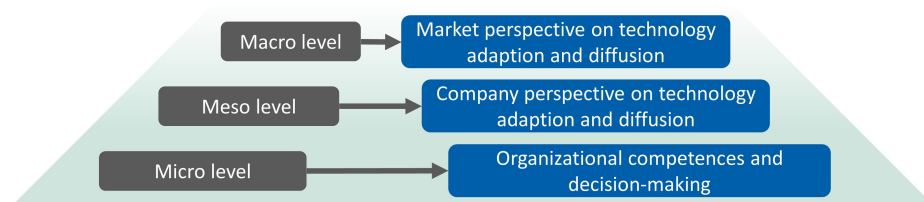
Figure 4.1: This figure visualizes the three levels of literature used for this research.

4.1.3. Structure

Figure 4.2 shows the structure of the theoretical framework. It shows that there is a distinction between context and applicable knowledge. Each subsection describes the search and/or selection before the subsection describes the literature. For each part shown in the figure, symbols indicate to which section it belongs. First of all, section 4.2 describes the context for the research. This results in the description of the TP and DP mechanisms research field with the help of Di Stefano et al. (2012). The five factors are each explained and supplemented with literature that helps describe the application of Di Stefano et al. (2012) his factors to this study. Next, this research uses two of these factors; 'technology adaptation and diffusion' and 'organizational competences' for more extensive research. Section 4.3 describes the macro level literature, including the market perspective on the factor technology diffusion and adoption. Section 4.4 describes technology diffusion and adoption from a company perspective, which is the meso level of the theoretical framework. Finally, Section 4.5 describes literature at the micro-level, which includes the description of organizational competences and the decision-making process.
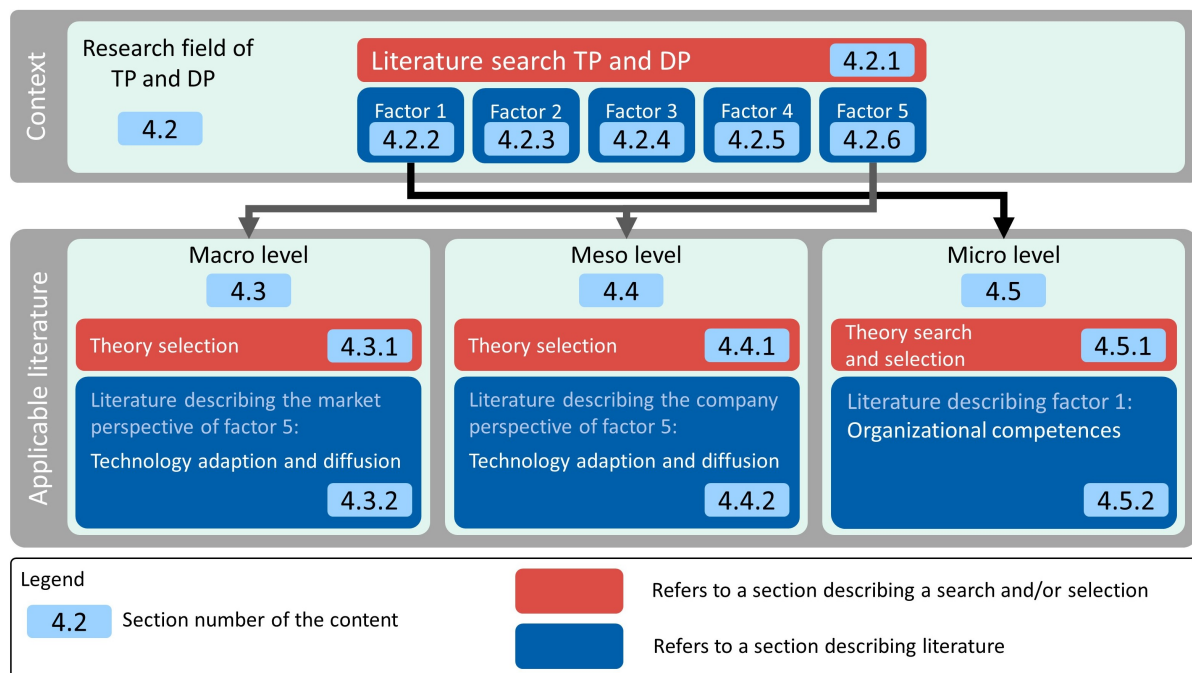
Figure 4.2: Structure of the theoretical framework. There is a distinction between context and applicable literature for this research. Two of the five factors described in the context include applicable literature. The theoretical framework contains the context of TP and DP mechanisms and three levels describing the applicable literature for this study. These levels are the macro, meso, and micro level. Symbols indicate the section that describes the content.

4.2. Research field of TP and DP

The research field of TP and DP describes five factors found in the search process that subsection 4.2.1 describes. The five factors are the scientific context of this research (subsection 4.2.2 to 4.2.3). subsection 4.2.7 discusses why two of these factors are used for a more extensive research as visualized in Fig. 4.2.

4.2.1. Literature search of context

This subsection describes the search and selection process of the research field of TP and DP mechanisms.

The decision for the research field

A field of tension was identified in the case study research between technology-driven organizational structure and the ambition to make a product that meets the needs of a market. The company has difficulties in determining which functionalities should be chosen to be successful in the market. The technology-driven strategy corresponds to a so-called technology-push mechanism. The ambition to make a product that meets

the needs of a market corresponds to so-called demand-pull mechanisms. Therefore, the research field of TP and DP mechanisms chosen as a focus. Literature often describes that TP and DP mechanisms are seen as a bifurcation (Schmookler, 1966; Mowery and Rosenberg, 1979; Van den Ende and Dolfsma, 2005; Di Stefano et al., 2012; Choi, 2018; King et al., 1994; Lubik et al., 2013). However, literature also recommends follow-up research to deal with these mechanisms (Lubik et al., 2013; Di Stefano et al., 2012). Subsection 1.2.1 defines a TP and DP mechanism.

Starting point of the theoretical framework
As a starting point, a focused literature search using the search terms "technology push and demand-pull" was conducted in the 'Scopus' to find articles. A forward and backward reference search checked for newer or older literature reviews. Subsection 1.2.2 describes that the review paper from Di Stefano et al. (2012) is the scientific starting point of this research, which is used as scientific starting point for this research.

Five factors define the TP and DP research field
For their study, Di Stefano et al. (2012) executed a literature review of TP and DP mechanisms. Di Stefano et al. (2012) identifies five factors describing the research field of TP and DP mechanisms. The list below shows the five factors.

List of factors capturing research field of TP and DP mechanisms (Di Stefano et al., 2012)

Factor 1: Organizational competences
Factor 2: Marketing practises
Factor 3: Demand and User innovation
Factor 4: Systems of Innovation
Factor 5: Technology Diffusion and Adoption

The search process to capture all required knowledge of the TP and DP research field
The five factors are subsequently used in the search process to find literature for each factor. 'Scopus' is used for the searches. Appendix C lists the search terms and table 4.1 shows the search process by showing the factors, the search terms and the literature finds. Selected articles contain knowledge about a factor described by Di Stefano et al. (2012), as well as about functionalities, respectively technology, and have a relation to TP and DP mechanisms. A forward and backward reference search checked for newer and older literature reviews.

#	Factor	Search process / succesfull search terms	Literature found or used
1	Organizational competences	Scopus: Technology-push AND Market-pull AND firms	(Lubik et al., 2013)
2	Marketing practices	References used from (Di Stefano et al., 2012)	(Hauser et al., 2006)
3	Demand and user innovation	"Literature review" AND Technology AND commercialization	(Kirchberger and Pohl, 2016)
4	Systems of innovation	References used from (Di Stefano et al., 2012)	(Geels, 2004; Bruner II and Kumar, 2005; Malerba, 2002; Garud and Karnøe, 2003)
5	Technology diffusion and adoption	"Literature review" AND Technology AND commercialization, "Pattern of development" AND technology,	(Kirchberger and Pohl, 2016), (Ortt et al., 2013)

Table 4.1: Search process of capturing all research fronts of the TP and DP research field

4.2.2. Factor 1: Organizational competences
Research from Lubik et al. (2013) shows that start-ups are flexible and as a result, they change from DP strategies to TP strategies and vice versa, the reasons why are discussed.

New companies or companies that work with small multidisciplinary teams can be flexible in developing new technologies. After the first development stages, companies might change from pull to push strategies, because they gained experience with the technology and are willing to expand the business. A company that stays too much TP oriented can result in a mismatch between technology and demand (Lubik et al., 2013).

4.2.3. Factor 2: Marketing practices
A marketing literature review by Hauser et al. (2006) distinguishes five factors within the research field of marketing for R&D (Hauser et al., 2006). The five factors are consumer response to innovation, organizations

and innovation, market entry strategies, prescriptive techniques for product development processes, and defending against market entry and capturing the rewards of innovating (Hauser et al., 2006).

People, customers, and decision-makers tend to follow specific patterns if they experience a new product, (Desmet and Hekkert, 2007). Emotional experience, aesthetic experience, and experience of meaning are the factors that play a role in solving a concern that they have (Desmet and Hekkert, 2007). These experiences can have value in themselves and therefore, should be considered to be incorporated in the requirements of the product (Desmet and Hekkert, 2007). Next to that, Matzler and Hinterhuber (1998) adresses a methodology to asses and evaluate technical requirements. Customer satisfaction is seen as a basis by Matzler and Hinterhuber to determine which product requirements are necessary and which can add value to the product (Matzler and Hinterhuber, 1998). The paper mentions that engineers should step into the customers' shoes to determine the right product requirements (Matzler and Hinterhuber, 1998).

4.2.4. Factor 3: Demand and user innovation

One of the conclusions from a literature review by Kirchberger and Pohl (2016) is that market orientation is essential to incorporate the product requirements meeting the needs of customers (Kirchberger and Pohl, 2016). They recommend further research to how this can successfully be done. Kirchberger and Pohl (2016) say about this: "An early understanding of what truly delivers value could be a powerful argument for commercializing the technology" (Kirchberger and Pohl, 2016). User-oriented design can stimulate that both the application of the technology as well as the needs of the market are addressed. Especially for heavily R&D-driven firms with often used TP processes, this can be helpful (Veryzer and Mozota, 2005).

4.2.5. Factor 4: System of innovation

Theories which include knowledge about 'system of innovation' describe another way of looking at innovation (Geels, 2004; Bruner II and Kumar, 2005; Malerba, 2002; Garud and Karnøe, 2003; Di Stefano et al., 2012; Kemp et al., 1998). Multiple systems of innovation can be distinguished, but literature from Di Stefano et al. (2012) distinguishes two subgroups. There is a distinction between theories describing a system of innovation that view innovations from a science perspective and systems of innovation that view innovations from a customer's perspective (Di Stefano et al., 2012). Literature describing systems of innovations with a focus to science discusses "the presence and nature of sectoral systems of innovation" (Di Stefano et al., 2012, p. 1287) and literature centring the role of customers discuss the different actors and technologies supporting the process of customers understanding and acceptance (Di Stefano et al., 2012, p.1288).

An example of a science perspective is literature from Kemp et al. (1998) that describes a system of innovation, including technological regimes (Kemp et al., 1998). An example of an of research that focusses on customer acceptance is the innovation system described by Bruner II and Kumar (2005). "The model posits that usefulness and ease of use of a system influence a person's intentions to use the system or product" (Bruner II and Kumar, 2005, p. 553). By taking the customers perspective into account, a company understands the essential value that is necessary to make the product or service relevant (Bruner II and Kumar, 2005).

4.2.6. Factor 5: Technology diffusion and adoption

There are several theories (Moore, 2014; Ortt et al., 2013; Rogers, 1962) that describe patterns during the introduction of technology. In contradiction of S-curve shapes as described by Rogers (1962), Ortt and Schoormans (2004) also describe the more erratic pattern during the introduction of these technologies. The erratic pattern is caused by barriers, which a company could overcome by the use of niche strategies (Ortt et al., 2013).

A recent literature review of technology commercialization by Kirchberger and Pohl (2016) describes the importance of market segmentation. "The degree to which a firm can successfully commercialize technological innovations is dependent on the link of the company's strategy and both its ability to select a suitable target market and the level of market orientation" (Kirchberger and Pohl, 2016, p.1096). How this can be done is described by Moore (2014). Moore (2014) describes how a company could position itself and let a new technology diffuse to the market. First, a new product might be adopted by the groups 'innovators' and 'early adopters.' After this, the 'chasm' needs to be crossed. The early majority could adopt the product, and by that, the new technology diffuses (Moore, 2014). A necessary step, according to Moore (2014), is accurate customer segmentation. In this way, a firm can position itself such that it can control both demand and technology.
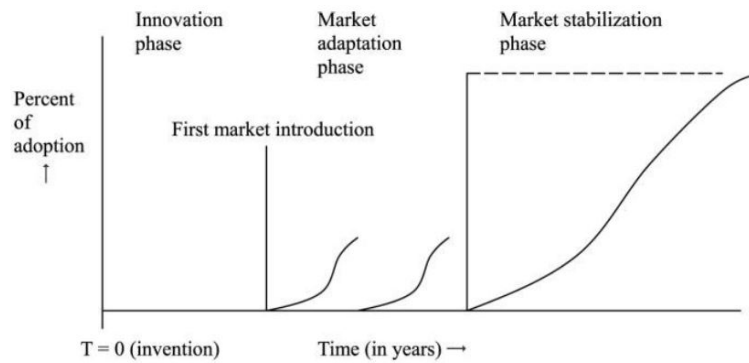
Figure 4.3: Three phases in the diffusion process (Ortt and Schoormans, 2004)

4.2.7. Selection of two factors

In the second phase of this literature study, a more extensive literature search on both the factors 'organizational competences' and 'technology adoption and diffusion' was conducted, as shown by Fig. 4.2. The company of the case study has difficulties with the decision-making of the selection of functionalities in the transition from project to product platform. Literature describing factor 2 'organizational competences' can best be used to describe how a company can organize their decision-making. However, the company decides about functionalities that enable the technology to diffuse to the market. Therefore, it is first required to understand how technology could diffuse to the market. Factor 5 'technology adoption and diffusion' could describe this from both a market and a company perspective. This research describes both factors by the use of three levels. The macro level contains a market perspective on new technology adoption and diffusion. The meso level contains the company perspective on new technology adoption and diffusion. At last, the micro-level contains organizational competences and the decision-making processes of companies regarding the transition from project to product platform. Figure 4.1 visualizes these levels.

4.2.8. Conclusion

The description of the five factors found by Di Stefano et al. (2012) is the context for this research. The continuation of the theoretical framework focusses on two factors that are required to answer the research questions.

4.3. Macro level literature

According to the structure visualized in Fig. 4.2, this section describes the literature on the macro level. This literature describes the market perspective on the factor 'technology adoption and diffusion'.

4.3.1. Macro level theory selection

This research needs theories that describe technology diffusion from the perspective of technology development. The pattern of technology development of the USV could be analyzed. Also, the current niche strategy the company is performing is a lead user niche strategy. Ortt et al. (2013) describes this niche strategy, which refers to the visualization of the technology development pattern described by Ortt and Schoormans (2004). Therefore, this research selects the market perspective about technology diffusion and adoption described by Ortt and Schoormans (2004) and Ortt et al. (2013) to describe the macro level for this research.

4.3.2. Theory description

This section describes the selected macro-level theory for this research.

Different phases in the diffusion process

Figure 4.3 shows three phases in a technology diffusion process, which are: "innovation phase, market adaptation phase and market stabilization phase" (Ortt and Schoormans, 2004). The next three paragraphs describe the different phases.

Innovation phase
The innovation phase period can be defined as: "The period from the invention of technology up to the first market introduction of a product incorporating the technology" (Ortt and Schoormans, 2004, p. 296). Ortt and Schoormans (2004) describes that it is important to find a good position for research funds in this phase because there is not yet a breakthrough technology introduced.

Market adaptation phase
"The market adaptation phase begins after the first market introduction of a product based on the break-through technology and ends when the diffusion of this product takes off" (Ortt and Schoormans, 2004, p. 296). This phase is about establishing new standards and dominant market adoptions. First introductions will occur but at a small scale. The different small S-curves as shown in Fig. 4.3 represent iterations towards a technology standard. Multiple companies can try to win a technology battle in this phase (den Hartigh et al., 2011).

Market stabilization phase
The market stabilization phase is the last. "The market stabilization phase begins when the diffusion of a product based on the breakthrough communication technology takes off and ends when the technology is substituted" (Ortt and Schoormans, 2004, p. 298). The period of this phase can be very long. For example, for televisions, this period is still not ended (Ortt and Schoormans, 2004).

The characteristics of the three phases
In Fig. 4.4 characteristics of the different phases can be found. On the horizontal axis, the different phases described and on the vertical the characteristics, belonging to the categories described on the left, can be found. This table can identify what phase a new product development process is in.

Characteristics	Innovation phase	Market adaptation phase	Market stabilization phase (the S-shaped pattern)
Begin and end of the phase	From invention of a technology up to the first market introduction of a product incorporating the technology	Begins after the first market introduction of a product on the basis of the breakthrough technology and ends when the diffusion of this product takes off	Begins when the diffusion of a product on the basis of the breakthrough communication technology takes off and ends when the technology is substituted
Length of the phase	Length can vary considerably (one to 30 years), but on average comprises seven to ten years	Length can vary considerably, but mostly comprises a decade or more	Length coincides with the life cycle of a product category
Market actors and factors in the phase	Individual inventors and entrepreneurs, R&D institutes, universities, and governments (in the role of provider of research funds)	Potential competitors working on the same type of product-technology. Innovative consumers and lead users. Market actors with products and services that are complementary to the technology. Government in the role of lead user or regulator	Early adopters up to the late majority of consumers, competitors of the same product or service, suppliers and organizations providing complementary products, and services
Market mechanisms	Supply and demand for research funds and excellent researchers	Substitution of alternative product technologies Chicken-and-egg problem Critical mass effects Finding the best product-market combinations on the basis of the technology Establish or reinforce standards Supply and demand for complementary products and services	Product life cycle mechanisms Gradual substitution by new product technologies

Figure 4.4: Differences between the three subsequent phases in the process of development and diffusion of breakthrough communication technologies (Ortt and Schoormans, 2004)

Niche strategies
Literature from Ortt et al. (2013) elaborates on the diffusion process as shown in Fig. 4.3. It describes that niches can be used as a strategy during the market adaptation phase. Research identified ten niche strategies from historical technology introductions. It suggests that in 80% of new high tech products, niche applications emerge before large scale applications (Ortt et al., 2013). Each niche strategy suits a specific market situation (Ortt et al., 2013). Understanding the pattern of diffusion, the market situation, the influencing fac-

tors and the possible niche strategies can help managers to make better-underpinned decisions. This starts with understanding which niche strategies can be distinguished and what influences the choice for certain niche strategies. The next paragraph describes the factors and their relation, how the hampering of factors results in certain market situations, and how niche strategies can help to diffuse technology.

Factors determining a market situation
Figure 4.5 shows factors determining a market situation. Six factors on the left influence the six core factors in the middle. The core factors result in a market situation, which needs a particular niche strategy (Ortt et al., 2013). "The influencing factors on the left, also called contextual factors, explain why problems in the core system may emerge" (Ortt et al., 2013). "The core factors represent the core technology and market system that is required for large-scale diffusion" (Ortt et al., 2013). For example, a company lacking knowledge of technology is unable to develop a new high-tech product that will be successful, and therefore, a particular niche strategy could be chosen. In this case, it can be a 're-design niche strategy'. To identify what hampering factor can be the problem, they are described in the next paragraph (Ortt et al., 2013).
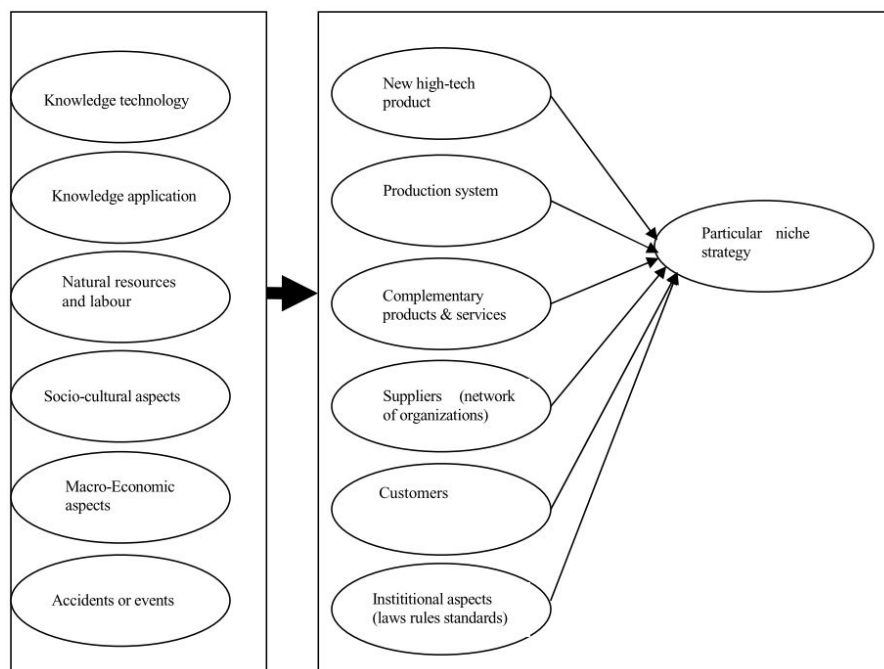
Figure 4.5: Factors important for the development and large-scale diffusion of new high-tech products (Ortt et al., 2013).

Twelve factors important for new technology diffusion
It is important for companies to understand the factors that define a market situation because the decision-making in the commercialization process of new technology depends on these factors. The twelve factors, as shown in Fig. 4.5 are explained by Ortt et al. (2013) as described in Table 4.2. In the left column, the name of the factor is presented, and on the right, the description can be found. Like in Fig. 4.5 is visualized, a distinction of core factors and influencing factors is indicated in the table.

This research looks to a market situation from both the perspective the company and the market. That is why the application of technology could also be called knowledge of customers for this research. Knowledge of customers refers to the knowledge required to understand customer their actual needs, and be able to devide the market into segments. This research is not about the application of technology, but more about which market and which customers do have a need for the technology. Meaning, the model might be adapted by the inclusion of a factor called knowledge of customers, which is a company factor and influencing factor.

Market situations and 10 niche strategies
The factors as described before in Table 4.2 and their relationship as seen in Fig. 4.5 determine a certain market situation. Combinations of factors that lead to market situations are linked to niche strategies that can help the technology diffuse by Ortt et al. (2013). The ten niche strategies can be found in Table 4.3. Each niche

Core factor	Description
New high-tech product	The product can be defined and distinguished using three elements: the functionality provided by the product, the technological principle(s) used and the main components in the system (first tier of subsystems). The unavailability of (one or more components of) the product means that large-scale diffusion is not (yet) possible. The product needs to have a good price/quality compared to competitive products in the perception of customers before large-scale diffusion is possible.
Production system	Availability of a good production system is required for large-scale diffusion. In some cases, a product can be created in small numbers as a kind of craftsmanship, but industrial production technologies are not yet available. In that case, large-scale diffusion is not possible.
Complementary products and services	Complementary products and services refer to products and services required for the production, distribution, adoption and use. The product, together with complementary products and services forms a socio-technological system. The unavailability of elements in that system means that large-scale diffusion is not (yet) possible.
Suppliers (a network of organizations)	The producers and suppliers refer to the actors involved in the supply of the product. Sometimes multiple types of actors are required to supply the entire system. In that case, a kind of coordination (network) is required. Sometimes actors with considerable resources are required, for example, to provide an infrastructure. If one or more vital roles, resources or types of coordination are not present in the socio-technological system, large-scale diffusion is blocked.
Customers	The availability of customers means that a market application for the product is identified, that customer segments for these applications exist and that the customers are knowledgeable about the product and its use and are willing and able to pay for an adoption. If applications are unknown or if customer groups do not exist, are not able to obtain the product or are unaware of the benefits of the product, large-scale diffusion is blocked.
Institutional aspects (laws, rules and standards)	The regulatory and institutional environment refers to the laws and regulations that indicate how actors (on the supply and demand side of the market) deal with the socio-technological system. These laws and regulations can either stimulate the application of radically new high-tech products (such as subsidy that stimulates the use of sustainable energy) or completely block it (such as laws prohibiting something).
Influencing factor	Description
Knowledge of technology	The knowledge of the technology refers to the knowledge required to develop, produce, replicate and control the technological principles in a product. In many cases, a lack of knowledge blocks large-scale diffusion.
Natural resources and labour	Natural resources and labour are required to produce and use a new high-tech product. These resources and labour can be required for the production system, for complementary products and services or for the product itself. In many cases, a lack of resources and labour block large-scale diffusion.
Knowledge of application	Knowledge of the application can refer to knowing potential applications. If a technological principle is demonstrated, but there is no clue about its practical application, large-scale diffusion is impossible. A lack of knowledge of the application can also refer to customers that do not know how to use a new product in a particular application. In that case, large-scale diffusion is not possible.
Socio-cultural aspects	Socio-cultural aspects refer to the norms and values in a particular culture. These aspects might be less formalized than the laws and rules in the institutional aspects, but their effect might completely block large-scale diffusion.
Macro-Economic aspects	Macro-Economic aspects refer to the economic situation. A recession can stifle the diffusion of a new high-tech product.
Accidents or events	Accidents or events such as wars, accidents in production, accidents in the use of products can have a devastating effect on the diffusion of a new high-tech product.

Table 4.2: Actors, factors and functions necessary for large-scale diffusion (Ortt et al., 2013).

strategy (left column) is most suitable in specific market situations of the technology (middle column). The most right colomn describes what the niche strategy exactly implies. These niche strategies are relevant for companies to understand, because being in a market situation and knowing the strategies of which can be effective to choose the right strategy.

In all market situations mentioned in Table 4.3 the situation starts with *knowledge of the technology* or *knowledge of the application* is lacking. This could mean that only the factors of which the company has a direct influence on and are of input of the other six factors (as is shown in Fig. J.1) define which niche strategy is required.

#	Niche strategy	Market situation in which they can be adapted to introduce a high-tech product or system	Description of the niche strategy
1	Demo, experiment and develop niche strategy	Knowledge of the technology is lacking, and that affects the availability of the product itself because the functionality is not provided with sufficient quality.	A niche strategy can be adapted to demonstrate the product in public in a controlled way, so the limited quality of performance is not a problem. As part of the strategy experimenting with the product, it is important to develop the product further, for example, in a research environment.
2	Top niche strategy	Knowledge of the technology is lacking, and that affects the availability of the product for a reasonable price. Knowledge of the technology is lacking, and that affects the production system with which controlled production of products with a consistent and good enough quality and reasonable price is possible. Resources for the product or the production are lacking or very expensive, and that affects the product's price.	A niche strategy can be adopted where hand-made products can be made to order, in small numbers, for a specific top-end niche of the market. A skimming strategy can be adopted in which the top niche of customers is supplied first with a special product.
3	Subsidized niche strategy	Knowledge of the technology is lacking, and that affects the availability of the product or the production system and that in turn affects the availability of the product for a reasonable price. Resources for the product or production are lacking or very expensive, and that affects the product's price.	A niche strategy can be adopted where the product is subsidized if the use of the product by a particular segment of users is considered as societally relevant or important.
4	Redesign niche strategy	Knowledge of the technology is lacking, and that affects the availability of the product or the production system and that in turn affects the availability of the product for a reasonable price. Resources for the product or production are lacking or very expensive, and that affects the product's price. Knowledge of the application of the product is missing or socio-cultural aspects affect the availability of appropriate institutional aspects (laws, rules and standards) and thereby hamper diffusion. Socio-cultural aspects affect the availability of suppliers or customers.	A niche strategy can be adopted where the product is introduced in a simpler version that can be produced with the existing knowledge, less use of resources and therefore for a lower price A niche strategy can be to explore an application where institutional aspects are more favourable. Mostly leads to redesign. A niche strategy can be to explore an application where suppliers or customers have no resistance to produce and use it. Mostly leads to redesign.
5	Dedicated system or standalone niche strategy	Knowledge of the technology is lacking, and that affects the availability of complementary products and services.	A niche strategy can be adopted where the product is used in stand-alone mode, or a dedicated system of complementary products and services is designed (e.g., a local network when infrastructure is not available on a wider scale).
6	Hybridization or adaptor niche strategy	Knowledge of the technology is lacking, and that affects the availability of complementary products and services. Resources are lacking, and that affects the availability of complementary products and services.	A Niche strategy can be adopted by which the new product is used in combination with the old product and thereby all existing complementary products and services can be re-used. Or an adaptor/converter is provided to make the product compatible with existing complementary products and services.
7	Educate niche strategy	Knowledge of the technology is lacking, and that affects the availability of suppliers or customers.	A niche strategy can be adopted aimed at transferring the knowledge to suppliers. An educate and experiment (pilot) niche strategy can be adopted aimed at increasing customer knowledge.
8	Geographic niche strategy	Knowledge of the technology or its application is lacking, and that affects the availability of appropriate institutional aspects (laws, rules and standards) Resources are lacking affecting the availability of the product or complementary products and services. Socio-cultural aspects of macroeconomic aspects affect the availability of suppliers, customers and appropriate institutional aspects. Accidents and unexpected events affect the availability of appropriate institutional aspects.	A niche strategy can be adopted where institutions (laws and rules) are relatively easy to arrange or are less strict. A niche strategy can be adopted in another geographic area where resources, suppliers or customers are available. A niche strategy can be adopted in another geographic area where suppliers are available and not hampered by these unexpected events or accidents.
9	Lead user niche strategy	Knowledge of the application of the product is missing, and that affects a clear view on customer applications, specific product requirements and customer segments by suppliers. Socio-cultural aspects, Macro-Economic aspects or accidents and unexpected events affect the availability of suppliers or customers.	A niche strategy can be adapted to finding innovators or lead users. These lead users can co-develop the product and innovators are willing to experiment with the product.
10	Explore multiple markets niche strategy	Knowledge of the application of the product is missing, and that affects the availability of a clear view on applications, usage patterns and product benefits by customers.	A niche strategy can be adopted in which multiple customer applications can be explored. Visibility of the first applications might stimulate explorative use in new applications.

Table 4.3: Adjusted version of "Ten different niche strategies" (Ortt et al., 2013).

4.3.3. Reduced results from macro literature

This section summarizes the macro literature to reduced results, derived from literature of Ortt and Schoormans (2004) and Ortt et al. (2013).

- A transition process from project to product platform takes place during the market adaptation phase. 'Establish or reinforce standards' and 'finding the best product-market combinations based on the

technology' indicate that the transition process takes place in the market adaptation phase (Ortt and Schoormans, 2004).

- A company could use the market adaptation phase to prepare the technology for the market stabilization phase (Ortt and Schoormans, 2004).
- Large scale technology diffusion is hampered by twelve factors (Ortt et al., 2013).
- Previous research to historical technology diffusions shows a distinction of ten niche strategies. These guide companies to find a suitable niche strategy for companies for the development of a high-tech product or system in comparable market situations Ortt et al. (2013).
- All market situations that could be resolved with a niche strategy are characterized by a lack of knowledge of technology or application (Ortt et al., 2013).

4.4. Meso level literature

According to the structure visualized in Fig. 4.2, this section describes the meso level literature. This literature represents the company perspective of the factor 'technology adoption and diffusion'. Theory from Moore (2014) describes what is essential from a company perspective for a successful market introduction of new technology, which differs from the market perspective that describes the diffusion pattern from a technology and market perspective (see subsection 4.3).

4.4.1. Meso level theory selection

During the search process of factor 5, technology diffusion and adoption, literature from Moore (2014) was found that can be used to describe the company perspective. The theory of Moore (2014) includes knowledge about what a company should do to diffuse technology into the market successfully. This level of looking to the problem is called the meso level. The goal is to describe what a company should consider to let a technology diffuse into the market, according to Moore (2014).

4.4.2. Theory description

This subsection describes the selected theory for the meso level.

Crossing the chasm

Crossing the chasm is defined by Moore (2014) as a process in new product development. The following definition of crossing the chasm is given by the book of Moore (2014): "The point of greatest peril in the development of a high-tech market lies in making the transition from an early market dominated by a few visionary customers to a mainstream market dominated by a large block of customers who predominantly pragmatists in orientation" (Moore, 2014, p. 6). Crossing this chasm can occur if a value proposition is delivered to a targetable set of customers at a reasonable price if this happens, a new market segment is defined according to Moore (2014).

The crack in the graph presented in Fig. 4.6 indicates the chasm that must be crossed (Moore, 2014). Which means to transition from an early market to a mainstream market. During the early adaptation, a company could prepare for the next phase according to Moore (2014).

The revised technology adoption life cycle

As can be seen in Fig. 4.6, the adoption process is described by the category of customers that are served. "*Innovators* pursue new technology products aggressively" (Moore, 2014, p. 15). *Early adopter* are identifying the benefits of new technology and are relating this to potential problems that can be solved with it; they rely on their intuition and vision (Moore, 2014). In contradiction, the *early majority* are pragmatists who think practical and they are want to first to get trusted references from early adopters before they invest their money in a technological solution (Moore, 2014, p. 16). Then the *late majority* buys the new product "after it became an established standard" (Moore, 2014, p. 16), not investing in the technology is no longer an option for them. Finally, the *laggards* do not want to buy the technology at all. However, sometimes they accidentally do because "it is hidden in another investment they make" (Moore, 2014, p. 17). The next three paragraphs describe the relevant type of customers relevant for this research as described by Moore (2014).

Innovators: technology enthousiasts

"Innovators are the customers who first appreciate the architecture of a product and why it, therefore, has a competitive advantage over the current crop of products established in the marketplace" (Moore, 2014, p.
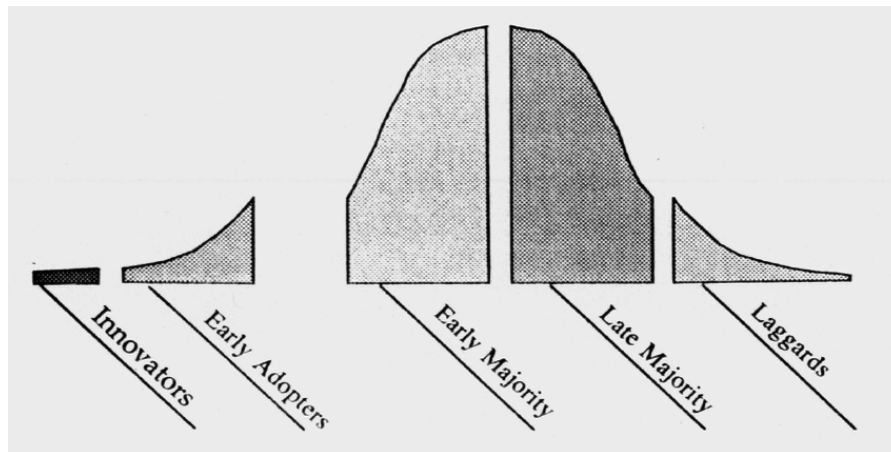
Figure 4.6: The revised technology adoption life cycle (Moore, 2014)

38). Therefore innovators are willing to co-develop your product from if the suggested potential of technology has a potential competitive advantage. Innovators can be seen as enthusiasts that help to develop a product. Access to the secret of technology should be shared, the share of these results in the feedback of which the initial company can start to improve and implement their feedback (Moore, 2014).

Early adopters: the visionaries
"Visionaries are that rare breed of people who have the insight to match up an emerging technology to a strategic opportunity, the temperament to translate that insight into a high-visibility, high-risk project, and the charisma to get the rest of their organization to buy into that project" (Moore, 2014, p. 42). Which means that the difference of innovators lays in focus on the value from a strategic perspective rather than a technology perspective. Early adopters are the least price-sensitive. They have budgets that let them put a large amount towards their strategic goals during technological development projects. "Visionaries like a project orientation. They want to start with a pilot project." (Moore, 2014, p. 45). Often, more project work follows, conducted in phases. More project work can lead to product spin-offs if a right window of opportunity takes place. According to Moore (2014), companies could use a top-level direct sales force and manage the expectations of the client.

Early majority: pragmatists
The early majority is crucial to understand because the bulk of the money in the market place comes from them; it is necessary to understand how to win their trust. According to Moore (2014), pragmatist tend to buy products from a company they care about, next to that they expect quality, supporting products and reliability of the service they get. They want a whole product for a good price for a compelling reason to buy (Moore, 2014). For gaining this trust, it is important to build references and relationships, which are also important for these people themselves (Moore, 2014). Pragmatists are hard to reach because they tend to be oriented on their industry (Moore, 2014). Whenever a pragmatist is reached, and the trust is growing, they tend to be loyal (Moore, 2014).

A market versus market segment
Defining a market segment is important, according to Moore (2014). Therefore the definitions are described, later in this chapter, the definition will be used in to describe what a company should do according to Moore (2014) to cross the chasm. A market can be defined as: "A set of actual or potential customers for a given set of products or services, who have a common set of needs or wants and who reference each other when making a buying decision" (Moore, 2014, p. 35). The referencing can be seen as important because if both customers would not communicate with each other, it can be seen as two different markets. For example, a football sold to a guy in Africa and another football sold to women in The Netherlands can be seen as different markets. According to the vocabulary Moore (2014) uses, a market segment is the same as a market. In this rapport, the definition above will be used for 'market segment'. If referred to the market, there is, for example, meant that the market for footballs reaches as well as Africa and The Netherlands.

Market segment size
To catch the eye of pragmatists of the whole market potential, reaching an installed base by 'owning' a market segment is described as an approach. Owning a market segment can be defined as having a market share of 50% or more in this segment. A company should first calculate the size of a market (Moore, 2014). For example, doubling the number of products they want to sell in a market can define the maximum size of the market segment that should be defined. Furthermore, Moore (2014) argues that diffusing the product starts with strategic target market segmentation. Which means the initial target market segmentation should be connected to adjacent segments.

In summary, a strategic target market segment can be defined as the following (Moore, 2014, p. 98):

- "Big enough to matter,
- small enough to win, and a
- good fit with your crown jewels."

Sales-driven versus market-driven
Moore (2014) makes an important remark that market-driven approach is essential to cross the chasm, instead of a sales-driven approach. As the first step in the market-driven approach, according to Moore (2014), is a company that tries to define a niche market that has needs which the company can meet. What lies behind this is the mindset to focus on the market and not only the understanding that it can be important. Often people tend to be sales focused. This can be called a sales-driven approach. However, a sales-driven approach is not the way to go because there is a high risk of mismatching the product with the needs of potential customers. For a successful chasm crossing, it is first important that a specific set of customers are satisfied in their needs to build on an 'installed base' (Moore, 2014). Trying to meet the needs of a specific set of customers is called a market-driven approach by Moore (2014).

Company unity
Crossing the chasm is difficult for a company, according to Moore (2014), a company unity is needed, and making time for careful plans and cautiously rationed resources is necessary. Pursuing a high-probability course of action should be a strategy (Moore, 2014). Crossing the chasm can be defined as a market development process in which the community of stakeholders, engineers, markets and financier should come to a common accord (Moore, 2014). From a company perspective, a company unity is needed, which means from the engineer to manager, all people working on the product have the same goal in mind (Moore, 2014). Moore (2014) uses 'company unity' to refer to the importance of a shared goal. A company must achieve this to ensure that everyone's work contributes to achieving the common goal (Moore, 2014). Moore (2014) complements to a large literature base that emphasizes the importance of sharing a goal, for example, a literature review from Salas et al. (2015) uses the knowledge base to design a framework for practical improvements. According to literature from Salas et al. (2015) the primary components of teams should include: "multiple individuals, interdependencies, and a shared goal" (Salas et al., 2015). Like Moore (2014) refers to a company unity indicated by a shared goal, Salas et al. (2015) refers to 'cooperation' indicated by a collective orientation. "Cooperation is an overarching teamwork consideration that captures the motivational drivers necessary for effective teamwork" (Salas et al., 2015), which is indicated by collective orientation (Salas et al., 2015). Therefore, 'collective orientation' complements and emphasizes the importance of company unity. Concluding, companies require company unity, which includes a shared goal and collective orientation, to drive a team accomplishing their common goal. The interview results reflect on the phenomenon company unity (see subsection 6.2) and subsection 7.2.3 uses 'company unity' for the framework design.

Four steps from idea to implementation
Moore (2014) distinghuishes four steps from idea to implementation of technology diffusion: Target the initial market segment, whole product management, defining the battle, and launching. The paragraphs below describe the steps.

Step 1: Target the initial market segment
The visionaries that have already experienced cannot be compared to pragmatists (Moore, 2014). Therefore the results of the first product cannot be extrapolated. Dividing potential customers into market segments and using informed intuition, rather than analytical reasoning is the way Moore (2014) suggests what the most reliable decision-making tool is (Moore, 2014).

Step 2: Whole product management
A whole product includes the generic product and everything around to make sure to deliver enough for customers to achieve their compelling reason to buy (Moore, 2014). Figure 4.7 shows a model that visualizes how the generic product, the product that is shipped, and everything around make can make the sale of a whole product successful (Moore, 2014). Standards and procedures, additional software, additional hardware, system integration, installation and debugging, change management, and training and support are needed to achieve a compelling reason to buy (Moore, 2014). Especially in business-to-business sales, customer relationships are far more important than the contract (Moore, 2014). Reason for this is that failure is fastly known among customers, due to the reference-oriented market in business-to-business sales (Moore, 2014).

According to Moore (2014), executing a whole product strategy has a high probability of mainstream market success, and it is vital to building tactical alliances to speed the development of the whole product infrastructure. "If you want to go fast, go alone; if you want to go far, go with others" (Moore, 2014, p. 154).

Step 3: Defining the battle
Important in launching the product is that the 'battle' is defined. "Focus the competition within the market segment established by your must-have value proposition, which is the combination of the target customer, product offering and the compelling reason to buy that establishes your primary reason for being"(Moore, 2014, p. 194).
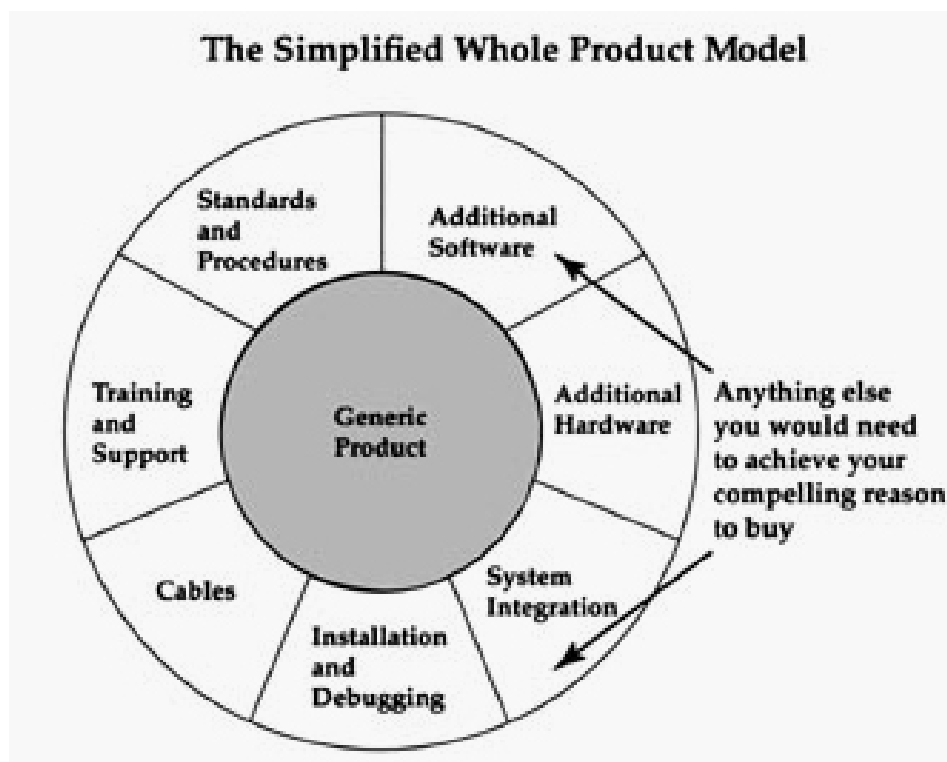
Figure 4.7: The simplified whole product model (Moore, 2014, p. 137)

Step 4: Launching
In this step, the goal is to secure access to a customer-oriented distribution channel and to put a price on the product that matches the pragmatists' customer expectations (Moore, 2014). It is important to find a way to meet the preferences of the customer their expectations regarding the distribution of the product (Moore, 2014). After the distribution channel is set, the price should be based on customer expectations and the competition. (Moore, 2014) calls these: customer-oriented pricing and competition-based pricing.

The situation right behind the chasm
The most important lesson is: "The commitments by the pre-chasm enterprise bind the post-chasm enterprise" (Moore, 2014, p. 214). Therefore, "the best is to avoid making the wrong kind of commitments during

the pre-chasm period" (Moore, 2014, p. 214). Another important point is the financing right behind crossing the chasm (Moore, 2014). A company should make sure it crossed the chasm, after which it is possible to make sure the pricing can be changed to increase revenue (Moore, 2014)s. Doing this too early, the trust of the customers falls back, and the company can be back in a chasm position (Moore, 2014).

Whole product development should not be technology-driven
"R&D is high tech, and everything else is secondary. As an industrial sector, before anything else, we are technology-driven" (Moore, 2014, p. 238). First products are created, and then markets are. However, whole product R&D differs from R&D because it is not driven by the laboratory but by the market place (Moore, 2014). It starts with creative market segmentation, instead of creative technology. "Nowadays, product life cycles truly are getting shorter" (Moore, 2014, p. 239).

New job descriptions
According to Moore (2014), two new job descriptions might be necessary to transition from pre-chasm to a post chasm market place. In the post-chasm market place, the pragmatists' customers should be served differently than the pre-chasm early adopters (Moore, 2014). One should be called a target market segment manager and the second a whole product manager (Moore, 2014). A target market manager should "transform a visionary customer relationship into a potential beachhead for entry into the mainstream vertical market that particular customer participates in" (Moore, 2014, p. 233). A whole product manager is a product-marketing-manager-to-be. In the early stages, before the chasm is crossed the whole product manager functions as a product development manager (Moore, 2014). However, the marketing effort that is necessary after the chasm should already be prepared in advance. "Like the shape of the mainstream market emerges, when the needs of this market can be increasingly identified through market research and customer interviews, then the whole product manager steps into the title that he or she has had all along on his or her business card, product marketing manager" (Moore, 2014, p. 233).

4.4.3. Reduced results from meso literature
This subsection summarizes the meso literature to reduced results, derived from literature of Moore (2014).

- Company unity is required to reach a common goal. A company unity includes a collective orientation and a shared goal (Moore, 2014; Salas et al., 2015).
- Pragmatist tend to buy products if enough trust in the product is gained and a good price can be paid for a whole reliable product in return. Pragmatists want to have alternatives so that they can better estimate how big the advantage is which matches their compelling reason to buy (Moore, 2014).
- A market is all market segments together, and a market segment can be described as a set of actual or potential customers for a given set of products or services, who have a common set of needs or wants and who reference each other when making a buying decision (Moore, 2014).
- There are four steps to cross the chasm: Target the initial market segment, whole product management, define the battle, and launching (Moore, 2014).
- The first step of entering a new market is selecting the initial target market segment (Moore, 2014).
- The second step; whole product management includes next to the generic product also: standards and procedures, additional software, additional hardware, system integration, installation and debugging, and training and support. These additionalities can also be managed with partnerships (Moore, 2014).
- The balance of demand and technology Di Stefano et al. (2012) can be linked to the product offering (technology) and the target customer with their needs (demand).
- The mindset should change from wanting to develop a 'cool product' that benefits their own company, towards a customer-need-driven mindset (Moore, 2014).

4.5. Micro level literature
According to the structure visualized in Fig. 4.2, this section describes literature for this research on the micro-level as visualized in Fig. 4.1.

4.5.1. Micro level theory search and selection
The micro level of this research should describe how a company can deal with its decision-making process during a transition from project to product platform. Literature research showed that this could not be found

in the TP and DP mechanisms research field. That is why there is also researched beyond TP and DP mechanisms. Despite an extensive search process, there was no literature found that met the requirements of literature about the transition process from project to product platform during the market adaptation phase. Literature from Lubik et al. (2013) describes the organizational competences as described by the fifth factor of Di Stefano et al. (2012). Besides, this research uses a definition of product platform derived from literature of Gawer (2014).

Furthermore, the inability to find literature is a finding in itself, it indicates the importance of research on how companies can organize a transition from project to product platform, and how companies can use this to let their technology diffuse in a market. Therefore, this subsection describes the search process. Also, this subsection describes the search process for the definition of a product platform, and the selection of theories for the micro level.

Literature search: product platform in market adaptation phase
First, a list of search terms is tried and titles were selected if they contained information about "product platform OR market-driven OR demand-driven AND strategy OR management". Literature was excluded if it did not cover the market adaptation phase. All selected literature is examined on the inclusion of knowledge about a "product platform" in the market adaptation phase. However, none of the literature that was listed met this requirement. An expert in this field of expertise validated the non-existence of relevant literature. This person could not help and suggested that this was evidence that this is a knowledge gap. Additional information about the search process can be found in appendix B. The lack of literature indicates a literature gab, which confirms the relevance of this research. However, it is strange that no literature can be found in this area. A product platform can be a common process to develop technology in the market adaptation phase. It does not mean that too little research is being done into new product development. However, this literature gap indicates that there is no literature describing how new technologies can be diffused through a product platform. This is supported by a lot of literature that points out that research is needed on the topic to balance technology and demand during new product development (Ardilio and Seidenstricker, 2013; Di Stefano et al., 2012; Lubik et al., 2013; Kirchberger and Pohl, 2016).

Literature search: definition of a product platform
A definition of a product platform is helpful for in the continuation of this research. Different types of platforms exist in literature. Therefore, there is searched to literature that distinguishes different perspectives, from which a definition can be derived. This will be done with the help of literature from Gawer (2014).

Literature selection: TP and DP mechanisms on organizational level
Literature from Lubik et al. (2013) describes "how and why firms change between TP and DP orientations" (Lubik et al., 2013, p. 23). It describes that companies could balance TP and DP mechanisms, like Di Stefano et al. (2012) also mentioned, on an organizational level. According to the findings of Lubik et al. (2013), there is a pattern of successful start-up firms that shifted from TP to a more DP orientation. This transition took place after a first product was developed, but the aim of the companies was to enter a bigger market. The entrepreneurs identified required adjustments to their process due to differences in actual versus assumed customer needs. The transition from project to product platform level as defined by the case study research shows similar characteristics. Therefore, literature from Lubik et al. (2013) is selected for this theoretical framework. The theory of Lubik et al. (2013) enables making connections between the transition from project to product platform and the transition from TP to DP orientation.

4.5.2. Theory description
This subsection describes the selected micro level theories for this research.

Defining a product platform
Gawer (2014) describes two different definitions of platforms with two distinct theoretical perspectives, which are related to either market places or modular technological architectures. "Platforms as markets play the role of facilitators of exchange between different types of consumers that could not otherwise transact with each other" (Gawer, 2014, p. 1240). Examples of these platform types are Facebook and eBay. According to Gawer (2014): "Platforms are products that meet the needs of a core group of customers, but can be modified through the addition, substitution, or removal of features" (Gawer, 2014, p. 1242).

For this research, the engineering perspective is chosen because this research is about the development

of a modular technological architecture. However, this definition is slightly reformulated for this research. 'A product platform is a technological design that meets the needs of a core group of customers and can be modified by the addition and substitution of features'.

Defining TP and DP orientation
To discuss the literature about TP and DP oriented firms, first, the definitions of both orientation will be mentioned. "TP oriented companies are set up to commercialise a specific technology, drawing product ideas from an existing or developing technology" (Lubik et al., 2013, p. 13). Opposite of that can the following be defined: "DP oriented companies develop and produce products to address expressed market needs is specified, existing market segments" (Lubik et al., 2013, p. 13).

Initial focus of start-ups
What often occurs according to Lubik et al. (2013) is that start-up companies in emerging industries are focused on technology: "Each of the TP oriented firms in our sample that began with a technology, but no clear market and corresponding value network appear to have originally focused almost entirely on developing the technology" (Lubik et al., 2013, p. 22). "The company often has limited market information and instead relies on prior experience or instinct" (Lubik et al., 2013, p. 22). People working on the project often have beliefs that there is true value in the innovations that are developed. Some experimental marketing often takes place, but the company as a whole tended to be inward-looking (Lubik et al., 2013, p. 22). The difference between start-up firms and established firms lie in the resources they have for product development. However, start-ups tend to have not enough resources in personnel and finance to find a balance in an early stage and therefore tend to focus on either a TP orientation or a DP orientation and transitions if necessary (Lubik et al., 2013, p. 23).

Balance TP and DP orientations
Companies that shift from a TP orientation to a more DP orientation tend to adopt a more market-focused orientation due to external influences (Lubik et al., 2013, p. 23). After a shift from TP orientation to a more DP orientation, a company can find a balance between TP and DP orientations. This is described by Lubik et al. (2013) as the following: "The market may also inspire the company to develop new products or applications that are supported by its existing technology. Eventually, the start-up may achieve an orientation that balances both DP" (Lubik et al., 2013, p. 22). "This initial shift toward a DP orientation often coincides with three main events" (Lubik et al., 2013, p. 22):

1. Finding a first partner (or being found), which can be the result of partners to develop new products.
2. A realization of actual versus assumed customer needs, can result in drastic changes in the product
3. A drastic change in management or management outlook, which is usually linked to impatient investors or the company beginning to run low on funds.

4.5.3. Reduced results from micro literature
This subsection summarizes the meso literature to reduced results, derived from literature of Gawer (2014) and Lubik et al. (2013).

- A product platform is a technological design that meets the needs of a specific group of customers and can be modified by the addition and substitution of features (Gawer, 2014).
- TP oriented companies are set up to commercialise a specific technology, drawing product ideas from an existing or developing technology (Lubik et al., 2013).
- DP oriented companies develop and produce products to address expressed market needs is specified, existing market segments (Lubik et al., 2013).
- Start-ups that are TP oriented should shift to a balance of TP and DP orientations (Lubik et al., 2013).
- A shift from TP to a more DP orientation is triggered by the following main events: finding a partner, realize actual versus assumed customer needs, a drastic change in management outlook (Lubik et al., 2013).

4.6. Reconsideration multi-level research

The literature study investigated the problem of this research on multiple levels. The company aims to enter a new market to let their technology diffuse by transitioning towards a product platform. Although, its perspective on the transition is different from the market perspective that focusses on how the technology itself could diffuse. Furthermore, chapter 3 revealed that the company identifies the biggest challenge in selecting the right functionalities for the product platform. Therefore, three levels of literature research were defined to capture all required knowledge for this research. The macro level described the diffusion pattern from a market perspective with the use of theory from Ortt and Schoormans (2004) and Ortt et al. (2013). The meso perspective described literature from Moore (2014), which contains knowledge on how the company could support diffusing its technology. At last, literature from Lubik et al. (2013) and Gawer (2014) provides the knowledge that is used by this research to describe the micro level of this research. The micro level contains the decision-making of functionalities for the product platform.

Without using multiple levels, a well-grounded answer to the main research question could not be found. Selected functionalities depend on how a company organizes its transition and how its technology could diffuse. Therefore, a company should understand what the effects for the technology diffusion could be while selecting functionalities. If a company does not consider this, a technology-push mechanism could be the result. That would go against it literature from Lubik et al. (2013) and Di Stefano et al. (2012), which states that TP and DP mechanisms should be balanced to ensure that technology could be adapted successfully. Therefore, multi-level literature research suits to reach the research goal.

Now the literature is described, this research will use the literature to build on. This research uses and adapts existing literature to design the framework, which complements to the lack of literature on transitions from project to product platform. That is why chapter 5 and 7 refer to parts from the literature study.

4.7. Chapter conclusion

The theoretical framework *discovered* and *defined* the required literature to design an initial framework. The three literature research levels enabled the research to capture all literature to answer the complex problem.

Furthermore, the theoretical framework, together with the case study research, can be the input for framework 1.0. The semi-structured interviews can use framework 1.0 to validate and complement to this research. This will be required to answer all research questions, and capture the knowledge in the design of framework 2.0. Therefore, this subsection lists conclusions that can be used as input for the design of framework 1.0 and framework 2.0 in chapters 5 and 7. Appendix J contains several discussion points of the theoretical framework.

- Macro level
    - The lead user niche strategy can be used as a strategy to let a technology diffuse from the market adaptation phase towards the market stabilization phase (Ortt et al., 2013).
    - A company can experience a lack of knowledge of technology and a lack of knowledge of customers (Ortt et al., 2013).

- Meso level
    - Establishing a company unity is required in the decision-making process from project to product platform (Moore, 2014).
    - A product platform could be developed for pragmatists buyers, and the type of product (platform) could be aligned with strategic goals (Moore, 2014).
    - 'Whole product management' supports a company to define functionalities for the product (platform) (Moore, 2014).

- Micro level
    - A product platform is a technological design that meets the needs of a specific group of customers and can be modified by the addition and substitution of features (Gawer, 2014).
    - The company should implement a process in which TP and DP orientations are balanced to prevent that they develop products for which there is no need in the market (Lubik et al., 2013).
    - Balancing TP and DP orientations enable a company to keep the error between assumed and actual needs as low as possible (Lubik et al., 2013).

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Framework 1.0 design

5.1. Introduction

Framework 1.0 *defines* the current knowledge base in a communicable artefact. It is the first version of a framework that communicates the findings of the case study research and the theoretical framework to the interviews. Subsection 5.1.1 describes the design process of framework 1.0. After that, section 5.2 describes the framework itself.

5.1.1. Design process of framework 1.0

The objective of framework 1.0 is to capture the major issues for the transition from project to product platform. The framework has been iteratively improved until the objective of framework 1.0 was reached. The conclusions of the case study research and literature study are used as input for the design of the framework. As a result, this research can use framework 1.0 to complement and validate the current findings, as shown in Fig. 2.3. The design of framework 2.0 deviates greatly from framework 1.0 since framework 1.0 is merely a concept that does not take into account all the results of the research.

5.1.2. Input for framework 1.0

This subsection describes how each included conclusion from the literature study and case study research has led to certain parts of the framework. The tables below describe the input by linking the conclusions to parts of the framework.

Case study research conclusions	Included in the framework by	In subsection
The company aims to transition from project to product platform because instead of getting paid per hour can, a profit margin per sold product can result in a higher profit.	Framework 1.0 includes this conclusion by describing the aim of the company.	§ 5.2.1
The company's main challenge is to determine the right set of functionalities for the product platform for successful market diffusion.	Framework 1.0 describes what a company needs regarding their decision-making process	§ 5.2.3
Literature study conclusions	**Included in the framework by**	**In subsection**
Macro level		
A company can experience a lack of knowledge of technology and a lack of knowledge of customers (Ortt et al., 2013).	Shows the importance of knowledge and technology and knowledge of customers, which framework includes as organizational competences	§ 5.2.3, § 5.2.2
Meso level		
Establishing a company unity is required in the decision-making process from project to product platform (Moore, 2014).	Subsection 5.2.5 describes the importance of a company unity in the decision-making process.	§ 5.2.5
Micro level		
The company should implement a process in which TP and DP orientations are balanced to prevent that they develop products for which there is no need in the market (Lubik et al., 2013).	Framework 1.0 tries to balance both mechanisms throughout all phases.	§ 5.2.5
Balancing TP and DP orientations enables a company to keep the error between assumed and actual needs as low as possible (Lubik et al., 2013).	Framework 1.0 describes how the factor knowledge of technology and knowledge of customers can be used to balance TP and DP orientations.	§ 5.2.4

Table 5.1: How framework 1.0 includes case study research and literature conclusions.

5.2. Framework 1.0

The first subsection shows a visualization, other subsections describe different parts of the visualization.

5.2.1. The transition from project to product platform

This subchapter shows a visualization of the transition from project to product platform, as was described by the case study research in section 3.3.6. The figure shows two main points of the transition. The first point lists the requirements to start the transition. The endpoint shows the balance between knowledge of technology and actual needs. The following subsections describe the figure in parts.
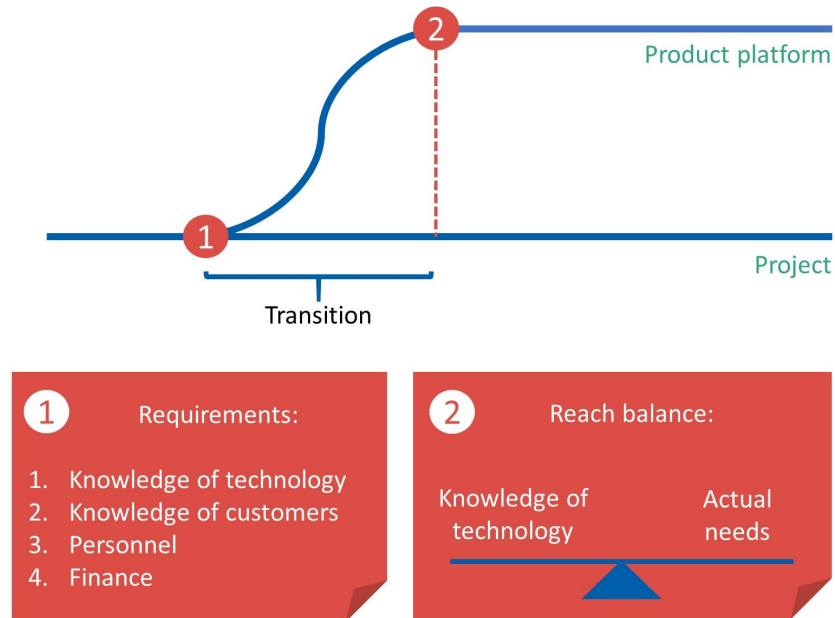
Figure 5.1: A visualization of major issues of framework 1.0

5.2.2. Project versus product platform

The characterstics of a project setting and a product platform setting describe the startpoint and the endpoint of the organizational transition process.

According to the definitions that are set: "Technology-push (TP) oriented companies are set up to commercialize a specific technology, drawing product ideas from an existing or developing technology" (Lubik et al., 2013, p. 13). Opposite of TP orientation, literature defines demand-pull (DP) orientation as: "DP oriented companies develop and produce products to address expressed market needs is specified, existing market segments" (Lubik et al., 2013, p. 13).

In a project, the focus is on gaining new knowledge and develop the best technology within the limitations of the budget. In a product platform, it is about using the knowledge and meeting the needs of a market segment.

5.2.3. Organizational competences

The required organizational competences to start a transition are knowledge of technology, knowledge of customers, personnel, and finance. Personnel and finance are mentioned by Lubik et al. (2013) as criteria for firms to be successful in focussing on both TP and DP orientations. Knowledge of technology is introduced by Ortt et al. (2013) and knowledge of customers is an adjustment to literature from (Ortt et al., 2013). The following paragraphs describe all requirements.

Knowlegde of technology

Knowledge of technology indicates the relevance of a company. "Knowledge of technology refers to the knowledge required to develop, produce, replicate and control the technological principles in a product" (Ortt et al., 2013, p. unkown). It leads to a competitive advantage by including unique selling points in their

products. It is an indicator of success in new product development (Kim and Kogut, 1996). Knowledge of technology is of high value if a company is able to patents certain ideas or modules that can be included in the product.

Knowledge of customers
To ensure a match between the technology and the market, knowing the potential customers is important. An adaptation of the statement of Ortt et al. (2013) replaces 'product' for 'knowledge of technology': "The availability of customers means that a market for the knowledge of technology is identified, that customer segments for these applications exist" (Ortt et al., 2013, p. unkown). If the needs of a market segment match the knowledge of the technology of a company, a unique selling market can be defined. In the case the customer market exists, the diffusion is blocked (Ortt et al., 2013). "If customer groups do not exist, are not able to obtain the knowledge or are unaware of the benefits of the knowledge of technology, large-scale diffusion is blocked" (Ortt et al., 2013, p. unkown).

Personnel
Sufficient personnel is required to extend or shift the focus from TP driven to DP driven (Lubik et al., 2013). Furthermore, companies could establish a company unity (Moore, 2014). Often at the beginning of new product development teams are small, which result in a focus limited to a TP orientation (Lubik et al., 2013). Additional personnel is needed for a shift towards a company unity of DP orientation.

Finance
There is a risk no balance can be found during the transition. Thus, there are financial resources required that can invest in time and personnel during the transition.

5.2.4. Defining the balance
A balance can be found in the knowledge of technology meets the actual needs of a market segment (Lubik et al., 2013). The balance between knowledge of technology and actual needs means a balance between TP orientation and DP orientation (Lubik et al., 2013). If this is the case, a product platform is born, and the development of a general product for the market segment can start. This situation is visualized in Fig. 5.2a. The shift from TP orientation to DP orientation minimizes errors in estimations of the market needs. If the shift does not occur, it might lead to a product that will not be sold (Lubik et al., 2013). In Fig. 5.2b this situation is visualized. At last, Fig. 5.2c shows that a too big focus on DP orientation can lead to the unsufficient competitive advantage of the technology. A focus on market needs might lead to problems to deliver and to create enough competitiveness (Lubik et al., 2013). In this case, the knowledge of technology is not respected nor available. For example, this is the case if a company tries to deliver something in which they are not good; in this situation, there is not enough knowledge of the company.

Historical cases showed that companies tend to shift late in the process, instead of preparing for it. They tend to focus on just one of the orientations, but later in the process shift to another orientation (Lubik et al., 2013). When a shift occurs towards a DP orientation, this often coincided with three main events: Partnering, the realization of difference in actual versus assumed customer needs, and drastic change in management if beginning to run in low funds (Lubik et al., 2013, p. 22). These events can occur as a result of a mismatched product or misused knowledge and therefore cost time and money. By finding the balance on time, a company stays ahead of unwanted events.

(a) A company taking both knowledge of technology and knowledge of customers into account for the decision-making of the minimum functionalities for the product platform balances both TP and DP orientations.

(b) A company that focusses to much on knowledge of technology has a TP orientation. The result might be a large error between estimated and actual needs of the product platform.

(c) A company that focusses too much on knowledge of customers results in a DP orientation. The result might be a lack of technical added value in the product platform.

Figure 5.2: Balance and imbalance of TP and DP orientations in relation to knowledge of technology and knowledge of customers.

5.2.5. Reaching the balance: the transition

A company that is engaged in a client-driven project development that wants to expand its business to a larger market should expand its focus toward DP orientation. The company must meet the requirements and understand the balance it wants to reach. According to literature, the company should shift towards a DP orientation, create a company unity, and define a market segment (Moore, 2014).

Balance TP and DP orientations

A Shift towards a DP orientation means a company extends the focus from TP orientation towards DP orientation. The focus toward a DP orientation leads the company question itself: "Which group of customers wants us, because of our knowledge of technology, to develop a product for their actual needs?" Many companies, like the company in the case study (see chapter 3), are initally TP oriented. A shift toward DP orientation is required if a high-tech company wants to meet market needs, as described before in subsection 4.5.1 (Lubik et al., 2013). Becoming DP oriented completely can result in disrespecting the knowledge of technology and missing the essential technological value in the product. Therefore, a company should find a balance between TP and DP orientations (Lubik et al., 2013; Di Stefano et al., 2012). Finding the balance between TP and DP orientation is related to the mindset of the people, the type of personnel, management, and finance (Lubik et al., 2013).

Create a team unity

According to literature, the company should create team unity with a focus on what customers needs, which is an essential part of the DP orientation (Lubik et al., 2013). One of the conclusions from the theory of Moore (2014), described in subsection 4.4.2, is that "achieving an unusual degree of company unity in the market adaptation phase is needed" (Moore, 2014, p. 8). Furthermore, Moore (2014) describes that "the consequences of being sales-driven during the chasm period are fatal" (Moore, 2014, p. 84). The DP orientation can result in a mindset where every choice depends on the customers' needs and what technology meets those needs.

Define a market segment

The knowledge of customers includes an estimation of customer needs. An error between estimated and actual needs can result in mismatches (Lubik et al., 2013). According to literature, a company should try with a balance of TP and DP orientation to keep the error low between the actual and the estimated needs (Lubik et al., 2013). Defining a market segment includes defining the size and shared needs. A market segment can suit when the actual customer needs can be identified, for which the company has knowledge of technology. If this match is found, this can be used to develop the product.

5.3. Chapter conclusion

This chapter captured the knowledge of the case study research and the literature study in a framework design. The semi-structured interviews can use framework 1.0 to validate and complement knowledge for this research.

6

Semi-structured interviews

6.1. Introduction

The semi-structured interviews validate framework 1.0 and provide complementing knowledge for the framework redesign. The interviewees are asked to *develop* a set of functionalities for the unmanned surface vessel (USV). The analysis of the results enables this research to *develop* a minimum set of functionalities for the product platform of the USV case.

6.1.1. Objectives of data gathering

This subsection describes two objectives for the interviews. The results of the interviews apply to the USV case and enable improvements to the framework. The two formal objectives of the semi-structured interviews are:

Objective 1: *Derive the minimum set of functionalities for the product platform of the USV case.*
Objective 2: *Improve framework 1.0 on at least three points.*

6.1.2. Method

This subsection shows the action plan for the semi-structured interviews. The semi-structured interviews consist of seven interviews held with employees, customers, and an expert in the field of organizational advice for high tech companies. The list below shows the list of interviewees.

List of interviewees

1. Market perspective: Manager of potential customer
2. Market perspective: Manager of the customer from the USV project
3. Company perspective: Manager of the USV project
4. Company perspective: Industrial designer
5. Company perspective: Engineer
6. Company perspective: Engineer
7. Expert in the field of organizational advice for high tech companies.

Appendix D shows the complete protocols for all interviews. One important notion to the method used for these interviews is the use of the word 'requirements' instead of 'functionalities' when interviewees are asked to select a set. 'Requirements' was used because during a test interview appeared that asking for functionalities can cause uncertainties at the interviewee. Some people prefer to refer to specific 'parts', for example, Part A instead of the functionality 'determine position'. The analysis in section 6.3.1 describes the different definitions and derives functionalities from the parts if interviewees selected parts instead of functionalities. The interviews with the employees of the developing company and (potential) customers are held with the same protocol. The interviews for potential customers and employees are the same to be able to analyze the results for similarities and differences. Central to the interviews is a selection process of functionalities for the USV. The interview with the expert is different; here, the selection process is left out. The expert interview validates and complements the findings in the research.

6.1.3. Structure

This chapter describes the semi-structured interviews in the following way. Section 6.2 describes the results, section 6.3 describes the analysis of the results, and section 6.4 describes the conclusions and input for the framework redesign.

6.2. Interview results

This section describes the results of the interviews. Sound records and pictures of the selection together contain all knowledge. The summarized interview results include only the relevant knowledge for this research. Each interview summary was sent to the interviewee to validate the results. The interviewee was asked to validate and complement the results.

6.2.1. Interview summaries

These interviews are held to analyze similarities and differences. Every interview is therefore conducted and analyzed in the same way. Appendix E shows all knowledge gathered through the interviews, including the reduced results drawn from each interview. All reduced results can also be found in table E.1 and E.2.

6.2.2. Selections of requirements

Table 6.1 shows the selection of requirements by each interviewee, see section 6.1.2 describing why the interviewees selected 'requirements' instead of functionalities. The first and second column of interviewees represents the market perspective. The others represent the company perspective. The table lists the requirements in random order.

Requirements: \ Interviewee:	1	2	3	4	5	6	Requirements: \ Interviewee:	1	2	3	4	5	6
Part A	X	X	X	X	X		Part E	X		X	X		X
Part B		X	X	X	X		Requirement 1			X	X		
Requirement 2	X	X			X		Requirement 3						X
Functionality M	X	X	X	X	X	X	Part H		X	X	X		X
Part D			X	X	X	X	Requirement 4			X	X		X
Functionality E		X	X	X	X	X	Requirement 5			X	X		
Requirement 6							Requirement 7						
Gc B	X	X	X	X			Requirement 8	X					X
Functionality N	X	X	X				Part F	X	X	X	X		X
Requirement 9							Gc A			X	X	X	X
Functionality C		X	X	X		X	Functionality O	X	X	X		X	X
Requirement 10			X	X		X	Functionality J	X		X	X		X
Requirement 11	X					X	Functionality H	X	X	X	X		X
Functionality W	X		X	X		X	Requirement 12						X
Requirement 13			X				Requirement 14		X				
Requirement 15		X	X		X		Requirement 16			X	X		
Requirement 17	X	X	X	X	X	X	Requirement 18		X				
Functionality F		X	X	X	X		Requirement 19						
Functionality L		X	X	X	X		Functionality G		X	X	X		
Gc C	X	X			X	X	Requirement 20	X		X			X
Requirement 21		X		X	X		Part G	X		X	X		X
Requirement 22	X					X	Requirement 23	X		X			X
Part C	X		X	X		X	Requirement 24						
Requirement 25				X			Requirement 26				X		
Requirement 27				X		X	Requirement 28						
Requirement 29	X	X				X	Requirement 30			X		X	
Requirement 31	X		X	X		X	Requirement 32			X			
Requirement 33							Requirement 34	X		X	X		
Requirement 35	X				X	X	Requirement 36	X		X	X		
Requirement 36	X		X	X	X		Requirement 37	X				X	X
Functionality P	X		X	X	X		Requirement 38		X				
Functionality B		X	X	X	X		Requirement 39	X	X				
Functionality I	X		X		X	X	Requirement 40		X				
Functionality X		X	X	X	X		Requirement 41		X			X	
Requirement 42	X				X	X	Functionality K	X	X		X	X	
Requirement 43		X	X	X			Requirement 44		X				
Requirement 45	X						Requirement 46		X				
Functionality A	X		X	X			Requirement 47						
Requirement 48	X						Requirement 49		X				
Requirement 50													

Table 6.1: The sets of selected requirements by each interviewee. An 'X' indicates that the requirement is selected. The table lists the requirements in random order. *Public version is encrypted*

The table lists all requirements and each requirement is followed by an 'X' if an interviewee selected the requirement. Some requirements are found to be required by everyone such as 'Functionality M', others by only a few or even none such as a radar or a winch. The figure shows that the interviewees selected very different sets of requirements, which indicates a lack of uniformity among employees and among employees and (potential) customers (see subsection 4.4).

This research uses the selected requirements to derive the minimum functionalities for the USV product platform, which section 6.3.1 describes. Furthermore, the workshop uses this list to research how interviewees of the company think about the similarities and differences in the selections.

6.3. Analysis of the results

The results are analyzed by interpreting the interview summaries and requirements selections. Table E.1 and table E.2 show summarized reduced results from the interviews as derived in appendix E.

6.3.1. Analysis for objective 1: minimum functionalities for the USV product platform

This section shows the derivation of the minimum functionalities for the product platform from the selected sets of requirements by the interviewees. The functionalities are derived with the help of table 6.1 and the summaries of the interviews in appendix E. In response to the selected sets of requirements by the interviewees, this section distinguishes the selected requirements into categories. The three categories are parts, functionalities and general criteria. Eventually 'parts' will be translated into 'functionalities' in order to arrive at a minimum set of functionalities for the product platform.

Derivation process of minimum requirements for the USV product platform

The definition of a product platform is derived in subsection 4.5.2. A product platform is a technological design that meets the needs of a specific group of customers and can be modified by the addition and substitution of features (Gawer, 2014). In general, included requirements meet a shared need for all potential customers. Also, according to a potential customer, requirements that do not meet the needs of all customers should not be included in a product platform. This is apparent from the following quote:

"I do not select requirements that do not belong to the specific application I have in mind."

Therefore, requirements that were left out in the derivation made by this research could either be seen as customization concerning the product platform or could be disregarded. If the interviewed customers are considered to be a specific group of customers, then the requirements for the product platform can be derived. This research took the number of times a requirement was selected into account and analyzed the reasoning behind the selection. Only if it seemed to be needed by all interviewed (potential) customers than it was included. Some requirements were not selected by all interviewees, but are yet selected. For example 'working instructions' was not selected by the interviewee 1. However, this research selected 'working instructions' because the employees stated that working instructions are required. Reason for is to make sure that the vessel could be used at all (see the selections of 'working instructions' in table 6.2). The result is the preparation of the product platform in the USV case, which table 6.2 shows.

Categorisation

The interviewees mentioned and selected requirements. A definition of a requirement is "Something needed or necessary" (Cambridge dictionary, c). The selected requirements can be categorized into three categories. The three categories are parts, functionalities and general requirements. A functionality is: "Any or all of the operations performed by a piece of equipment or a software program" (Cambridge dictionary, a). A part is: "A separate piece of something or a piece that combines with other pieces to form the whole of something" (Cambridge dictionary, b). With 'general criteria' is meant that this selected requirement is required in general, for example, 'sustainability' is required up to a certain level for all parts of the product platform. Parts are selected as requirements if it is required to meet customer needs or to comply with regulations. Otherwise, interviewees tend to select functionalities for the product platform. For example, an interviewee selected Part A because it is a standard of the functionality of localization. Part A might be the 'part' that is compatible with the customer its sensor system. Therefore, the interviewed customer need the availability of Part A at the USV. Another example is 'Part E', which are required to sail in public waters to comply with regulations. In this case, the Part E is used for 'Functionality U'. Interviewees selected 'general criteria' that specify a require-

ment influencing the selection of all other requirements. For example, the price influences the selection of requirements because all requirements together should add value to the customers.

Table 6.2 shows 30 of the 79 requirements that together are the minimum selected requirements for the product platform, subdivided into the three categories: functionalities, parts and general criteria. Each category lists the requirements in random order. Besides, this table contains the same checkboxes as table 6.1. An 'X' indicates a selected requirement by that interviewee.

To be included \ Interviewee:	1	2	3	4	5	6	Explanation of the selection for the minimum requirements:
Functionalities							
Functionality A	X		X	X			....
Functionality B		X	X	X	X		....
Functionality C		X	X	X		X	....
Functionality D	X	X	X	X	X	X	....
Functionality E		X	X	X	X	X	....
Functionality F		X	X	X	X		....
Functionality G		X	X	X			....
Functionality H	X	X	X	X		X	....
Functionality W	X		X		X	X	....
Functionality I	X		X	X		X	....
Functionality J	X		X	X		X	....
Functionality K	X	X		X	X		....
Functionality L		X	X	X	X		....
Functionality M	X	X	X	X	X	X	....
Functionality N	X	X	X				....
Functionality O	X	X	X		X	X	....
Functionality P	X		X	X	X		....
Functionality X		X	X	X	X		....
Parts							
Part A	X	X	X	X	X		....
Part B		X	X	X	X		....
Part C	X		X	X		X	....
Part D			X	X	X	X	....
Part E	X		X	X		X	....
Part F	X	X	X	X		X	....
Part G	X		X	X		X	....
Part H		X	X	X		X	....
General criteria							
Gc A			X	X	X	X	....
Gc B	X	X	X	X			....
Gc C	X	X			X	X	....

Table 6.2: Derivation of the minimum requirements for the product platform for the USV case. The table lists the requirements in random order. *Public version is encrypted*

Derivation to functionalities

The categories parts and functionalities are not at the same level because parts fulfil a certain functionality. Therefore, the parts selected by the interviewees are translated to functionalities. This results in a set of functionalities that should minimally be included in the product platform. General criteria can not be translated to functionalities, because these are related to the product platform in total. Therefore, general criteria stay a separate category. Figure 6.1 visualizes the distinction of three categories as a result in the interviews and visualizes that parts are translated to functionalities. Table 6.3 shows the minimum functionalities and general criteria.
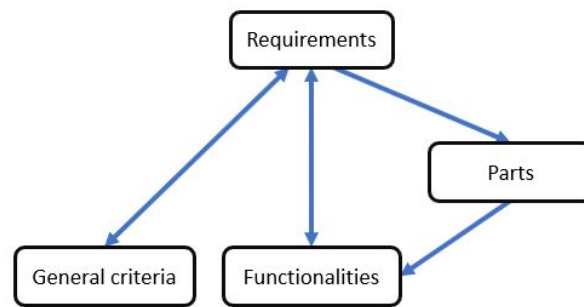
Figure 6.1: As a result of the interviews, the subdivision of requirements into functionalities, parts and general criteria.

Part	Corresponding functionality
Part A	Functionality Q
Part B	Functionality R
Part C	Functionality S
Part D	Functionality T
Part E	Functionality U
Part F	Functionality V
Part G	Functionality W
Part H	Functionality L

Table 6.3: Derivation of functionalities from parts. *Public version is encrypted*

The result of the derivation of parts to functionalities provides a list of minimum functionalities. Table 6.4 shows these minimum functionalities together with the general criteria. The conclusion of this chapter excludes the general criteria because this research focuses on the minimum functionalities for the product platform.

Functionalities			General criteria
Functionality A	Functionality I	Functionality Q	Gc A
Functionality B	Functionality J	Functionality R	Gc B
Functionality C	Functionality K	Functionality S	Gc C
Functionality D	Functionality L	Functionality T	
Functionality E	Functionality M	Functionality U	
Functionality F	Functionality N	Functionality V	
Functionality G	Functionality O	Functionality W	
Functionality H	Functionality P		
Functionality X			

Table 6.4: Minimum functionalities and general criteria for the product platform of the USV case presented in random order. *Public version is encrypted*

Reflection on the minimum set of functionalities

Table 6.2 shows several requirements that deserve additional attention. Functionality P is a functionality that was developed during the project. During the interview with the customer from the project, it appeared that the customer is not necessarily interested in this Functionality Iut still identifies sufficient value in it. This phenomenon is an example of a technology-push (TP) mechanism. The developer is convinced that there is much value in this functionality. Therefore, a possibility is to test the product platform preparation for this product platform, including the 'Functionality P' functionality with other potential customers. This could show that Functionality P might be a USP of the product platform. In this case, Functionality P is selected as a minimum functionality for the product platform. However, literature from (Lubik et al., 2013) and Di Stefano et al. (2012) claims that TP and demand-pull (DP) mechanisms should be balanced. Therefore, according to Lubik et al. (2013) and Di Stefano et al. (2012), in the case that Functionality P appears to be not of interest of other potential customers, the company should consider excluding 'Functionality P' of their product platform.

Table 6.2 shows that it is possible to make a product platform preparation for a specific group of cus-

tomers at an early stage. The company of the USV case can use the minimum set of functionalities to iterate and validate a product platform preparation. Questions for iterations are, for instance: Is the knowledge of technology to its best advantage in this product platform? As a developer, can we provide a product platform that the group of customers needs? Is there another market segment to which our knowledge of technology can offer even more value? Does the group of customers still benefit from a product platform, what was our ambition to develop, or do they need a one-off or a standard product?

6.3.2. Analysis for objective 2: validation of framework 1.0

This paragraph describes three main points that were missing in framework 1.0 derived from the interviews. Appendix E contains interview summaries and reduced results that support this section. The validation presented in this paragraph is derived from the reduced results of the interviews. Quotes from the summaries described in appendix E are used to link the analysis to the observations.

Importance of gathering data from the market
The potential customer, an engineer and the organizational advisor, agreed that a developer would do well to validate their ideas about a product platform in the earliest possible stage with the market. Interviewees that were not related to the project were clear about what should be taken into account when defining the platform. Market needs are essential to include in the platform. Furthermore, the needs should be based on a specified market segment for which the company can create the most added value. The importance of defining a market segment corresponds to literature from Moore (2014), which is still missing in framework 1.0, so it was recommended as an improvement. This was interpreted because of the following quotes:

Potential customer: *"When determining which requirements should be included in the platform, it is essential for me that a developer has a clear understanding of the needs of the market segment."*
Engineer: *"If a company has enough time and financial resources, then it would be best to do market research in parallel."*
Organizational advisor: *"Go to the market as soon as possible. Validating important choices for the design at the customer is a must. However, validating ideas with customers and with other market parties leads also to a better understanding of the real problem. "This results in a minimum viable product (MVP) that matches 90% with their needs instead of 40%, meaning less additional iterations are needed in the end."*

Unclear start and endpoint of framework 1.0
During the interviews, it was observed that interviewees had difficulties with the interpretation of the process described in framework 1.0. These observations indicated the lack of specific decision moments and things that had to be done in preparation for those moments of choice.

Lack of relationship with the minimum viable product
All the interviewees of the company agreed on the relationship between the MVP and the product platform. However, all employees are mainly focused on the development of the MVP. It seems as if they would rather see a redesign than a lead user niche strategy. On the other hand, a lead user niche strategy may lead to diffusion in less time, according to other interviewees.

Engineer: *"An MVP proves to potential customers that the company can develop a customized USV. Therefore, the MVP must first be finished and then the company should think about the next step."*
Industrial designer: *"After the MVP has been developed, the developer can contact similar customers as the current customer. Subsequently, the developer can develop a follow-up design."*
Organizational advisor: *"The idea, concept or MVP must be validated in the early stage of a project. The earlier, the better, in the interest of a rapid development cycle. In the fast-moving world of today, getting started with the right knowledge and vision, which can be done by investing extra time and effort in the beginning."*

6.4. Chapter conclusion

The semi-structured interviews helped to *develop* the minimum requirements for a product platform. The practical results complement to the research and are input for framework 2.0. Also, framework 2.0 can take the validations of framework 2.0 into account by using the conclusions as input for the redesign. Chapter 7 describes the redesign of the framework.

Furthermore, this paragraph reduces the results to conclusions. The research uses the conclusions to redesign the framework. A more extensive derivation can be found in appendix 6.3.2

- Table 6.5 shows the minimum requirements for the product platform of the USV case. Included requirements meet a shared need for all potential customers (See subsection 6.3.1).

Minimum functionalities for the USV product platform		
Functionality A	Functionality I	Functionality Q
Functionality B	Functionality J	Functionality R
Functionality C	Functionality K	Functionality S
Functionality D	Functionality L	Functionality T
Functionality E	Functionality M	Functionality U
Functionality F	Functionality N	Functionality V
Functionality G	Functionality O	Functionality W
Functionality H	Functionality P	Functionality X

Table 6.5: Minimum functionalities for the product platform of the USV case presented in random order. *Public version is encrypted*

- A successful process should include gathered knowledge of the market at the start of the project. This is beneficial for both the project and the preparation of the product platform (See subsection 6.3.2).
- Time and personnel barriers should be dealt with at the start of a transition from project to a product platform (See subsection 6.3.2).
- A clear start and endpoint of the transition from project to product platform are required to transfer the knowledge of the framework (See subsection 6.3.2).
- The input of the MVP launch to the product platform is found to be important by all interviewed employees (See subsection 6.3.2).

7

Framework 2.0 design

7.1. Introduction

Framework 2.0 *delivers* the findings of this research to both practitioners and researchers, it captures the decision-making process for a set of requirement for a product platform. According to the methodology framework, 2.0 is a redesign of framework 1.0. As described in the methodology, the adjustments are the result of the validation of framework 1.0 through interviews. Due to the interviews, not only new knowledge has been added, but also knowledge collected in the case study and literature research that deserves more emphasis is included in framework 2.0.

Subsection 7.1.1 describes the main differences between framework 1.0 and framework 2.0. Next, subsection 7.1.2 describes the input. Section 7.2 contains framework 2.0.

7.1.1. Differences between framework 1.0 and framework 2.0

The main differences between framework 1.0 and framework 2.0 have both originated from the additional knowledge obtained through the interviews and from another emphasis of previously gathered knowledge of the case study research and the literature study. The review of previously gathered data resulted in more detail in framework 2.0 and three main differences. This subsection describes the reason for the three main differences.

The inclusion of going to the market at the start of the project

During the interviews, it appeared that the potential customer would like to influence the product platform from the start of a new product development process. The experiences of the organizational advisor confirmed this insight. That is why this research emphasized on literature from Lubik et al. (2013). Lubik states that companies are indeed sometimes technology-push (TP) oriented for too long. Ideally, companies could balance TP and demand-pull (DP) orientations from the start of the development process. Based on this, and the reconsideration of the case study research, phase 1 is added to the process described in framework 1.0. Also, framework 2.0 emphasizes balancing TP and DP orientations, instead of only a shift from TP to DP orientation, it makes sure TP and DP orientations are balanced during the entire process, according to literature from Di Stefano et al. (2012); Lubik et al. (2013).

The distinction of phases

The redesign introduces a distinction in phases. Either a decision-moment or the launch of the minimum viable product (MVP) closes a phase. Framework 2.0 includes this improvement because it appeared that the interviewees did not well understand the start and endpoint of the transition.

The relation between the MVP and the defining the product platform.

All interviewed employees from the company that mentioned a strong relation of the MVP launch to the product platform development. This relationship was missing in Framework 1.0. Therefore, framework 2.0 includes iterative phases that take the influence of the MVP launch intro account in phase 3. The literature of Moore (2014) states that the mainstream market includes mainly pragmatic customers and that pragmatists like to buy a proven product. The MVP launch can prove used technology, which results in input for the product platform.

7.1.2. Input for framework 2.0

According to the methodology and figure 2.2, the input for framework 2.0 includes all conclusions of the case study research, literature study and the interviews. This subsection describes how each conclusion has led to certain parts of the framework. The tables below describe the input by linking the conclusions to parts of the framework. Table 7.1 describes how framework 2.0 includes conclusions from the case study research. In the same way, table 7.2 describes how framework 2.0 includes the literature study conclusions and table 7.3 the interview conclusions.

Case study research conclusions	Included in the framework by	In subsection
The company aims to transition from project to product platform because instead of getting paid per hour can, a profit margin per sold product can result in a higher profit.	Framework 2.0 includes this conclusion by describing the company characteristics.	§ 7.2.1
A potential niche market to focus on is the inland water market of the Netherlands. For this market should USVs be able to carry enough instruments, and be small enough to transport by car and trailer.	Framework 2.0 includes this conclusion by the use of an example of a unique selling market (USM).	§ 7.2.7
The company's main challenge is to determine the right set of functionalities for the product platform for successful market diffusion.	Framework 2.0 emphasizes the importance of organizing actual decision-moments to structure the process.	All, especially § 7.2.3, § 7.2.7

Table 7.1: How framework 2.0 includes all case study research conclusions.

Literature study conclusions	Included in the framework by	In subsection
Macro level		
The lead user niche strategy can be used as a strategy to let a technology diffuse from the market adaptation phase towards the market stabilization phase (Ortt et al., 2013).	Framework 2.0 is based on these characteristics of the USV company. Therefore, at the project start, companies should understand that their technology and the lead user niche strategy should be suitable to diffuse to the market.	§ 7.2.1
A company can experience a lack of knowledge of technology and a lack of knowledge of customers (Ortt et al., 2013).	This conclusion defines the company characteristics at the project start and shows the importance of knowledge and technology and knowledge of customers. These factors are used to describe how a company can balance TP and DP mechanisms	§ 7.2.1,§ 7.2.4
Meso level		
Establishing a company unity is required in the decision-making process from project to product platform (Moore, 2014).	This conclusion leads to the inclusion of decision-moments. Subsection 7.2.3 describes the importance of company unity in the decision-making process.	§ 7.2.3
A product platform could be developed for pragmatists buyers, and the type of product (platform) could be aligned with strategic goals (Moore, 2014).	This input resulted in the description of company characteristics and the explanation of why pragmatic customers should be triggered with a proven product.	§ 7.2.1, § 7.2.5
'Whole product management' supports a company to define functionalities for the product (platform) (Moore, 2014).	Because of this conclusion, framework 2.0 explains why and how a company should define the end product.	§ 7.2.7
Micro level		
A product platform is a technological design that meets the needs of a specific group of customers and can be modified by the addition and substitution of features (Gawer, 2014).	This definition is used to determine that a USM is required to define the functionalities for the product platform. Furthermore, it is used to arrive at the set of functionalities as presented in chapter 6.	§ 7.2.4, § 7.2.7
The company should implement a process in which TP and DP orientations are balanced to prevent that they develop products for which there is no need in the market (Lubik et al., 2013).	Framework 2.0 tries to balance both mechanisms throughout all phases.	§ 7.2.7
Balancing TP and DP orientations enables a company to keep the error between assumed and actual needs as low as possible (Lubik et al., 2013).	Framework 2.0 takes this balance into account from the first phase of the transition process.	§ 7.2.2

Table 7.2: How framework 2.0 includes all literature conclusions.

Interview conclusions	Included in the framework by	In subsection
A successful process should include gathered knowledge of the market at the start of the project. This is beneficial for both the project and the preparation of the product platform.	Framework 2.0 uses this conclusion to emphasize to collect knowledge in phase 1.	§ 7.2.2
Time and personnel barriers should be dealt with at the start of a transition from project to a product platform.	Framework 2.0 uses this conclusion to define a decision moment. Decision moment 1 enables the company to discuss and decide how the company should deal with these barriers.	§ 7.2.3
A clear start and endpoint of the transition from project to product platform are required to transfer the knowledge of the framework.	This conclusions results in the inclusion of a project start and the extensive description of defining the product platform.	§ 7.2.1, § 7.2.7
The input of the MVP launch to the product platform is found to be important by all interviewed employees.	Framework 2.0 includes the event MVP launch. The effects of this launch are emphasized by the inclusion of the iterative symbol in Fig. 7.2.	§ 7.2.5, § 7.2.6

Table 7.3: How framework 2.0 includes all interview conclusions.

7.2. Framework 2.0

Framework 2.0 captures the decision-making process for the selection of the functionalities for the product platform for companies that aim to transition from a project to a product platform. With this transition, a company aims to use the product platform to enable a technology to diffuse in the market. The framework is based on the company characteristics as found in the case study research, see subsection 7.2.1. Therefore, framework 2.0 especially suits to this specific company. However, subsection 7.2.1 describes company characteristics that other companies can use to compare the applicability on itself. The framework implicitly answers the research questions. Figure 7.1 shows the field of tension determinative for the selection of functionalities for the product platform. On the one hand, a developing company can influence the product platform by having specific knowledge of technology (see subsection 7.2.2. The developing company is called 'developer' to emphasize that the company should consider its influence on the product platform. The remainder refers to developing company as 'developer' in the case it is about the relation between the developing company, customers, and partners. On the other hand, the market segment, which refers to the customers of that market segment, can have influence because customers of the market have particular needs for functionalities for the product platform. The figure shows that a developer should consider both the influence of itself as well as the market segment influence. Figure 7.1 shows what part of the field of tension is answered by what question.
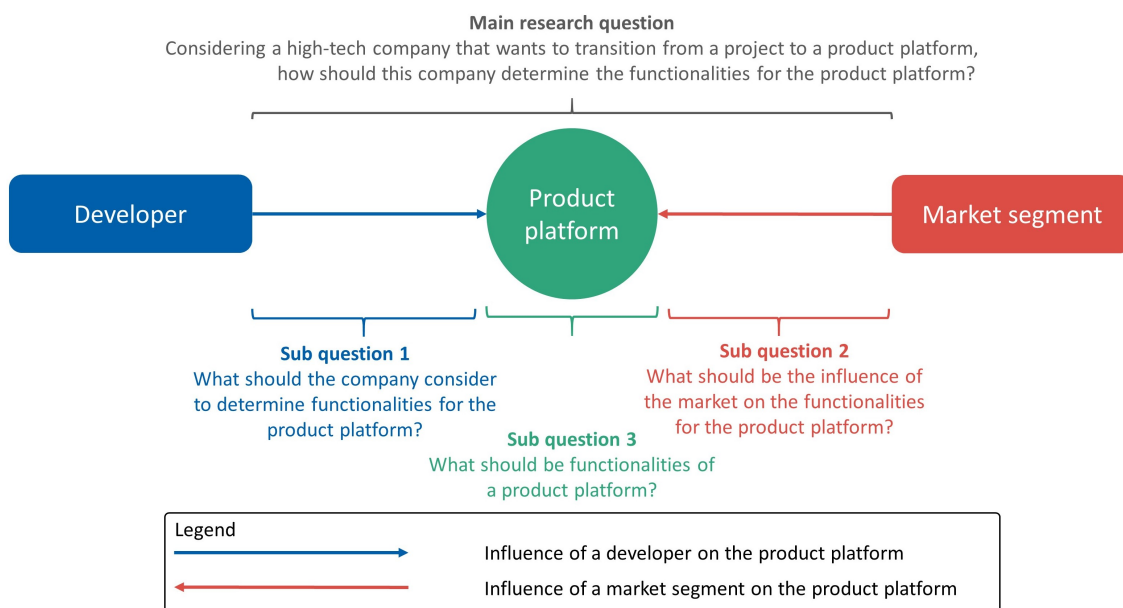
Figure 7.1: The coherence of the research questions and the tension between the market and the developing company.

The visualization of framework 2.0 shows the decision-making process for the set of functionalities for the product platform. This subsection describes the process shortly, the other subsections 7.2.1 to 7.2.7 elaborate the process.

Figure 7.2 shows phases, points that distinguish the phases and two lines. The two lines pointing at 'product platform' and 'custom made product' in Fig. 7.2 are processes, meaning after the split-off, the transition starts towards two parallel processes. The phases indicate the main focus needed by the developer and the red dots describe actions and events determining the course of the transition. The goal is to develop new technology in a project and allow it to diffuse into the market by the product platform. Section 7.2.1 describes what this means for the market adaptation of the technology. The phases indicate the focus needed by the developer and the arrows indicate that all processes do have an iterative character instead of linear.
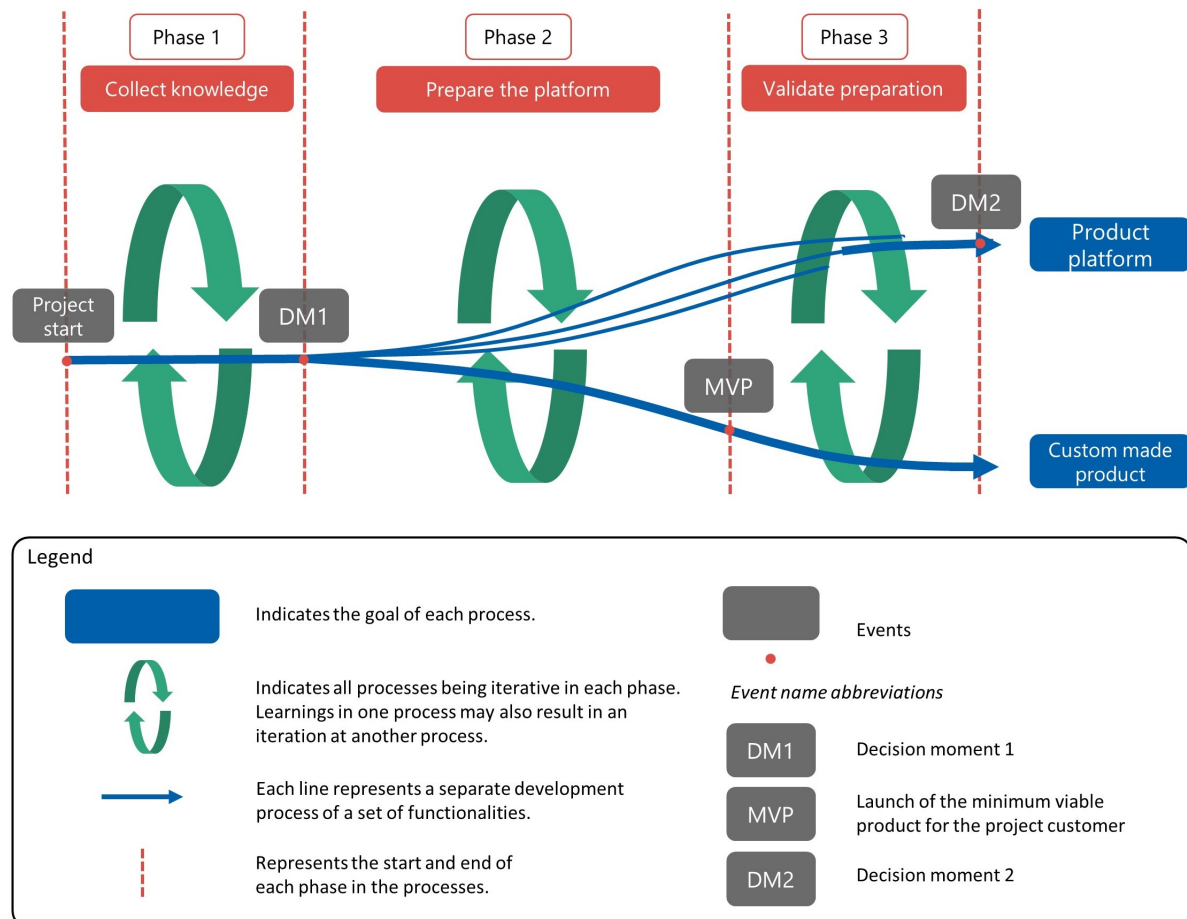
Figure 7.2: The decision-making process of the functionalities for the product platform in a transition from a project to a product platform as described in Framework 2.0.

From now on, this section describes Fig. 7.2 from left to right. On the far left of figure 7.2 'Project start' is indicated as the start of phase 1. Whether this framework suits for a situation depends on the company and project characteristics, subsection 7.2.1 elaborates on the project start. Given the ambition of the company to scale, it means that the company can set the project as lead user niche strategy.

After the project is started, the figure below shows that phase 1 starts. During phase 1, the developer has to focus on collecting knowledge of customers and knowledge of technology. Collecting this knowledge results in an understanding of the problems of the customer and other potential customers, which is necessary to collect before determining the set of functionalities for the platform (see subsection 7.2.2). Phase 1 concludes if all employees together, which is called 'company unity', decides that there is sufficient knowledge of technology, knowledge of customers, and organizational competences. The company unity decides in decision moment 1 (DM1) if the developer is going to transition from project to product platform. DM1 is described in subsection 7.2.3. After DM1, figure 7.1 shows that the transition starts with phase 2. The developer uses

the gathered knowledge in phase 1 to prepare for the product platform.

Subsection 7.2.4 describes how both the customers' needs and the knowledge of technology is used to prepare selection(s) of functionalities that together can be the platform. In the meantime, the project is also progressing, and the product is being developed. The result is the launch of the MVP in the project. Knowledge of technology has been used to develop a product, and this has been delivered to the customer. The MVP proves the relevance of the technology to the customer, the customer of the customers and other potential customers (see subsection 7.2.5). The MVP also provides input for the product platform preparation. This preparation can now be validated. Due to the MVP launch, demands from potential and pragmatic customers arise. Subsection 7.2.6 describes phase 3. After phase 3, decision moment 2 (DM2) defines the platform. Subsection 7.2.7 describes how the market segment should be defined, how functionalities should be selected, and how and why the end product should be defined.

7.2.1. Project start

At the project start, two parties agree to co-develop a product. One party is a developing company (developer), and the other party is the customer. This subsection describes the characteristics of technology development, the developer, and the project customer.

Technology development characteristics

The developer in the case study aims to use the transition from project to product platform to let their technology adapt to the market and let the technology diffuse in the market. Companies having the same ambition can use this framework. This paragraph describes how the transition can be used to let the technology diffuse.

Subsection 1.1.1 introduced a developer that co-develops the unmanned surface vessel (USV) project with a lead user. The macro perspective of the problem stated in subsection 4.3 describes how co-developing with a lead user could be a strategy to let a technology diffuse from the market adaptation phase to the market stabilization phase (Ortt et al., 2013). This strategy is called a 'lead user niche strategy' (Ortt et al., 2013). Framework 2.0 is a version of a lead user niche strategy. Meaning, framework 2.0 uses the transition from a project to a product platform to let a technology diffuse to the market. A developer should understand the macro perspective of technology adoption and diffusion because its decisions for functionalities should induce the technology to diffuse to a market stabilization phase. The technology will then be adopted by more customers, resulting in a higher turnover. Figure 7.3 visualizes this strategy. The figure shows three phases, which are visualized by figure 4.4. Next, the figure shows the first market introduction and a representation of the lead user niche strategy. How effective the lead user niche strategy is, depends on the per cent of adoption (see the vertical axis of the figure).
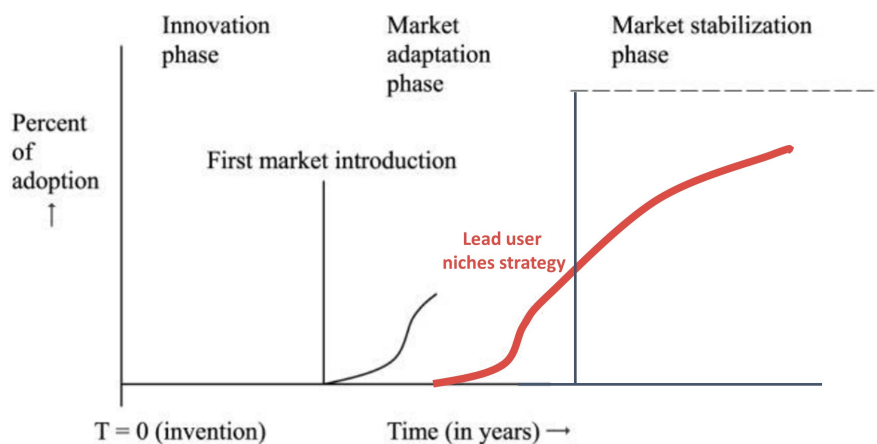
Figure 7.3: Adjusted figure of market adaption pattern, including a lead user niche strategy to diffuse a technology to the market stabilization phase (Ortt and Schoormans, 2004).

If the lead user niche strategy is not effective enough. Other nice strategies might be required to diffuse the technology to the market stabilization phase. Subsection 4.3.2 describes alternative niche strategies, for example, subsidized niche strategy or a redesign niche strategy (Ortt et al., 2013). Table 4.3 summarizes all possible alternatives described by Ortt et al. (2013) and figure 7.4 visualizes the result on the market adaption

pattern of the technology.
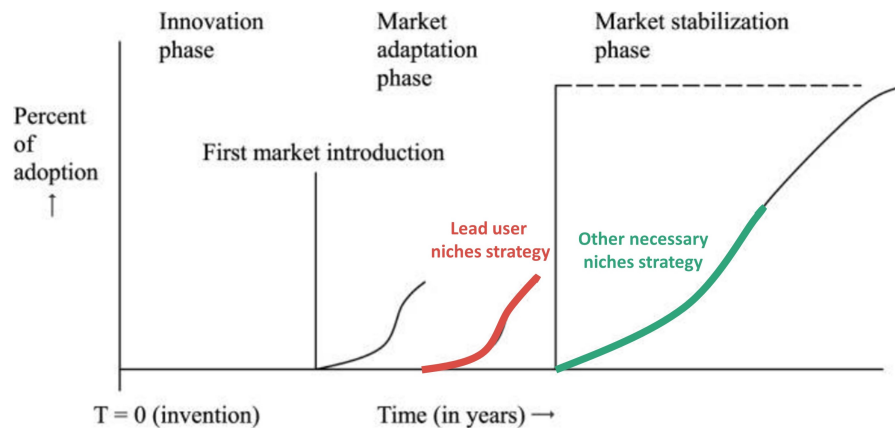
Figure 7.4: Adjusted figure of market adaption pattern. When another niche strategy is required to let the new technology diffuse to the market stabilization phase (Ortt and Schoormans, 2004).

Company characteristics
This framework is developed using a case study research on a company with certain characteristics. Companies considering framework 2.0 can compare the applicability with the help of these company characteristics. The list below summarizes the most important company characteristics:

- High-tech company
- Business-to-business orientation
- Client-driven development as a core business strategy
- Ambition to scale from project to product platform
- Small and flexible project team(s)

A high-tech company with client-driven development as a core business strategy indicates that the company is good at customizations. A company that uses the framework should have the ambition to transition to a product platform. Other possibilities, like standardization or multiple projects, are not the focus of this framework. Figure 3.2 shows the relation of these categories. The size of the team is important for the flexibility of the team. Too many people that have to switch between project and product platform costs more money and effort and can be a barrier (Lubik et al., 2013). On the other hand, too few people cause problems to keep a balance between market and technology (Lubik et al., 2013). This is one of the reasons start-ups tend to stay for too long TP oriented, as also described in subsection 4.5.2.

Project customer characteristics
This research studies a case in which the customer is a lead user. The customer has a certain need to be involved in the design process. Not only to influence the design but also to learn from technology. The customer pays for the development costs. This allows the developer to develop new technology. A company that uses framework 2.0 should be aware that at the project start, the customer is a lead user. The company uses this collaboration as a lead user niche strategy. Ortt et al. (2013) describes the innovative character of lead users as: "lead users can co-develop the product and innovators are willing to experiment with the product" (Ortt et al., 2013).

7.2.2. Phase 1: Collect knowledge
First, this subsection describes what knowledge should be collected. Second, the subsection describes why and how this knowledge could be collected.

Collect both knowledge of technology and knowledge of customers
A developer should collect both knowledge of customers and knowledge of technology to be able to make decisions about the functionalities for the product platform. Knowledge of customers refers to the knowledge required to understand customer their actual needs and be able to divide the market into segments

(see subsection 4.3.2). "The knowledge of the technology refers to the knowledge required to develop, produce, replicate and control the technological principles in a product" (Ortt et al., 2013). Collecting both types of knowledge enable the developer to balance TP and DP orientations. Balancing TP and DP orientations helps a developer to keep the error between innovations and actual needs as small as possible, and to include sufficient technological innovations (Lubik et al., 2013) (see section 4.5.2). The developer can expect that balancing between TP and DP orientations results in a better and faster development process (see subsection 4.4.1). Customers want to be able to influence the design and make sure it meets their needs. During the interviews (see chapter 6), it appeared that the potential market party, the expert and especially the customer of the project, explained that (potential) customers want to be involved at the beginning of the project. The developer should take this seriously because the developer can use its involvement to improve both their project and product platform preparation. Start-ups or small teams often tend to focus too much on the technology (Lubik et al., 2013). The interviews concluded this as well, see subsection 6.3. People working on the project often have beliefs that there is true value in the innovations, and experimental marketing takes places only occasionally. However, the developer may be too inward-looking (Lubik et al., 2013, p. 13).

Knowledge of customers
Market research provides insights that allow fewer design iterations needed at the end of the project. Validation of design choices with all these parties ensures that errors and mismatches can be adjusted at an early stage, without too much effort. Meaning that the customer of the project mainly benefits from these early market research and validations. The way in which companies can do so is by tailoring the market research methodology to the information that is required. Examples of methods are scheduling multiple meetings with the project customer, scheduling meetings with customers of the project customers, making calls with potential customers, organizing meetings with potential customers, visiting congresses and fairs. The developer can approach potential customers more often, so the influence of this customer can be fully utilized. Customer involvement can be important at a later stage of the product platform development process.

Knowledge of technology
The experience of the developer and the research and development for the project provide knowledge of technology. The developer would do well to investigate which knowledge can offer value in the market. Can the knowledge be used to create USP in a product? Ideally, the developer has intellectual property rights over technology that can result in a competitive advantage.

Visualization of a market situation
Figure 7.5 shows why knowledge of technology and knowledge of customers are crucial. The figure shows that this knowledge is required to control a market situation.

Figure 7.5 is an adjusted version of figure 4.5. The original figure was made by Ortt et al. (2013) to understand a market situation and to decide which niche strategy could be used to resolve the situation. The updated figure shows factors a company should control to make their lead user niche strategy successful. Another change is the replacement of knowledge or application by knowledge of customers and the addition of application at customers at the core factors. This adjustment results in more focus on the understanding of the needs of (potential) customers. This perspective is required for this specific research. It enables the developer to design the right product for potential customers, and therefore be more successful in the market situation, instead of searching for an application of the technology. The application of technology is still important but has shifted to core factors. It now is included in the process of defining the customers who benefit from the technology. These customers ensure that the high-tech product has an application.

The six influencing factors on the left can be seen as input for the core factors in the middle. "The influencing factors on the left indicate why problems in the core system may emerge" (Ortt et al., 2013). A distinction is made between factors that a company can influence and factors that are circumstantial. This visualizes the required focus on both knowledge of technology and knowledge of customers. Furthermore, companies should take the circumstantial factors into account and could act with company factors to control the market situation. Controlling the company factors could result in a thriving niche strategy.

7.2.3. Decision moment 1
At DM1, the developer should as a unity answer the question: "Are we going to transition?" This question enables a company to establish company unity. A company unity includes a shared goal and collective orientation to drive a team accomplishing their common goal (Salas et al., 2015; Moore, 2014) (see subsection 4.4).
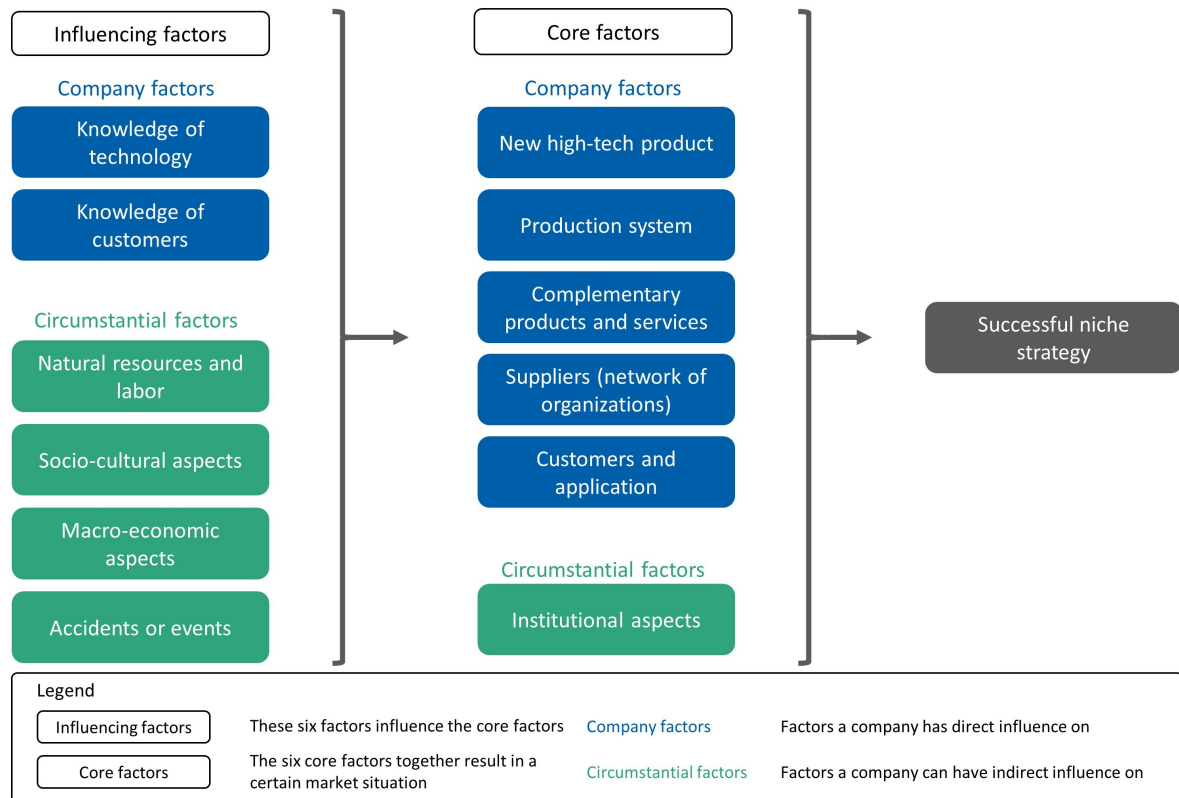
Figure 7.5: Twelve factors describe the system of large-scale diffusion of new high-tech products. (Based on Figure 4.5 and literature from Ortt et al. (2013)).

Therefore, everyone should agree on the requirements belonging to the transition, which are mentioned below. This indicates that from the engineer to manager, all people working on the product agreed on their goal (Moore, 2014). At the project start, the developer might have the ambition to transition from project to product platform. However, after phase 1, while having collected knowledge of the technology and knowledge of customers, the developer can decide to go for the transition. Organizing decision moment 1 is needed to ensure that the decision is made with everyone. Aligning the mindset of the personnel is important to prevent misunderstandings. The transition from project to product platform means some people are also working on the product platform in parallel with the project. There are multiple alternatives to guarantee company unity. Decision moment 1 should be a meeting, which has the goal to create a company unity about the decision. Therefore, the meeting can be recorded, and during the meeting, everyone involved can be asked if he or she accepts the plans.

There are three possible answers to the question, namely: 'yes', 'not yet', and 'no'. Figure 7.2 visualizes a developer that chooses 'yes'. A company can decide for 'yes' as soon as the team as a company unity (Moore, 2014) can conclude that the requirements have been met sufficiently. The requirements are described below. If a developer decides 'not yet', not all requirements have been met yet. In other words, phase 1 continues, and the decision moment 1 is postponed. A developer decides 'no' if the acquired knowledge shows the project will be a one-off and no relevant technology from the project can be used to develop a platform. Whether the requirements are met, depends on the conditions the developer sets for them. The list below sums up the requirements, after which each will be explained.

- Finance
- knowledge of technology
- knowledge of customers
- Organizational competences

Finance
The framework tries to keep the risks low. However, there is a financial risk. During the transition, there is

a risk that no product platform can be established. For the product platform preparation, there could be invested in personnel and time. The risk of the development of the platform is not included in this framework, because the development starts after decision moment 2.

Knowledge of technology
A developer must have sufficient knowledge of technology to be able to make a new, competitive and problem-solving product platform. Defining the unique selling points of potential products and the underlying technology helps to identify which part makes the solution in the project relevant. Defining the unique selling points ensures identification of which technology developed in the project can also be of value to other customers. Preferably, the technology is distinctive, new and relevant in such a way that the developer has intellectual property rights.

Knowledge of customers
The developer should have sufficient knowledge of customers, including knowledge of the customer of the project, the customer of the customer, other potential customers, competitors, and competitive products. To know what the potential customer needs, the developer should understand the problems of these customers. Also, it must be clear which potential customers have a joint problem that may be solved in the project by a knowledge of the developer its technology. Subsection 4.4.2 describes literature from Moore (2014), which shows that he endorses the necessity of dividing potential customers into market segments. The reason for this is one of the market segments will be the "target market segment", which is important to let the technology diffuse to the mainstream market (Moore, 2014).

Organizational competences
The list below sums up the organizational competences that need to be sufficient. Afterwards, all competences are explained.

- Right personnel
- Company unity
- Expected sales numbers and desired positioning

Right personnel
In the next phases, additional time and effort next to the development of the project are required for the product platform preparation. People working on these plans must be able to transfer the knowledge of the project to the product platform preparation. Literature from Moore (2014) also states the importance of hiring the right personnel for the search process of suitable market segments. This is described in subsection 4.4.2. Employees should be able to estimate the value of technology from the project and consider which potential customers might benefit their USPs. It should be possible to deploy the right personnel. Otherwise, it can be decided at decision moment 1 not to transition from project to product platform. Furthermore, it is recommended that a developer could establish two functions in their team: a market manager and a whole product manager (Moore, 2014) (See subsection 4.4.2). A market manager has the responsibility to search for potential markets, and the whole product manager has the responsibility to collect knowledge for the end products for all potential customers. In the end, they ensure together that both the influence of the developer and that of the market are sufficiently included in the product platform.

Company unity
A company unity includes a shared goal and collective orientation to drive a team accomplishing their common goal (Salas et al., 2015; Moore, 2014) (see subsection 4.4). As already mentioned, the decision in decision moment 1 must be made as a company unity. This company unity could also be retained during the transition. During decision moment 1, the team should conclude that this is feasible. It is possible that differences arise between design choices in the project and required choices for the product platform. Companies should determine if the team is able to retain company unity. There must be a clear policy to prevent annoyances and lost development time. Literature from Moore (2014) states a company unity is necessary, which is described in subsection 4.4. The case study research describes in subsection 3.3.1 that annoyances or misalignment can occur. The result might be that additional time and effort is needed if no clear policy for these design choices is set. If a company unity is too difficult to achieve, it may be better to decide not to transition from project to product platform. Besides, company unity also includes collective orientation. This orientation can be interpreted as a shared balance of TP and DP orientations as stated to be required by Lubik et al. (2013). Therefore,

subsection 7.2.4 describes how a company could balance TP and DP orientations.

Expected sales numbers and desired positioning
In decision moment 2, the focus is on a specific market segment. This also requires the developer to know how many customers it wants to serve, as described in subsection 4.4.2. An expected sales number depends on three factors, namely: The competition, which relevant technology from the project is used for the product platform, and the competences of the developer. For example: If the technology is only a small module, a higher sales number may be more appropriate. In the USV case, the developer wants to have certain customization within each product because that is one of their USPs. Then an initial smaller number of sales might be more suitable, for example, an order of magnitude of five to ten.

Regarding positioning, the competences of the developer and competition are decisive. The knowledge of the competition is known from phase 1, which enables the developer to identify how a potential market segment can be served. Furthermore, to serve a larger market, a certain positioning may be required, as described in subsection 4.4.2. The final positioning cannot yet be defined because it depends on the chosen platform and the corresponding market segment. However, formulating a desired positioning helps the decision-making of the set of functionalities. At decision moment 1 it may turn out that the desired positioning is not possible with the knowledge of technology or the knowledge of customers from the project until now. This may mean that the decision entails to not transition (yet) from project to product platform.

7.2.4. Phase 2: Prepare the platform
Phase 2 means using the time to prepare the product platform in addition to project development. The aim of phase 2 is to find the underlying problem of a market segment where innovation adds the most value. Phase 1 provided both knowledge of technology and knowledge of customers, which can be supplemented with new developments in the project and market research. A product platform should include the set of functionalities that balances customer's actual needs and a developer its knowledge of technology. A developer can derive the actual needs from the collected knowledge of customers. Meaning, preparing the product platform should be done by taking both knowledge of technology and knowledge of customer into account. A balance between knowledge of technology and knowledge of customers is a parallel with a TP orientation or a DP orientation. A TP orientation indicates that a developer focusses on knowledge of technology and a DP orientation indicates that a developer focusses on knowledge of customers. A balance between both TP and DP mechanisms should be found (Moore, 2014; Lubik et al., 2013). The explanation of why this balance is required is described in subsection 4.4.2 and 4.5.2. The interviews in chapter 6 validate the importance of the balance.

Taking both knowledge of technology and knowledge of customers into account in the decision-making process of the set of functionalities for the product platform results in a balance of TP and DP orientations. Figure 7.6a shows this balance. Knowledge of technology results in the understanding of what technical USP could be included in a product platform. Knowledge of customers enables the developer to determine the actual needs of a specific set of customers. If a developer focusses too much on knowledge of technology, a TP orientation might result in a large error between estimated and actual needs (Lubik et al., 2013, p. 18), which is described in subsection 4.5. Figure 7.6b shows this imbalance. If a developer focusses too much on knowledge of customers, a lack of technical added value might be the result of a DP orientation (Lubik et al., 2013, p. 18). Figure 7.6c shows this imbalance.

(a) Balance of TP and DP orientations.

(b) TP orientation due to too much focus on knowledge of technology.

(c) DP orientation due to too much focus on knowledge of customers.
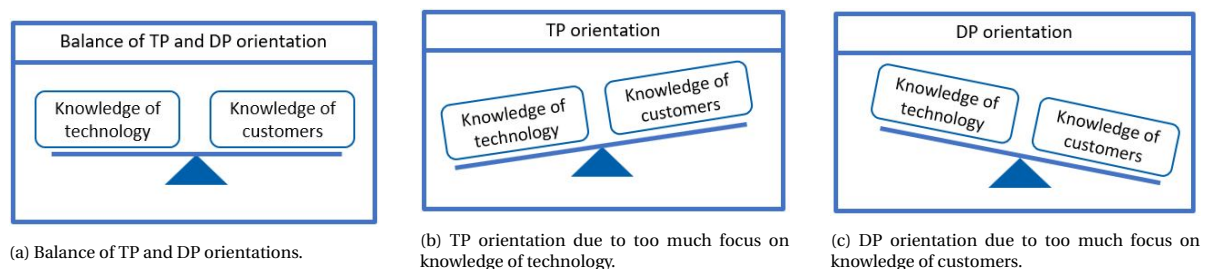
Figure 7.6: Balance and imbalance of TP and DP orientations in relation to knowledge of technology and knowledge of customers.

The preparation includes potential product platforms that each belong to a specific potential market segment. It is necessary to understand the shared problem of customers within a potential market segment to

prepare the functionalities for the product platforms. Understanding the shared problem enables the developer to identify shared actual needs. If the unique selling points (USP) of the product platform match the shared actual needs of the market segment, this segment is defined as a unique selling market (USM) by this research. The definition of a USM is: 'A market segment in which unique selling points of a developing company meet the actual shared needs of the customers from the market segment'.

Figure 7.7 is an extension of the field of tension as visualized in figure 7.1. Figure 7.7 visualizes the static relationship between the product platform, the developer, the competition and the USM. Although the relationship is visualized statically, the decision-making of the set of functionalities of the product platform is dynamic and iterative. Validations enable the developer to decrease the error between the estimated needs and the actual needs. The result should be a product platform that meets the specific needs of the USM and adds value by including USP in the set of functionalities. At last, the product platform should add value and should include a set of functionalities that has a competitive advantage.
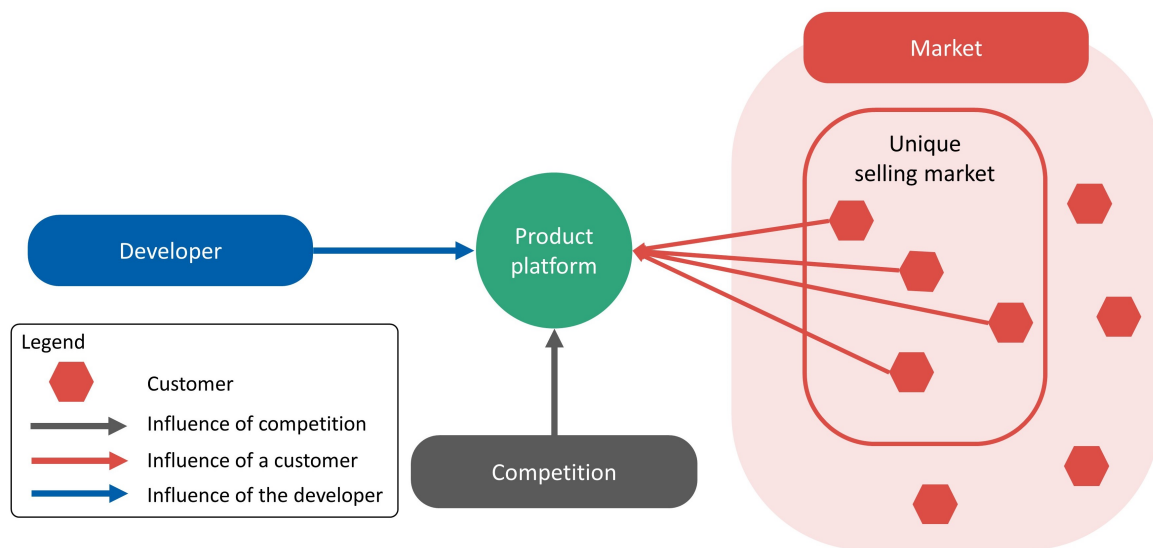
Figure 7.7: Static visualization of the influences on the product platform of the developer, the unique selling market and the competition.

By the end of phase 2, the launch of the MVP can provide additional knowledge of technology and knowledge of customers. Therefore, the developer can best seek several well-prepared product platforms. Preferably, the preparation of the set of functionalities for the product platform is almost complete. If demand got triggered by the launch of the MVP, the developer should respond to this instantly.

7.2.5. MVP launch in project

The launch of the MVP in the project is a proof of the knowledge of the technology. The MVP is co-developed with a lead user (see subsection 1.1.1 and 4.4.2). Meaning, the knowledge is initially proven to this customer. However, demand from other potential customers might get triggered because of the launch. According to Moore (2014) this is because the potential customers of the early majority are pragmatists. Subsection 4.4.2 describes that it is important to build references and relationships, and pragmatists want to buy a proven product. The interviews emphasized that the MVP has an important place in the transition from project to product platform. New knowledge of customers and validation of knowledge of technology is input for the decision-making process of the set of functionalities for the product platform.

7.2.6. Phase 3: Validate product platform preparation

Chapter 6 showed that the MVP triggers demand. This means the product platform preparation can be validated and can be fine-tuned. The interest of pragmatic potential customers in the technology of the developer has grown due to the introduction of the MVP (see subsection 4.4.2). Due to the product platform preparation, the developer already knows what their problems are and which technology can solve their problems. Before the platform is defined, it can now be validated. New knowledge can still influence the

decision-making of the set of functionalities, and it may also appear that a certain market segment is easier to reach. This knowledge can also be taken into account for decision moment 2.

7.2.7. Decision moment 2: Define the product platform
Phase 2 concludes by defining the product platform in decision moment 2. The list below sums up three parts of the decision. Afterwards, all parts are explained.

- Define a unique selling market
- Define the end products
- Define the minimum functionalities

Define an unique selling market
The developer should define a USM to decide for which customers the developer wants to develop the product platform. Defining a unique selling market depends on the desired positioning, the expected sales numbers, the organizational competences, the knowledge of technology, and the knowledge of customers. The goal should be to define a USM for which the knowledge of technology of the developer can add the most value. Defining a unique selling market includes defining the characteristics, size of the market segment, and the potential customers (see subsection 4.4.2). A USM is characterized by a shared problem that requires a shared solution to meet their shared actual needs. The product platform will be their shared solution, which can be customized to meet specific needs for each customer.

Example of a USM for the developer in the case study: A USM could be the market of USVs for inland water surveys in the Netherlands for which USVs are required that are small enough to transport by a single person with a car and a trailer. The size of the market would be 5 to 10 sold products to approximately four customers. On of the customer is a company that carries out dredging activities. Another customer is a company that carries out inspections above water. A third customer wants to use the USV for water quality measurements. At last, the government wants to use the USVs to map the waterways again.

Define the end products
First of all, defining the end product for each USM customer is required because the developer can derive what functionalities are needed for all customers. These could be selected for the product platform. Defining the end product needed by each customer enables a developer to define what a customer actually needs. According to Lubik et al. (2013), a developer could better prevent an error between actual and assumed needs. Therefore, this research states that defining the end product is required before a developer defines the minimum functionalities for the product platform. Besides, a product platform should be customized to complete the end product, with that the developer can meet the needs of all USM customers. The developer should design the product platform in such a way that customizations are easy. For example, in the product platform of the USV, customers likely need a different set of equipment for different applications. The inclusion of a 'Functionality X' in the set of functionalities enables easy customizations for these different applications. In general, a part that needs customizations for many customers should be easy to customize. Therefore, all potential end products for USM customers should be defined. On the one hand, this enables a developer to determine which the minimum functionalities for the product platform. On the other hand, this enables a developer to make a product platform that should easily be customized for the customers it belongs to.

Schematic representation of the end product
Schematic representation shows how to define the end product, which supports the company to define the minimum functionalities of the product platform. The end product distinguishes a physical part and a non-physical part. The non-physical part is, for example, training or installation. The physical end product can be divided into different parts: product platform, customizations by partners, customizations by the developer, and additions by the customer. The product platform includes all functionalities that are the same for every customer of the market segment. Customizations by partners are outsourced customizations. Developer customizations include all added or customized functionalities to meet the needs of individual customers. Besides, the customer can also make customizations to the physical end product himself. These are called 'additions by the customers'. These parts together are the physical part of what customers needs. The physical part, and therefore also the product platform, is dependent on the non-physical part of the end product. For example, certain business models or complementary products may have an influence on which functionalities can best be chosen to solve the problems of the customers. Figure 7.8 represents the parts schematically

as described in this subsection. The coloured circles are functionalities added or customized to the product platform. Subsection 6.3.1 describes how functionalities can be chosen. These circles together visualize the functionalities or parts that could be added to the product platform to complete the physical product needed by a specific customer. The figure was developed specifically for framework 2.0, but is based on literature from Moore (2014) as described in subsection 4.4.2 and knowledge collected during the case study research (chapter 3) and the interviews (chapter 6). Parts of the to be customized or added physical end product could be: additional software, additional hardware, system integration, cables (Moore, 2014).
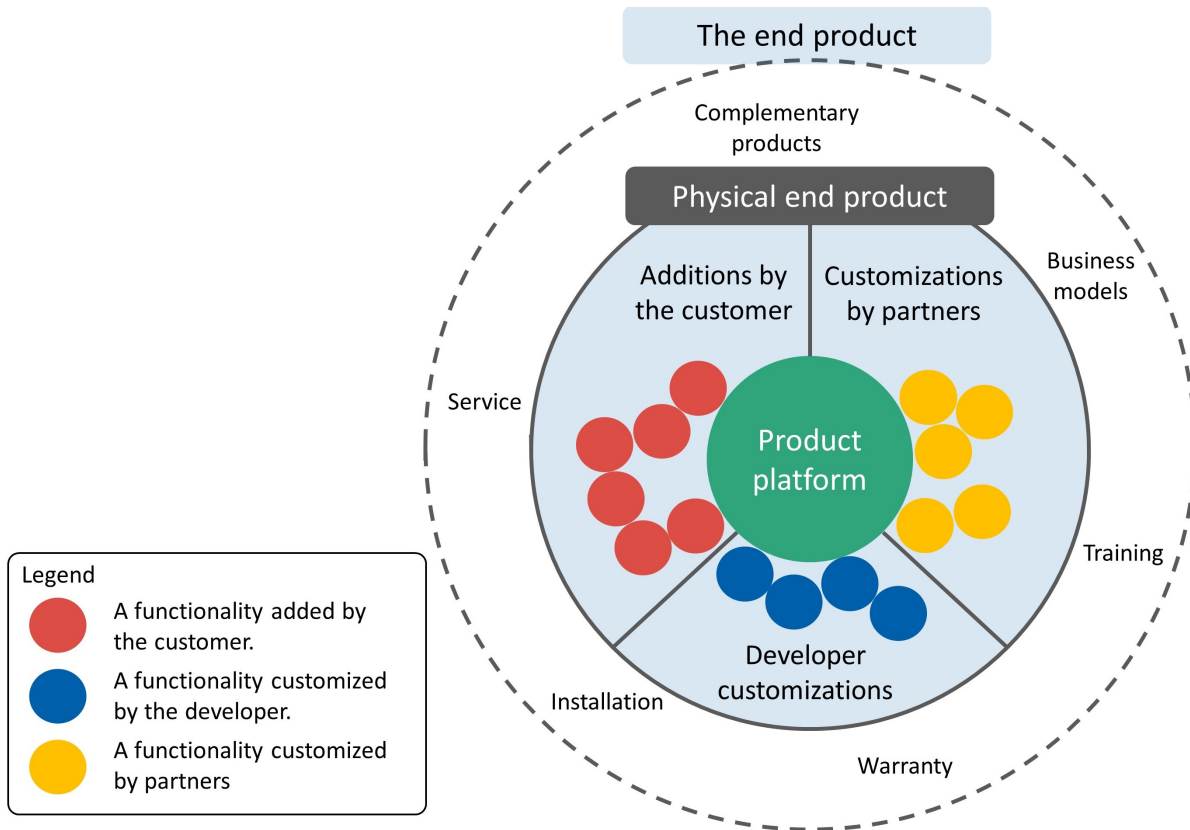
Figure 7.8: Devision of the end product. The end product is divided into the product platform, customizations necessary for each product by the developer, customizations outsourced to partners and additions by the customer itself. Each circle is a functionality.

Alternative physical end product configurations
Figure 7.8 showed a schematic representation of the end product. The physical end product contained additions by the customer, customizations by partners and developer customizations. Together all these additional and customized functionalities complete the product for a specific customer. Every customer receives a different end product. Depending on the needs of the specific customer, more or fewer customizations are required. The result might be the configuration that can differ for each customer. The figures below show several different physical end product configuration as visualized in 7.8. An example for each image is written in a black box for clarification of the configuration. Figure 7.9a shows a configuration of the physical end product that includes few customizations of partners, the developer and additions of the customer.

Example of the configuration presented by figure 7.9a: This example considers a case of a product platform that includes the minimum functionalities for the USV case as presented in table 6.2. In this example, the customer needs the USV to be more robust for an easy application for which they want to use their own equipment. In order to meet the needs of the customer, it might be that the developer should customize a fender around the vessel. As a result, the developer should also customize a software module to connect the added equipment of the customer. As a result, a partner has to customize the trailer with additional parts to enable the trailer to carry the customized vessel.

(a) This figure shows a configuration of the physical end product that includes few customizations of partners, the developer and additions of the customer.

(b) This figure shows a configuration of the physical end product with multiple customizations by both partners and the developer.

(c) This figure shows a configuration that only includes multiple developer customizations that are required for the physical end product.

Figure 7.9: Examples of configurations of the physical product.

Figure 7.9b shows a configuration of the physical end product with multiple customizations by both partners and the developer. However, to meet the needs of the customer, it is not required to include additional functionalities added by the customer in the physical end product.

> *Example of the configuration presented by figure 7.9b:* This example considers a case of a product platform that includes the minimum functionalities for the USV case as presented in table 6.2. This example is about a customer that needs a USV for autonomous inspections of bridges above water surfaces. In order to meet the needs of the customer, multiple software and hardware functionalities should be customized. In this case, inspection parts of partners could be added to the product platform, and the developer could customize software and hardware functionalities to enable autonomous inspections.

At last, figure 7.9c shows a configuration that only includes multiple developer customizations that are required for the physical end product.

> *Example of the configuration presented by figure 7.9c:* This example considers a case of a product platform that includes the minimum functionalities for the USV case as presented in table 6.2. This example is about a customer that needs a USV to transfer small loads in and around caves. The needs of this customer result in customizations of the software and hardware. The vessel should be able to position itself without 'Part Y', which requires customized software and hardware functionalities. Furthermore, the vessel should be able to carry small loads. The 'Functionality X' could be customized for this application.

The relation between the defined product platform and the defined physical end products.
Different configurations of the product platform enable the developer to meet the needs of each of the customers of the USM. Each customer receives a physical end product that is customized to meet their specific needs. Figure 7.10 shows how customizations to the product platform make sure the product meets the needs of each customer from the unique selling market. The figure shows that each customer of this USM needs a product platform, and also needs specific functionalities that could be customized by either the developer, a partner or added by the customer itself. To simplify the figure, all functionalities or parts that could be customized by the developer are represented by a single square. This is different than the representations of functionalities of Fig. 7.8 and Fig. 7.9. This also applies to the representation of functionalities customized or added by partners and customers.
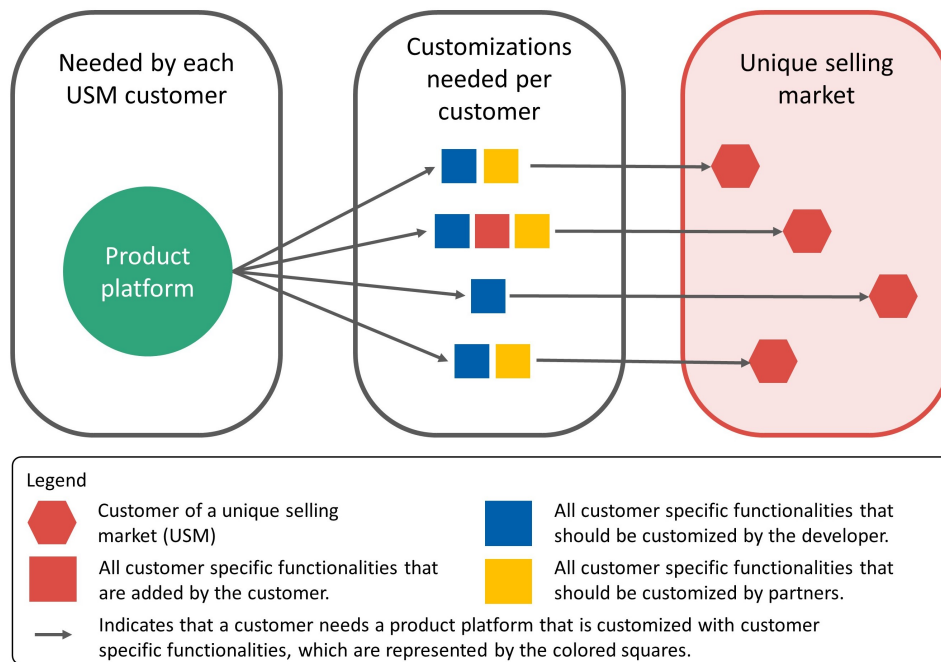
Figure 7.10: A product platform that meet the needs of all USM customers through different customizations.

Define the minimum functionalities

After a company has defined the USM and the end products for all customers, the company is able to define the minimum functionalities for the product platform. All, and only these, functionalities that meet the actual shared needs of USM customers should be included in the product platform. This means that every functionality that needs to be customized or added for specific customers of the USM should not be included in the product platform. The company can use knowledge of customers to determine the shared problem of the USM. The minimum functionalities solve the shared problem. This makes the product platform needed for all customers of the USM. Like previous subsections describe, functionalities for the product platform should be chosen in such a way that customizations are easy for the defined end products of all USM customers. This is derived from the definition described in subsection 4.5.2 and literature from Moore (2014).

Table 7.4 shows an example of the minimum functionalities for the product platform for the USV case.

Minimum functionalities for the USV product platform		
Functionality A	Functionality I	Functionality Q
Functionality B	Functionality J	Functionality R
Functionality C	Functionality K	Functionality S
Functionality D	Functionality L	Functionality T
Functionality E	Functionality M	Functionality U
Functionality F	Functionality N	Functionality V
Functionality G	Functionality O	Functionality W
Functionality H	Functionality P	Functionality X

Table 7.4: Minimum functionalities for the product platform of the USV case presented in random order. *Public version is encrypted*

7.3. Chapter conclusion

Framework 2.0 captured all knowledge of this explorative research. As a result, the workshop described in chapter 8 can *deliver* the results to the company. Also, the workshop validates framework 2.0.

8
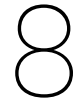
Workshop

8.1. Introduction

The workshop validates framework 2.0 and *delivers* the interview results to the company. According to the methodology described in chapter 2, conclusions of the workshop validate the main improvements of framework 2.0.

8.1.1. Objectives of data gathering

The formal objectives of the workshop are formulated below, and the list describes the to be validated parts.

Objective 1: *Validate the conclusions drawn from the interviews*
Objective 2: *Validate main improvements of framework 2.0, which are:*

1. Collecting knowledge of customers in the first phase
2. Decision moment 1
3. The minimum viable product (MVP) launch

8.1.2. Method

This subsection shows the action plan for the workshop. Framework 2.0 aims to support high-tech companies in their decision-making. Therefore, the interviewed employees have been invited to discuss the results. The list below shows the invited participants.

List of participants

1. Company perspective: Manager of the USV project
2. Company perspective: Industrial designer
3. Company perspective: Engineer
4. Company perspective: Engineer

A protocol has been made to prepare the workshop. This protocol provides a logical content and order of the workshop, and the protocol ensures the achievement of the objectives of the workshop. Appendix F describes the protocol and explanation of the protocol.

8.2. Analysis of results

This section describes the analyzed results of the workshop. The workshop was recorded and the workshop form is filled out by each of the participants, appendix H shows the results of the workshop form. There are results of three participants because one of the invited participants was not able to attend nor fill in the form.

Much difference in the requirement selections
The participants agreed with that there was a lot of inconsistency between the interviewees. Though, one participant identified some set of requirements that were included by almost all interviewees. He concluded that the current MVP is aligned with customer needs. The first quote of the workshop record was:

"There are a lot of inconsistencies, but our MVP is reasonably aligned with the wishes of the customer."

Early market validation and iteration
The participants agreed that collecting information from the market is essential at the start of the project. One participant states as the argument:

"The performance of a certain functionality should be tested with other customers to identify its value for the MVP and the product platform."

Validation essential elements framework 2.0
Earlier during the workshop, all participants agreed that it was essential to go to the market for collecting information for the project. The participants unanimously agreed that validating the decisions on requirements and performances of prototypes must be validated with the (potential) customers.

"The potential customer wants us to talk with him because he wants to influence the design of a solution for his problem. However, for us, it is also relevant."

One of the participants was thinking out loud about the distinction of the phases. The distinction of phases was clear. However, during phase 1, people might already think about phase 2. As an example, the participant mentioned:

"Knowledge of technology is already validated if it is relevant in an early stage of the project. Then people also are thinking about possible options for scaling before decision moment 1."

The relation between the MVP and the platform was clear. All participants agreed that this relation should be included in platform 2.0, according to the findings of the interviews. One of the participants was interested in what the validation process would include. Therefore, a discussion about how the MVP and the platform should be related to each other. The participants agreed that the product platform should be defined after the introduction of the MVP. By this time, the development of the product platform won't yet be started. One of the participants stated:

"The development can not start before the MVP is ready. We, as developers, agree that we should first develop the MVP of the project."

8.3. Chapter conclusion
The workshop validates the conclusions derived from the interviews and the main elements, as included in framework 2.0. Furthermore, recommendations for follow-up research are mentioned by the participants. These suggestions will be used to formulate the recommendations in chapter 9.2.2.

Furthermore, this section reduces the analysis of the results to statements that validate framework 2.0 and describe future research. Appendix 8.2 describes the results of the discussions and appendix H the workshop form results.

- The participants agreed that there is an inconsistency between all the selections of the engineers, indicating a lack of company unity.
- All participants agreed to collect information from the market at the start of the project, which validates the inclusion of collecting knowledge of the market and iterate with this in phase 1 of framework 2.0.
- Decision moment 1 comes when the team agrees that from that moment, it is time to prepare for a possible product platform.
- The MVP launch result in much input for the product platform. However, participants stated that they first want to spend their time on completing the MVP. This resembles a TP orientation.
- The model might be extended by a development planning of the product platform, including how the balance between technology and demand can be retained.
- Further research might focus on the duration of the phases and more details in the process.

9

Conclusion and discussion

9.1. Conclusions

The introduction described the following research problem: *Several companies experience challenges in their decision-making of the functionalities for their product platform when they aim to use a transition from project to product platform to enter the market successfully.* This research supports companies with a framework that captures the decision-making process of the minimum functionalities for the product platform. Figure 1.1 showed the coherence of the research. It visually shows how the answers to the three sub research questions (SQ) lead to the answer to the main research question (MQ). The first three subsections answer one SQ each and indicate how that SQ relate to the MQ. Subsection 9.1.4 answers the MQ.

9.1.1. Conclusion SQ 1

The first sub research question is: *What should the company consider to determine functionalities for the product platform?*

The answer to SQ 1 is: A developing company (is referred to as 'company' in this chapter) should consider what could be USPs of their knowledge and experience of technology, as well as knowledge of market segments and individual actual needs to select the right minimum functionalities for the product platform. The required knowledge is called knowledge of technology and knowledge of customers (Ortt et al., 2013), section 9.1.2 elaborates on knowledge of customers. The company requires company unity during an effective decision-making process of functionalities (Moore, 2014). A company unity includes a shared goal and collective orientation to drive a team accomplishing their common goal (Salas et al., 2015; Moore, 2014) (see subsection 4.4). Considering both knowledge of technology and knowledge of customers throughout the decision-making process enables a company to balance technology-push (TP) and demand-pull (DP) orientations (Lubik et al., 2013; Di Stefano et al., 2012). Therefore, companies should use both knowledge of technology and knowledge of customers throughout the entire decision-making process. However, this research showed that the company of the USV case is TP oriented in chapter 3 and section 6.3.1. Section 6.3.1 describes, for example, that the company wants to include a functionality in the product platform that is according to the customers not necessarily required. Thus, the decision-making process should be a dynamic and iterative process, which results in a balance between TP and DP orientations. The method used during the interviews, especially collecting knowledge from both the company and market perspective for the decision-making for the minimum set of functionalities, is an example of how a company could balance TP and DP orientations.Balancing TP and DP orientations enables a company to develop a product platform that contains technological USPs and meets the actual shared needs.

This research has found that, for a company that carries out client-driven projects, a transition from project to product platform can be a significant change. The expertise of all employees is required to decide on the set of functionalities. Therefore, the company should establish unity within the team. Interviews indicated many varying points of view on desired USV functionalities among employees. A company can ensure that the transition succeeds by preventing incorrect internal alignments with the result that time and effort is lost. This is called a company unity (Moore, 2014). This has led to the inclusion of two decision-moments (DM) in framework 2.0. The interviews revealed that the launch of the minimum viable product (MVP) in the project provides input to the preparation of the product platform. Also, the launch triggers the demand of potential customers, resulting in higher interest in the technology (Moore, 2014). The company can use this moment to start the dialogue by approaching potential customers and validating the product platform with them. That is why framework 2.0 emphasizes the influence of the MVP on the decision-making process. As a result of the DMs and the MVP launch, the process should be separated into three phases.

9.1.2. Conclusion SQ 2

The second sub research question is: *What should be the influence of the market on the functionalities for the product platform?*

The answer to SQ2 is: The market, which means the customers from a market segment, should have the opportunity to influence the functionalities by making clear what their problem is. The company should increase their knowledge of customers by performing market research and investigate the shared needs of potential customers. This enables the company to investigate if their technology is ready to diffuse to the market. Next, it allows the inclusion of the influence of the market in the decision-making process for the minimum functionalities. Investigating the actual needs of potential customers enables a company to select a unique selling market (USM). Selecting a USM enables a company to select functionalities that meet the shared need of all potential customers of the USM. A USM is a market segment in which unique selling points of the company meet the actual needs of the customers from the market segment. Ideally, the company can choose a USM in which their technology can offer the most added value. Literature states that a company must determine the actual needs of customers not too late (Lubik et al., 2013) and that companies should balance TP and DP mechanisms (Lubik et al., 2013; Di Stefano et al., 2012). Interviews showed that customers prefer to be included in the early stages of the requirement decision-making process. Framework 2.0 emphasizes that companies should collect 'knowledge of customers' in the first phase of a transition from a project to a product platform. Companies can collect knowledge of customers by scheduling meetings with clients of the project customers, make calls with potential customers, organize meetings with potential customers, visit congresses and fairs.

Market research should be carried out by all employees. For example, software engineers look at the problems of customers differently than managers. All specialisms are needed to determine actual customer needs, which will help to establish a company unity.

9.1.3. Conclusion SQ 3

The third sub research question is: *What should be functionalities of a product platform?*

The answer to SQ 3 is that all functionalities that meet the shared actual needs of all customers of the USM should be included. Therefore, the answer to SQ1 and SQ2 emphasized to collect knowledge of customers and knowledge of technology. Table 9.1 shows the minimum functionalities for the product platform of the USV case.

Minimum functionalities for the USV product platform		
Functionality A	Functionality I	Functionality Q
Functionality B	Functionality J	Functionality R
Functionality C	Functionality K	Functionality S
Functionality D	Functionality L	Functionality T
Functionality E	Functionality M	Functionality U
Functionality F	Functionality N	Functionality V
Functionality G	Functionality O	Functionality W
Functionality H	Functionality P	Functionality X

Table 9.1: Minimum functionalities for the product platform of the USV case presented in random order. Subsection 6.3.1 describes the analysis. *Public version is encrypted*

The analysis of the interview results (see subsection 6.3.1) revealed that included functionalities meet a shared need for all potential customers. Left out functionalities could either be seen as customization concerning the product platform or could be disregarded entirely. The derivation of the minimum functionalities for the product platform in the USV case is used to determine what should be functionalities for a product platform in general. Framework 2.0 describes that all functionalities derived from the knowledge of technology and required to meet the shared actual needs of the customers from the USM should be included in the product platform. These should be selected in consultation with the USM customers by validating and iterating the set of functionalities with them. Functionalities that need to be customized for a specific customer are excluded from the product platform. However, the minimum functionalities should be chosen in a way that customizations could quickly be done.

Because of multiple applications, some functionalities of a product platform are selected due to the multi applicability of the product. For example, enable a USV to use different equipment can result in the inclu-

sion of 'Functionality Y' in the product platform. For such decisions, it is required to define the needed end products of potential customers. That is why framework 2.0 describes that companies should define the end product. It shows that multiple configurations of product platform and customizations result in the physical end products for customers. The functionalities for the product platform could be defined with the help of defining the end product.

9.1.4. Conclusion MQ

The main research question is: *Considering a high-tech company that wants to transition from a project to a product platform, how should this company determine the functionalities for the product platform?*

The answers to the SQs describe what and why companies should do to determine the minimum functionalities that should be included in the product platform. The answer to the MQ describes the main points of how companies should do this. Figure 9.1 visualizes how companies should organize their decision-making process.
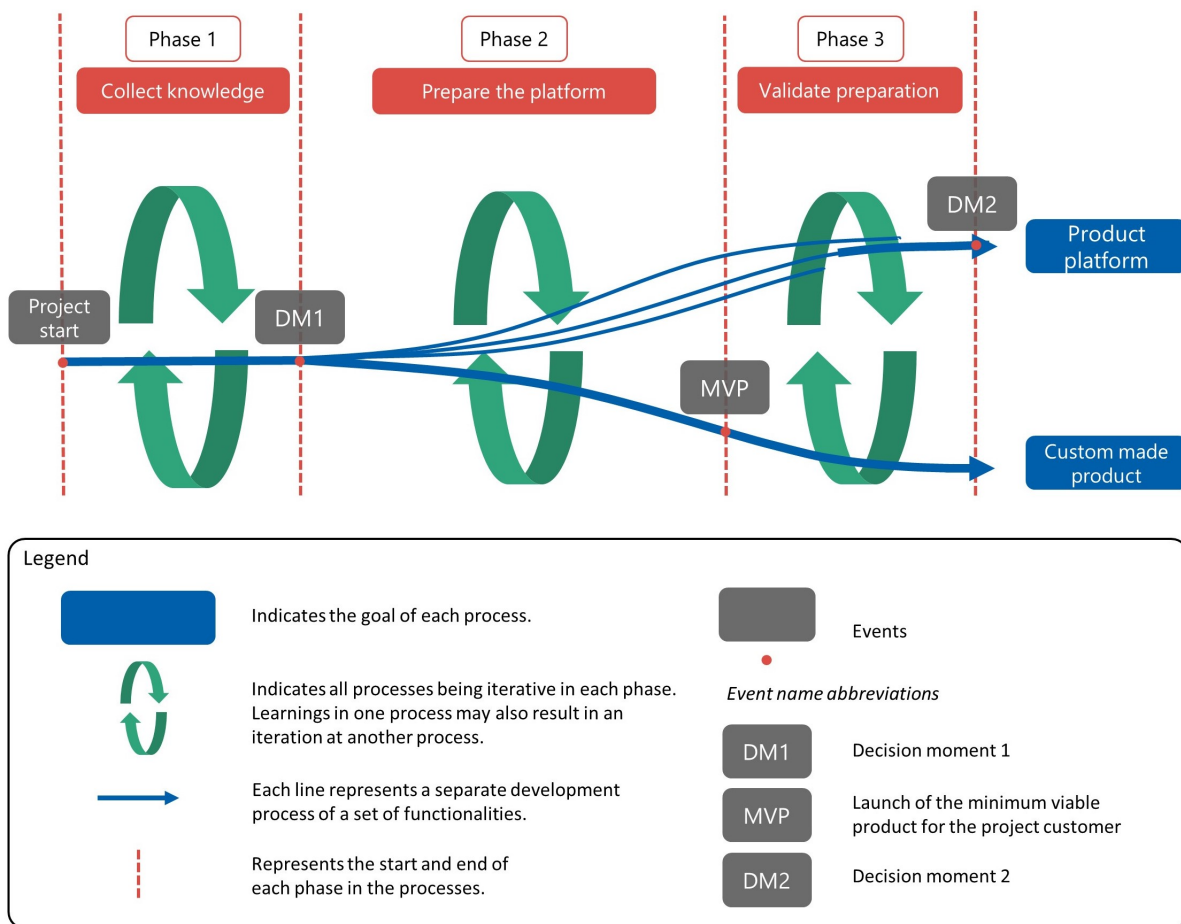
Figure 9.1: The decision-making process of the functionalities for the product platform in a transition from a project to a product platform as described in Framework 2.0.

Framework 2.0 shows that there are phases in which both knowledge of technology and knowledge of customers are used to develop the product platform. This is a dynamic and iterative process, indicated by the arrows. The market manager and whole product manager described in section 7.2.3 are responsible for this process. In this way, knowledge of technology and actual needs are balanced. In phase 1, a company should focus on collecting both knowledge of technology and knowledge of customers. From the start of phase 2, there is a distinction between two separate processes. Firstly, the project with the lead user is continuing towards the development of the MVP. Secondly, a process to prepare the product platform starts. The company prepares the product platform with the use of both knowledge of technology and knowledge of customers. At

last, the launch of the MVP enables the company to validate the product platform preparation.

The interview results showed the disunity among employees about the functionalities that should be included in a USV. This indicates that establishing unity is required in order to transition to a product platform. The answer to SQ1 described this. Therefore, DMs should be organized to structure the decision-making process and to establish a company unity during the entire process. Framework 2.0 shows that a company considers DM1 before the company starts to prepare the product platform to prevent time and effort from being lost due to a mismatch between actual and assumed needs (Lubik et al., 2013). Everyone should be on the same page regarding the following requirements. The requirements are based on the barriers described by Lubik et al. (2013) (see subsection 4.5.1) and the influencing factors described by Ortt et al. (2013) (see subsection 4.3.2). A company has to consider at DM1 whether they have..

- .. sufficient financial resources to take the risk of the hours necessary for the preparation and defining the product platform;
- .. sufficient knowledge of technology to be able to make a new, competitive and problem-solving product platform.
- .. sufficient knowledge of customers to determine the shared actual needs of potential customers.
- .. the right organizational competences, including the right personal, (the ability to create) a company unity and have set expected sales numbers and the desired positioning.

DM2 should be organized to define the minimum functionalities for the product platform together with all employees. Defining the USM and the end product is required to define the minimum functionalities. These steps are derived from literature from Moore (2014), see subsection 4.4.2. A company has to define at DM2 what should be ..

- .. the unique selling market (USM). Ideally, the USM is the market in which the USPs of the knowledge of technology add the most value.
- .. the end product. Considering the end product ensures that functionalities for the product platform are aligned with the configuration of the end product, and also ensures that functionalities are chosen in such a way that customizations are quickly done.
- .. the minimum set of functionalities for the product platform

Framework 2.0 shows how companies can approach the decision-making process .It structures the process and ensures that the company as a company unity can find a balance between knowledge of technology and knowledge of customers. This can result in a product platform that contains USPs and meets the shared actual needs of the customers of a USM. In this way, a company can find a balance between TP and DP mechanisms, which enables the company to diffuse its technology into the market.

9.2. Discussion
Subsection 9.2.1 describes the contributions, subsection 9.2.2 the recommendations, and subsection 9.2.3 the reflection.

9.2.1. Contributions
This subsection describes practical contributions and scientific contributions.

Practical contributions
The company of the USV case received a set of minimum functionalities for the USV. The company can use this set to validate and iterate its final product platform. The decision-making process that they can implement to make the transition to a product platform has been worked out in framework 2.0. The case study research of the USV case and the interviews with employees and (potential) customers ensure that the decision-making process captured in framework 2.0 fits in well with the company. Implementing the decision-making process can ensure that the company can develop a successful product platform of the knowledge of technology of the USV.

Framework 2.0 can also provide valuable knowledge to other high-tech companies that have adequate financial resources, employees and flexibility in strategy and aim to use a transition from project to product platform to enter a new market. Subsection 7.2.1 describes the technology, company and project customer on which the framework is based. Companies can implement the decision-making process described by framework 2.0, which starts with organizing DMs and assign a whole product manager and market manager.

Those managers could be responsible for further implementation of the process described by framework 2.0. The decision-making process supports their decision-making of the minimum functionalities for the product platform. By doing this, they can enable themselves to develop a product platform with low risk. Also, the implementation of the process described by the framework enables a company to balance TP and DP orientations. With that, a company can enable itself to let their technology diffuse to the market.

Scientific contributions

This research provides a way to balance TP and DP mechanisms (Di Stefano et al., 2012) and to balance TP and DP orientations (Lubik et al., 2013). Literature from Di Stefano et al. (2012) is the starting point for this research. One of the recommendations of his research was the question of further research on how companies could balance demand and technology. This research answers this question in case companies want to transition from project to product platform. Framework 2.0 describes how a company can retain a balance between demand and technology during the transition from project to product platform. With that, this research elaborates on the discussion of how companies should deal with TP and DP mechanisms (Schmookler, 1966; Mowery and Rosenberg, 1979; Van den Ende and Dolfsma, 2005; Di Stefano et al., 2012; Choi, 2018; King et al., 1994; Lubik et al., 2013).

During the research, it appeared that little is known about the use of a transition from project to product platform to allow a technology to diffuse into the market. An extensive literature study showed that there was no scientific literature on how a company should transition from project to product platform to diffuse technology. Therefore, this research contributes to scientific literature with new insights into a strategy to enter a new market and let a technology diffuse in the market. The framework offers a process to try to develop a product platform safely. The proposed transition is safe because a company could always cancel the scaling of their business and revert to single project development (see subsection 3.2).

To fill the knowledge gap, in particular existing literature from Ortt and Schoormans (2004); Ortt et al. (2013); Moore (2014); Lubik et al. (2013); Di Stefano et al. (2012); Gawer (2014) is used. Therefore, this research also complements the existing literature. This subsection describes the three most important complements. Firstly, this research states what functionalities should and should not be included in a product platform. All, and only these, functionalities that meet the actual shared needs of USM customers should be included in the product platform. This complements literature from Gawer (2014). Secondly, the use of figure 4.7 enabled this research to derive a model for defining the end product in the case of a product platform. This complements to the model presented by Moore (2014), see 4.7. Thirdly, figure 4.5 of Ortt et al. (2013) concerned the factors important for the development and large-scale diffusion of new high0-tech products is adjusted by including the factor 'knowledge of customers' and a distinction between company and environmental factors is made as visualized in Fig. 7.5. These complements contribute to scientific literature because they provide a specific use to the existing models. Researchers could use these adjustments to improve their models. Furthermore, the description of what does and does not belong in a product platform as described in subsection 7.2.7 supplements literature from Gawer (2014).

9.2.2. Recommendations

Firstly, this subsection describes practical recommendations. The first practical recommendations are case-specific and the second are general practical recommendations. Secondly, this subsection describes future research.

Practical recommendations

Case specific practical recommendations

Framework 2.0 is based on the company of the USV case its characteristics. Also, the company experiences problems with the decision-making process to which framework 2.0 offers an answer. Therefore, it is recommended to the company of the USV case to implement the decision-making process as described by framework 2.0.

Furthermore, there are two specific recommendations for the company of the USV case. Firstly, as is found in the case study research, the company of the USV case is TP oriented. The company seems to have a particular product idea and then looks for a customer for which the company can execute a project. This strategy may help them in obtaining projects, but literature and the interview results state that it is crucial to combine TP and DP orientations especially since the product platform will have to meet multiple customers' needs. That is why the company is recommended to experiment with active early market research. In practice, this means that more time must be sought to identify the problems of potential customers. Examples of

potential customers concerning the USV case are customers: who measure water quality, want to stop excess plant growth in lakes, and carry out port and quay inspections. At the moment, there have been exploratory talks with a few parties, but more market research can already be done in preparation for the product platform. It is recommended that the company also involves engineers in its market research. This research states that market research both improves the development of the MVP in the project and the development of the product platform.

Secondly, it was found that engineers have the idea that the decision for the product platform is primarily managerial. However, it seems that the engineers do not have an idea of what might be the influence for them. It feels like the employees are uncertain about what is expected of them in a transition to a product platform. The research shows that company unity is required to let technology diffuse to the market. Since that seems to be the goal of the ambition to transition to a product platform, it is recommended to establish a team unity as quickly as possible. The company could offer more inclusiveness to employees on a strategic level, which can reduce the uncertainty among employees. Besides, DM1 enables a company to align all employees formally. The result might be a shared mindset for the transition to a product platform. In this way, the employees probably also know better what they can expect and what is expected of them.

General practical recommendations
In general, it is recommended for companies that want to transition from project to product platform to use framework 2.0 as a guideline. The change for the company that occurs while implementing the proposed process can lead to difficulties. The company may have been accustomed to implementing projects for a while, making changes takes time and energy that is currently being used for performing projects. Therefore, a company would do well to define what changes it requires to their current process and who should be responsible for these changes. Examples that could help are: make one person responsible for the decision-making process, plan DMs, and create documentation of the DMs. In the case of establishing a company unity is tough, multiple meetings might be required to align all employees.

This research recommends a company, that wants to transition from project to a product platform, to build in time in each meeting with a customer or other market parties to gain specific knowledge for the product platform. Furthermore, a company could organize a meeting before DM1 to discuss when the requirements of DM1 are sufficiently met. This might result in a faster alignment of all employees.

Future research
This research is explorative. It is recommended for further research to validate the knowledge captured in framework 2.0. Are companies more successful in diffusing their technology to the market in the case they apply the decision-making process of framework 2.0? Follow-up research could observe how other companies deal with a transition from a project to a product platform. These observations can complement and validate the knowledge captured in framework 2.0. There are specific findings in this study that deserve additional research. This subsection describes these below.

This research discovered that individual employees could have a significant influence on the company its TP or DP orientation. It appears that some engineers seem to be more comfortable on a TP orientation. They do not necessarily like to talk to the customer but prefer to design an excellent technical product. Their TP orientation can be the result of their education, but there may also be other reasons. This research states that it is necessary to balance TP and DP orientations in the company. However, it appeared that some individual employees could be TP oriented and can result in imbalance in the company. Therefore, follow-up research can focus on how companies can organize a TP and DP balance among all employees. Besides, follow-up can focus on how individual employees can learn to balance TP and DP orientations. How could individual employees become more DP oriented?

Also, this research discovered that there was a lack of clarity about which managerial tasks belong to which employees. It was unclear which employee performs the merging of various technical components. Despite this, the team does not seem to be bothered by that now. However, with the upcoming transition, there might be more tension on the leadership. Good leadership is likely needed to lead this transition. Framework 2.0 introduces two new positions: a market manager and a whole product manager (see subsection 7.2.3). These suggestions for these functions are based on literature from Moore (2014) described in 4.4.2. Further research could investigate what the effect of the proposed leadership is on the transition from project to product platform.

This research states that a TP oriented company that wants to transition from project to product platform should do market research with both engineers and managers. In this way, the company becomes TP, and

DP oriented, which could lead to a better result according to Lubik et al. (2013) and the interview results. However, follow-up research can focus specifically on the following: What are the effects of executing market research together with all employees at an early stage on both the MVP of the project and the development of the product platform. Does this lead to more technical innovations? Is the team becoming more creative? Does this result in a team that balances TP and DP orientations? Can this shorten the development time for the MVP of the project?

The focus of this research was on a transition from project to product platform. The research used a single case study, which showed that scaling to a product platform is the ambition but also suits its current organizational structure. The transition to a product platform allows the company to diffuse its technology to the market. So, this is one case where the product platform is used to diffuse the technology to the market. However, this research does not describe when a product platform is suitable for diffusing the technology, or when it is better to use a different (niche) strategy. Further research could focus on: When is a product platform suitable for diffusing technology to the market?

This research leaves open the question of when a company has used sufficient knowledge of technology and knowledge of customers to define the set of functionalities. The study emphasizes the importance of balancing, but it is unclear how exactly that leads to a complete set of functionalities. This research states that the set of functionalities can be successful if it adds value to the USM customers. However, additional research into when the set of functionalities is complete can further support companies. Are there categorizations of functionalities that are needed in any case to define a complete set? Which type of functionalities must, in any case, be present in a product platform to be competitive? How can a company measure whether the set of functionalities is complete?

After decision-moment 2 of framework 2.0 start, the sale and development of the (end) products start. The interviews revealed that employees are interested in the process that will follow after DM2. Follow-up research could focus on this process, which is also recommended during the workshop, see subsection 8.2. How can the balance between technology and demand be maintained in the development process of the (end) products? How does defining the product platform lead to actual sales agreements with the USM customers?

9.2.3. Reflection
A case study research is found to be a suitable method to start in explorative research. This research started with a single case study to discover the empirical problem. The case study research resulted in input for the framework designs. Other researchers doing explorative research at companies are therefore advised to consider starting with the use of a case study.

The research problem is complicated due to multiple problem levels. That is why multi-level literature research was chosen as a research method. It is recommended that researchers who want to investigate a problem that also has multiple levels too, consider to carry out multi-level literature research. See also the reconsideration of the multi-level literature research described by subsection 4.6.

This research has used multi-methods to come to a conclusion and a framework design. The multi-methods enabled the research to capture the complexity of the problem. The observations and interviews of the case study research and the investigation of the literature led to input for the framework. The first framework provided a structure for many results. This research used the first framework to make an iteration by including additional input from interviews. The result was a significant improvement to framework 2.0 compared to framework 1.0. Therefore, researchers who aim to deliver a framework are advised to consider the use of an additional research method to iterate their framework.

Chapter 3 described that the company has the ambition to scale to a product platform. Other options would be to do multiple custom made projects using the same knowledge or develop a standardized product. Figure 3.2 shows these alternatives. This research shortly investigated why a product platform could be suitable for diffusing the company its technology to a market. However, this research did not investigate whether one of the other alternatives would be better even if that would be a larger change to the organization in the case of standardization.

This research stated that defining the end products for all USM customers is required to define the functionalities of the product platform and because of taking possible customization into account. In this way, a company ensures that the functionalities can be aligned with all the USM customers their needs. Defining the end product needed by each customer enables a company to define what a customer actually needs and with what the company deal with if it should customize its product platform. However, it might be that in practice, not the complete end product has to be defined in order to define the minimum functionalities and

ensure the product platform can be customized for each USM customer. Defining the complete end product before actually defining the minimum functionalities might be expensive. Therefore, a company should consider up to what level it should define the end product. Future research could also focus on what a company needs to know about the actual needs of a customer in order to determine the functionalities of the product platform.

One researcher executed this research. Therefore, it is essential to mention that informal manipulation might have occurred during this case study observation as a shortcoming of this method regarding the validity of the research (Yin, 1994). Also, the framework is based only on one case instead of multiple cases. The use of one case resulted in a lot of research depth but complicated the validation of the results.

The research of Ortt and Schoormans (2004) is done on communication technology. This research assumed that the pattern of the development of communication technologies could be generalized to other new technology development patterns because a comparable pattern is also extensively described by other literature (Moore, 2014). Therefore literature from Ortt and Schoormans (2004) and Ortt et al. (2013) can be used as state-of-the-art for this research. However, these assumptions may lead to bias if technology development has a different pattern than expected.

This research intended to design a framework 1.0 and a framework 1.1. However, due to the new insights from the interviews, the emphasis of earlier findings drastically changed. Therefore, the redesign is called framework 2.0.

This research states that knowledge of customers should be gathered from the beginning of the process. Also, a company should validate its knowledge of technology with (potential) customers. This research did not take intellectual property (IP) rights into account as a barrier to validate knowledge of technology with customers. The reason is that knowledge of technology does not necessarily have to be explicitly validated; it can also be implicitly validated by conducting potential customer-oriented research into actual needs associated with the technology to be validated. This was mentioned by the interviewed expert. However, there might be cases IP issues can still be a barrier. Agreements between the project customer may be a solution, certainly if the developing company can explain that the validations will contribute to the project development. More research could be done on how companies can deal with this barrier properly.

In order to gather knowledge for different perspectives of the problem, interviews were held with a customer, a potential customer, with different employees and with an organizational advisor. This decision was based on the available time of this research. However, the market might be under-represented. Additional interviewees of the market could have led to additional insights.

Interviews were held with (potential) customers, with employees, and with an organizational advisor, but not with the competition. Therefore, the importance of taking into account the competition in the decision-making process may be underexposed. The research revealed that early market research is needed to stay ahead of the competition. Why that is necessary and what the influence of the competition is on the platform is not included.

A

Document: competitive environment

This information is provided by Demcon unmanned systems as material for analysis of this study. This information was sent by mail and is slightly changed and translated to make it suitable for use in this study.

The competitive field concerns manufacturers of Unmanned Surface / Survey Vehicles / Vessels (USV) or Autonomous Surface Vehicles (ASV). They make systems for, for example, the following applications: marine surveys, monitoring, hydrographic surveys, oceanographic research and maritime missions.

Here are a few links to for a first market insight:

- http://www.teledynemarine.com/oceanscience

- https://www.aquaticdrones.eu/

- https://www.oceanalpha.com/

- https://www.asvglobal.com/

- https://www.clearpathrobotics.com/heron-unmanned-surface-vessel/

- http://www.chcnav.com/index.php/product/detail?id=48&ctype=5&cid=1 : Singlebeam capaciteit ipv Multibeam (nodig) en 1 type sensor.

- http://www.ceehydrosystems.com/products/unmanned-survey-vessels/cee-usv/

- http://www.chcnav.com/index.php/product/detail?id=48&ctype=5&cid=1 : Singlebeam capaciteit ipv Multibeam (nodig) en 1 type sensor.

- https://maritimerobotics.com/

- https://evologics.de/sonobot-system

- https://www.dotocean.eu/products/

- https://www.kongsberg.com/maritime/products/mapping-systems/multibeam-echo-sounders/geoswath-4r-usv-unmanned-surface-vehicle/

- https:www.searobotics.com/products/autonomous-surface-vehicles/sr-utility-2-5

- http://en.marinetech.fr/Marine-survey-USV

- http://www.heliceo.com/en/produits-pour-geometres/superbathy-bathymetric-drone/

- https://deepocean.com/usv-phantom-1650.php

- ...

Important concurrents: Ocean Alpha, ASV Global, Teledyne/ Oceanscience, Evologics, Maritime Robotics, Kongsberg (EU of VS based bedrijven)

B

Literature search micro level

The following steps were done:

1. A list of search terms, see Table B.1 are tried and titles were selected if they contained information about "product platform OR market-driven OR demand-driven AND strategy OR management", but were rejected if already was clear it was not about the pre-diffusion phase of product development.

2. Articles and books matching the requirements are listed

3. The list, see the next page, was screened and if the subject contained information about "product platform" in the pre-diffusion phase it should be relevant.

With these steps there was identified that no literature regarding the topic of product platform in the pre-diffusion phase exists.

No.	Search terms
1	R&D product platform
2	R&D "Market-driven"
3	Product platform management transition
4	Product platform
5	Product platform transition
6	Scalable product platform
7	Product platform management
8	Product platform management segmentations
9	Product platform segmentation
10	Product platform commercialization
11	"Market segment" commercialization
12	"Market segment"
13	"Market orientation" transition
14	"Market orientation"
15	"Developing markets"
16	"Demand-driven" commercialization
17	Demand-driven
18	Market-driven
19	"Mass customization"
20	"Market segment" commercialization
21	"Market segment"
22	"Market orientation" transition

Table B.1: Search terms used in scopus to search for literature about product platform development in a pre-diffusion phase

List of articles found:

- Talonen, T., & Hakkarainen, K. (2008). Strategies for driving R&D and technology development. Research-Technology Management, 51(5), 54-60.

- Cheng, X., Lan, G., & Zhu, Q. (2015). Scalable product platform design based on design structure matrix and axiomatic design. International Journal of Product Development, 20(2), 91-106.

- Bäckstrand, J., & Lennartsson, M. (2018, August). Customizations vs. Platforms–A Conceptual Approach to COSI. In IFIP International Conference on Advances in Production Management Systems (pp. 116-123). Springer, Cham.

- Simpson, T. W., Bobuk, A., Slingerland, L. A., Brennan, S., Logan, D., & Reichard, K. (2012). From user requirements to commonality specifications: an integrated approach to product family design. Research in Engineering Design, 23(2), 141-153.

- Farrell, R. S., & Simpson, T. W. (2008). A method to improve platform leveraging in a market segmentation grid for an existing product line. Journal of Mechanical Design, 130(3), 031403.

- Marion, T. J., Freyer, M., Simpson, T. W., & Wysk, R. A. (2006, January). Design for mass customization in the early stages of product development. In ASME 2006 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference (pp. 673-682). American Society of Mechanical Engineers.

- Frenkel, A., Maital, S., Leck, E., & Israel, E. (2015). Demand-driven innovation: An integrative systems-based review of the literature. International Journal of Innovation and Technology Management, 12(02), 1550008.

- Li, D., Wang, X., & Qian, L. (2012, November). The impact of market orientation and R&D strategy on business performance: An empirical examination. In 2012 International Symposium on Management of Technology (ISMOT) (pp. 168-172). IEEE.

- Verma, D., Mishra, A., & Sinha, K. K. (2011). The development and application of a process model for R&D project management in a high tech firm: A field study. Journal of Operations Management, 29(5), 462-476.

- Comanita, B. (2011). Market research & new product development The market size. Chimica Oggi-Chemistry Today, 29, 3.

- Olavarrieta Soto, S., & Friedmann, R. (2008). Market orientation, knowledge-related resources and firm performance.

- Kumar, D., Chen, W., & Simpson, T. W. (2009). A market-driven approach to product family design. International Journal of Production Research, 47(1), 71-104.

- McGahn, D. P. (2005). Commercializing a new technology in six easy pieces: It all starts with focus. Nanotech. L. & Bus., 2, 90.

- Ortt, J. R., Langley, D. J., & Pals, N. (2007). Exploring the market for breakthrough technologies. Technological Forecasting and Social Change, 74(9), 1788-1804.

- Ortt, R. (2012, June). Market creation for radically new technologies: A literature review on the role of market niches. In 2012 18th International ICE Conference on Engineering, Technology and Innovation (pp. 1-16). IEEE.

- Simpson, T. W., Maier, J. R., & Mistree, F. (2001). Product platform design: method and application. Research in engineering Design, 13(1), 2-22.

- Simpson, T. W. (2004). Product platform design and customization: Status and promise. Ai Edam, 18(1), 3-20.

- Qu, T., Bin, S., Huang, G. Q., & Yang, H. D. (2011). Two-stage product platform development for mass customisation. International Journal of Production Research, 49(8), 2197-2219.

C

Search terms for general literature

These search terms are used in the medium 'Scopus', articles were selected if they contained knowledge about a factor described by Di Stefano et al. (2012), and about funtionalities, respectively technology, or commercialization strategies, and should have a relation to TP and DP mechanisms.

#	Factor	All search terms
1	Organizational competences	Organizational AND competences, High Tech organizational competences, Push pull competences, Technology-push AND Demand-pull AND firms, Technology-push AND Demand-pull AND companies, Technology-push AND Market-pull AND companies, Technology-push AND Market-pull AND firms, Push AND Pull organizations, Balance AND Push AND Pull, Balancing AND Push AND Pull
2	Marketing practices	Marketing AND push AND pull, Marketing AND technology-push AND demand-pull, Marketing AND technology-push AND market-pull, Marketing "literature review", Marketing AND Push AND Pull, Marketing review, Market AND innovation AND Push AND Pull
3	Demand and user innovation	"Literature review" AND technology AND commercialization, Customer oriented AND push AND pull, Customer based AND push AND pull, Demand AND User AND innovation, Demand AND customer AND innovation AND organization, "literature review" AND user innovation
4	Systems of innovation	"Systems of innovations", Technology and systems of innovations, innovations systems AND technology AND demand, innovations systems AND technology AND market, "literature review" AND innovation systems
5	Technology diffusion and adaption	"Literature review" AND Technology AND commercialization, "Pattern of development" AND technology, Adoption AND cycle, Adoption AND Technology AND demand, Adoption AND technology AND demand, diffusion process technology, "diffusion process technology", Diffusion AND technology AND adaption, Diffusion AND technology AND adoption, Push AND Pull adoption, Push AND Pull adaption, Push AND pull diffusion

Table C.1: Search terms used for capturing all research fronts of the TP and DP research field

D

Protocol for interviews

The interviews held with the employees of the developing company and (potential) customers are the same. The expert interview is different. Therefore, this appendix describes two different protocols.

D.1. General interview protocol

The protocol describes 'the opening', 'first part', 'second part', 'third part', and 'the closing' separately, to structure the interviews.

Introduction of each interview

At the start of each interview, both objectives must be explained, and the structure of the interview must be proposed. Furthermore, a short introduction to the research must be provided. This includes the subject and naming that both the market and the company are involved in the study

Protocol opening (5 min):

- Introduction of interviewee and interviewer
- Introduction of the structure of this interview
- Introduction of the interest of this research, without talking about content
- Inform the interviewee why this interview is important for the research
- Ask approval to record and use data from the interview

First part of the interview

The first part of the interview is about gathering data on their reasoning of what functionalities should be included in a USV. Plasticized cards on with requirements and functionalities and blank cards with pencils are provided to the interviewee. The blank cards ensure that the interviewer can add additional requirements and functionalities. The interviewee is asked to make a selection of what he wants in a USV. The interviewee creates a visualization and a selection with the cards. The interviewer observes the decision-making process. At this moment, the interviewee is asked to think out loud.

Protocol for the first part (15 min):

- Provide cards with requirements and functionalities.
- Explain the blank cards, and also if wanted other material.
- First question: From your perspective, what are requirements [1] to include in a USV.
- Second question: Do you want to change anything; otherwise, I want to take a picture and ask some questions about your chosen set of functionalities?

Second part of the interview

The second part of the interview is about identifying the method the interviewee used to come up with a set of functionalities.

Protocol for the second part (20 min):

- How did you come up with this set of functionalities?
- What are the consequences of your set of functionalities?

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[1] There is chosen for 'requirements' instead of 'functionalities' to identify all USP. There might be USPs in requirements that are not in functionalities.

- ...especially for the customer?
- ...especially for the market?
- ...especially for the company?
- Do you want to change your set of functionalities after this discussion?

Third part of the interview
The third part of the interview is about complementing and validating the current findings of this research regarding the answering of the research questions. The unstructured time can be used to find answers for the following:

1. What is the reasoning behind the set of minimum requirements selected by the interviewee from his perspective?
2. How and when do the developer and the market try to reach each other?

Protocol for the third part (10 min):

- Unstructured discussion time to validate framework 1.0.

Closing the interview
A summation of the main points of the interview must be formulated, and there is asked to validate the summation. Next, the research will continue. The interview will be concluded with a word of thanks and an invitation to perceive the results will be provided.

Protocol for closing the interview (5 min):

- Summation of the main points
- Time for the last remark by the interviewee for validation
- Ask permission to send a brief report of the interview and ask if the interviewee wants to evaluate it.
- Word of thanks and invitation for the workshop (in case if the interviewee is a worker from the company), and for the graduation date.

Required materials

- Cards with functionalities
- Empty cards
- Memo paper
- Pens and pencils

D.2. Expert interview
The main difference between the expert interview and the other interviews is the exception of the functionalities selection process. The expert interview validates the findings in the research and the other interviews and complement if there are differences in the findings and his experience and knowledge.

Protocol expert interview:

- Opening will be the same as the other interviews (5 min)
- Explain the research and the research questions.
- First question: What is your vision on the problem?
- Describe the findings of the other interviews.
- Second question: What do you think of the findings?
- Third question: Can you complement the knowledge, what do you observe in the field?
- Fourth question: What should a company in transition from project to product platform do? (Regarding the decisions of the set of functionalities)
- Closing is the same as the other interviews (5 min)

Interview results

E.1. Results of interview 1

This interview is held with a potential market party for a USV, the function of the interviewee is 'Manager Development & Innovation.'

How did you derive this set of requirements?
The following steps can summarize the method to derive the minimum set of requirements:

1. Define requirements essential for its mission.
2. Set "Need-to-haves" enabling the USV to execute a mission
3. Determine operational requirements.

What are the consequences of your set of requirements?
The answers can be summarized as follows:

- ... for the market:
  - The introduction of an unmanned inspection vessel disrupts the market because normally these missions are done by vessels estimated around 15 meters long and with two to three persons on board.
  - A cost reduction can be the cause of disruption for inspection missions. For example, an inspection right above water level on difficult locations can be simplified with an autonomous vessel.

- ... for the customer:
  - Depending on the application, additional and more specific requirements must be taken into account. These must be added to the minimum set of requirements of a USV.

- ... for the developer of the USV:
  - "First of all, the developer must translate the needs and requirements of customers or potential customers to a product that has a better price/performances than alternatives.
  - "It must physically be possible."
  - "The developing company must have the knowledge to develop the system."
  - "The system to be developed must be able to accomodate a certain volume and weight in the hull"
  - "Equipment must be available."

Summary of unstructured interview time
In the unstructured interview time, a discussion is held to identify the influence the market has on the requirements, which refers to SQ2. In this case, the interviewee is a market party and customer of the project. In this way, the gathered knowledge validates and complement the current knowledge from the perspective of a potential customer.

- The focus on a MVP instead of other potential market needs with a relatively small team might have to do with barriers of personnel and financial resources. This also depends on the organizational structure.
- "The role of the developer is to create a product that provides substance to the market needs. That is why the development process is an iterative process."
- The boundary of the platform lies in determining which generic aspects must be in the platform.

- The decisions what should be included and what should not depend on for whom the platform should be developed. Therefore, understanding multiple wants from a number of market parties is necessary to validate if a platform would suit.
- "When determining which requirements should be included in the platform, it is essential for me that a developer has a clear understanding of the needs of the market segment."

Reduced results from interview 1

1. *What is the reasoning behind the set of minimum requirements selected by the interviewee from his perspective?*
   The set of requirements is closely related to the mission or application of the USV. Determining the set of requirements should be based on the mission. However, a minimum set of requirements can be defined independently of the mission, the "Need-to-haves" of a general USV. This minimum set of requirements can be defined as the platform.
2. *How and when do the developer and the market try to reach each other, according to the interviewee?*
   It is the responsibility of a developer to understand the market needs before defining the product platform to fulfil the needs as well as possible.

E.2. Results of interview 2

This interview was held with a manager of the market party for whom the company of the case study research is doing a project.

How did you derive this set of requirements?

The following steps can summarize the method to derive the minimum set of requirements and requirements:

1. Select the minimum set of requirements of which I think should be included.
2. Exclude requirements that can be decided by the developer

What are the consequences of your set of requirements?

The answers can be summarized as follows:

- ... for the market:
  - I don't know if it means a lot to the market, but it certainly fills a gap in our required equipment
  - With the use of an autonomous vessel, the working hours for a skipper can be saved. Depending on the regulations where you can sail with it, it can mean a big cost reduction.

- ... for the customer:
  - "For us, it really fills a gap in our equipment".
  - "For us, the only question was whether we were going to make it ourselves or not, in the end, the choice was made to outsource it. This choice was made with the idea that we can also learn from the development process."

- ... for the developer of the USV:
  - The specific requirements that we define for the developer make sure that the entire design they are developing must be optimised for these.
  - The challenge for them is to find an optimum in the requirements that we set.

Summary of unstructured interview time

In the unstructured interview time, a discussion is held to identify the influence the market has on the requirements, which refers to SQ2. In this case, the interviewee is a market party and customer of the project. In this way, the gathered knowledge validates and complement the current knowledge from the perspective of a customer.

- "The fact that the developer determines some requirements ensures that estimates are made of requirements that could be useful. Some of them are required in itself for us. For example, the functionality 'Functionality X' does not yield much in terms of operationality, but in terms of safety, it can be a good interpretation. I think the developer is proud of the functionality."

- "For us, the platform is a sensor platform for our sensors and enables us to create a cost reduction in our current equipment."
- "The developer can always talk to other parties, of course, but when the boat arrives and sails, the demand will increase. Enthusiasm about the technology will increase enormously after the prototype has convinced sceptics."
- "For us, it is important that we show an improvement in our equipment. Instead of a large boat with a real crew, we will be able to do that with a relatively small boat. This means that we can serve our customers more easily."

Reduced results from interview 2

1. *What is the reasoning behind the set of minimum requirements selected by the interviewee from his perspective?*
   The customer expects the developer to incorporate his needs and to design a vessel that can replace current equipment. The minimum set of requirements according to the customer of the project include the set of predefined sensors, requirements and applications.
2. *How and when do the developer and the market try to reach each other, according to the interviewee?*
   The platform of the USV might be interesting for his customers and other customers after the MVP has proven its relevance, questions and need from other customers could then be raised.

E.3. Results of interview 3

This interview was held with the manager of the business unit from the developing company.

How did you derive this set of requirements?
The following steps can summarize the method to derive the minimum set of requirements:

1. Define the requirements minimum set requirements to develop an operational vessel.
2. Add peripherals to make a widely applicable USV.
3. Side note: "Because I am now focused on the project, I know what is needed. If I were a person with an objective perspective, I would have chosen even more generally, and my decision-making would have been more structured."

What are the consequences of your set of requirements?
The answers can be summarized as follows:

- ... for the market:
  - The availability of a competitive product that is new
  - Automating services increases reliability
  - Cost reduction due to making surveys less labor-intensive
  - Enabling continuation of surveys

- ... for the customer:
  - That the customer buys a functional boat with this set of requirements
  - "A customer must have the sensor system or must purchase and implement it on these minimal set of requirements."
  - "We offer them a robust platform for their sensors."

- ... for the developer of the USV:
  - "We must have the knowledge to develop all these parts of the system."
  - "An MVP must validate this."

Summary of unstructured interview time
In the unstructured interview time, a discussion is held to identify the factors the company should consider determining the requirements, which refers to SQ1. In this way, current findings of the research are validated and complementing knowledge is gathered from the perspective of the company towards deciding what should be included in the platform.

- "The set of requirements is determined based on the estimation of what the market is. Namely, large surveyors that have a whole set of sensors for which they want to use the boat."

- "It must be a fully functional system, but what it will do is application dependent. The right connectors and connectivity can be seen as the last requirements that should be included in the platform."
- "As a first step in automating, the product should be able to mimic current equipment. Next, the additional value should be added to compete with alternatives."
- "We must first ensure that something demonstrably works. A launching customer is ideal for this. When the case has been delivered, and we have something to make marketing material from, then we will go to the market. Without a physically working product, it is tough to sell."
- "The MVP can be seen as a calling card to what we can do. The product and marketing material can prove this."
- "Understandably, potential customers would like to get involved in the process as early as possible. However, the decision-making process to purchase is extremely slow if we try to sell our knowledge instead of a proven product. In his eyes, we are the umpteenth party with a good idea, without a track record. A proven product ensures a much faster decision-making process of the customer, which enables us to sell faster."

Reduced results from interview 3

1. *What is the reasoning behind the set of minimum requirements selected by the interviewee from his perspective?*
   The minimum set of requirements is based on what every USV should have and how it can compete in the market.
2. *How and when do the developer and the market try to reach each other, according to the interviewee?*
   The company should start to go to the market after the MVP has proven the knowledge the company has.

E.4. Results of interview 4
This interview was held with the industrial designer of the business unit of the company that develops a USV.

How did you derive this set of requirements?
The following steps can summarize the method to derive the minimum set of requirements:

1. Include any requirement that is generally required for a USV.
2. "Depending on the needs of the customer and my experience, I choose which requirements should be included in the minimum set of requirements."
3. This minimum set of requirements exclude application specific requirements.

What are the consequences of your set of requirements?
The answers can be summarized as follows:

- ... for the market:
  - Our design makes a USV a lot more industrially relevant.
  - Regarding that we now have a project with a customer, this means that it is widely available yet. Meaning that we are making something with this product that it is new on the market.
  - Including more automation in the platform makes it even more competitive.

- ... for the customer:
  - Our development right now is about developing a product for the customer.
  - This customer wants a specific set of sensors on the vessel, which means that we are customizing the product for these requirements.

- ... for the developer of the USV:
  - Hopefully, the MVP shows what we can do and enables us to develop for other markets. Examples of other markets are inspections above water.

Summary of unstructured interview time
In the unstructured interview time, a discussion is held to identify the factors the company should consider determining the requirements, which refers to the SQ 1. In this way, the gathered knowledge validates and complement the current knowledge from the perspective of a developer.

- After we made an iteration on the MVP that we are developing right now, we would be able to compete on the niche market of high-end missions for USVs.
- To determine the requirements of the platform, the company must select the minimum set of requirements. Besides, there are 'nice-to-haves' that increase the value of the platform. Furthermore, some are visions of the future, but currently, we cannot include that in the platform.
- Because it is all new, our MVP has been designed for one specific application. For other applications, we have to wait and see what exactly is required. With the results of the MVP, we can talk to potential customers that are close to the customer of the project. Showing the results and identify the relevance for them can allow us to develop a follow-up design for other customers.
- We can hardly say to the customer that we are now also going to develop something for other parties. We are simply working for him. On the other hand, the more ideas and the more parties involved in the process, the more possibilities there will be.

Reduced results from interview 4

1. *What is the reasoning behind the set of minimum requirements selected by the interviewee from his perspective?*
   The minimum set of requirements must ensure that the USV can be used in any case.
2. *How and when do the developer and the market try to reach each other, according to the interviewee?*
   After the MVP has been developed, the developer can contact similar customers as the current customer. Subsequently, the developer can develop a follow-up design.

E.5. Results of interview 5

This interview was held with an engineer of the business unit from the company that develops a USV.

How did you derive this set of requirements?

The following steps can summarize the method to derive the minimum set of requirements:

1. Exclude the things I am not sure about it
2. Include the minimal requirements that are of interest to sell a USV.

What are the consequences of your set of requirements?

The answers can be summarized as follows:

- ... for the market:
  - The market wants different things. We have to develop an optimal design.
  - The needs of the market are an application of the USV. We should customize this per customer.

- ... for the customer:
  - "The customer wants a specific application, which means a set of sensors and additional requirements that solve their problems."

- ... for the developer of the USV:
  - This depends on the number of vessels we want to sell
  - I would say that up to five customizations per year would fit our current organization.
  - Scaling to a high number, if that is a goal, might be better outsourced.

Summary of unstructured interview time

In the unstructured interview time, a discussion is held to identify the factors the company should consider determining the requirements, which refers to the SQ 1. In this way, the gathered knowledge validates and complement the current knowledge from the perspective of a developer.

- "It is difficult to imagine what the impact is for our organization if we are going to scale. If we have the goal to develop a USV that will be sold 200 times a year, we need a clear standardization. "This has an impact on the product."
- "Being able to develop this product in a project means being able to adapt it for other customers that need specific customization. This would be very suitable for us. Our strength lies in customizing rather than mass production."

- "We have a project that results in knowledge that we can use in a platform. We also learn how to customize for one customer. This prototype of the platform proves to other market parties that we can customize this, thereby increasing the demand of other market parties. That is why we must first have finished the minimum viable product and then see what will do next."
- "If we invest to develop a product that we can sell next to the project, then we will also make more parts by ourselves. For example, we buy quite a lot now, sometimes with less quality. If we know that we can customize something because we will sell it to other customers, it will also have added value for the project that we are currently implementing. Some parts are not yet on the market; if we have them, then we will be competitive."

Reduced results from interview 5

1. *What is the reasoning behind the set of minimum requirements selected by the interviewee from his perspective?*
   The minimum set of requirements defines the set that is necessary to develop a general USV, of which we can customize it to their needs.
2. *How and when do the developer and the market try to reach each other, according to the interviewee?*
   This MVP proves to potential customers that the company can develop a customized USV. Therefore, the MVP must first be finished and then the company should think about the next step.

E.6. Results of interview 6

This interview was held with an engineer of the business unit from the company that develops a USV.

How did you derive this set of requirements?

The following steps can summarize the method to derive the minimum set of requirements:

1. Exclude all requirements that are not important in a general USV.
2. Make sure that the remaining requirements form a good basis for a USV, independent of the application.

What are the consequences of your set of requirements?

The answers can be summarized as follows:

- ... for the market:
  - Every USV that wants to be succesfull must have these requirements.
  - All potential applications for USV rely on these set of requirements.
- ... for the customer:
  - "The customer has to understand this system is needed to solve their problems."
  - A customer wants a product that incorporates all requirements that are in the selection.
- ... for the developer of the USV:
  - The developer must ask the customer what the selection of requirements has as value for them, and ask what additional requirements they need.
  - This set of requirements enables the developer to create a product for the customer that solves their problems.
  - "We must have the knowledge to develop this core set of requirements."

Summary of unstructured interview time

In the unstructured interview time, a discussion is held to identify the factors the company should consider determining the requirements, which refers to the SQ 1. In this way, the gathered knowledge validates and complement the current knowledge from the perspective of a developer.

- It is important to define a minimum set of requirements. If a too specific requirement is included in the platform, the platform will become more expensive. This makes sure that you can serve a smaller market with your platform, and the platform is less competitive.a
- The selection of what should be included in the platform is dependents of the target audience. This target customers can be chosen depending on the knowledge the company has and also depend on which customers are reachable.

- If a company has enough time and financial resources, then it would be best to do market research in parallel.

Reduced results from interview 6

1. *What is the reasoning behind the set of minimum requirements selected by the interviewee from his perspective?*
   The set of requirements should be the bare minimum to keep it affordable. Additional requirements depend on the target customers.
2. *How and when do the developer and the market try to reach each other, according to the interviewee?*
   It would be best if a company can do market research in parallel with the project. With this information, the target customers can be chosen and decisions for additional requirements to be included in the platform can be made.

E.7. Results of interview 7

Below every question, the summary of the answer of the interviewee is described.

First question: What is your vision on the problem?
The explanation of the research description and the main research question made the interviewee describe several steps a company in this position should do. This list below shows the described steps.

1. What modules can we produce?
2. What products can we make with these modules?
3. What is the relevance of these products and for whom?
4. Understand the problem or challenge in a context that is as broad as possible.
5. What will it solve for the customer and the customer of the customer.
6. What are market segments that do have an interest in these products?
7. Select a market segment for which a certain product creates the most added value.
8. Define the customers and research their needs.
9. Redefine the product, what is included and what not. Is the value in the platform or additional services of the full product?
10. Start the development process and iterate above steps.

Second question: What do you think of the findings of the interviews?
The set-up of the interview and the global results were discussed. The similarities and differences between the interviewees led to the answer below given by the interviewee.

- It sounds as if the various interviewees have too little alignment. Understandably the developers like to deliver the MVP. However, iterations needed for the MVP do not go linear.
- By better aligning needs and possibilities between the developer, the customer, their customers, and other potential customers of the product a company can adjust the design in the meantime and arrive at a design that will better solve the problem for the customer.
- Changes later in the process cost more money and effort because a larger part has already been developed that must be changed.

Third question: Can you complement the gathered knowledge, what do you observe in the field?

- From my experience at other companies, I can explain a successful product innovation process. Successful products often arise from a technical idea. However, choosing the right market segment and developing a product that exactly matches the needs for that market segment made the team successful.
- At that time, the team chose a market segment where their technical idea could deliver the most value. They then developed their idea into a complete product. In the end that technical idea turned out to be just a component of the end product.
- A development team should consist of several disciplines that can give their own view of the problem and the solution. An multidiscplinary team provides better solutions and more opportunities for the company for both its own organization and the customer.

Fourth question: What should a company in transition from project to product platform do?
Before asking this question, the question was introduced by explaining the case study research that is done in this research. With this, the phases of the project and the ambition to scale with a product platform are explained.

- "Go to the market as soon as possible."
- The idea, concept or MVP must be validated in the early stage of a project. The earlier the better, in the interest of a rapid development cycle. In the fast-moving world of today, getting started with the right knowledge and vision, which can be done by investing extra time and effort in the beginning.
- Validating important choices for the design at the customer is a must. However, validating your ideas with their customers and with other market parties leads also to a better understanding of the real problem. "This results in an MVP that matches 90% with their needs instead of 40%, meaning less additional iterations are needed in the end."
- Going to the market is relevant for the customer but also ensures the company to understand other market needs and possibilities.
- "Because of the faster-changing market, companies nowadays need staff who do not just think about technology. They also should have the social skills to be able to determine what they should design in a market-oriented way."

Additional question: Who in the company should be more market-oriented?

- "The more people, the better."
- If every discipline can think in a market-oriented way, then you ensure that all components fit together well, in line with the needs of the customer.
- The creativity and knowledge of every person should be triggered by insights that show the real problem.

Reduced results from interview 7

1. *What is the reasoning behind the set of minimum requirements selected by the interviewee from his perspective?*
   What should be included in the platform must be related to the value proposition that a company offers and which market segment at most needs this set.
2. *How and when do the developer and the market try to reach each other, according to the interviewee?*
   As soon as possible, from the start of a project, a company should communicate with the customer their customers and other potential customers. This validates their idea of what product is needed, and additional knowledge and insights ensure a faster design process.

E.8. Summation of reduced results of interviews

he tables below show reduced results of the interviews, all results correspond to the reduced results below each interview. The results are reduced with the help of the questions described in paragraph 6.1.1.

What is the reasoning of the set of minimum requirements selected by each interviewee? How and when do

#	Perspective and function	Summarized result from each interview
1	Market perspective: Manager of potential customer	The set of requirements is closely related to the mission or application of the USV. Determining the set of requirements should be based on the mission. However, a minimum set of requirements can be defined independently of the mission, the "Need-to-haves" of a general USV. This minimum set of requirements can be defined as the product platform.
2	Market perspective: Manager of the USV project	The customer expects the developer to incorporate his needs and to design a vessel that can replace current equipment. The minimum set of requirements according to the customer of the project include the set of predefined sensors, requirements and applications.
3	Company perspective: Manager	The minimum set of requirements is based on what every USV should have and how it can compete in the market.
4	Company perspective: Industrial designer	The minimum set of requirements must ensure that the USV can, in any case, be used in the defined conditions by the customer.
5	Company perspective: Engineer	The minimum set of requirements defines the set that is necessary to develop a general USV, of which we can customize it to their needs.
6	Company perspective: Engineer	The set of requirements should be the bare minimum to keep it affordable. Additional requirements depend on the target customers.
7	Organizational advisor	What should be included in the platform must be related to the value proposition that a company offers and which market segment at most needs this set.

Table E.1: Reasoning behind the selected set of minimum requirements by interviewees.

the developer and the market try to reach each other?

#	Perspective and function	Summarized result from each interview
1	Market perspective: Manager of potential customer	It is the responsibility of a developer to understand the market needs before defining the product platform to fulfil the needs as well as possible.
2	Market perspective: Manager of the USV project	The platform of the USV might be interesting for his customers and other customers after the MVP has proven its relevance, questions and need from other customers could then be raised.
3	Company perspective: Manager	The company should start to go to the market after the MVP has proven the knowledge the company has.
4	Company perspective: Industrial designer	After the MVP has been developed, the developer can contact similar customers as the current customer. Subsequently, the developer can develop a follow-up design.
5	Company perspective: Engineer	This MVP proves to potential customers that the company can develop a customized USV. Therefore, the MVP must first be finished and then the company should think about the next step.
6	Company perspective: Engineer	It would be best if a company can do market research in parallel with the project. This information helps to choose the target customers and additional requirements for the product platform.
7	Organizational advisor	As soon as possible, from the start of a project, a company should communicate with the customer their customers and other potential customers. This validates their idea of what product is needed, and additional knowledge and insights ensure a faster design process. The result is a product solving the real problem and

Table E.2: How and when do the developer and the market try to reach each other.

Similarities between the interviewees their reasoning of the selection of the minimum set of requirements

- The overlap revealed that the minimum set of requirements is a robust autonomous vessel including general mission functionalities, but which could be customized for different applications.
- Four of the six interviewees agreed that the first added requirements are dependent on the application.

Differences between the interviewees their reasoning of the selection of the minimum set of requirements

- There is much difference in the selections of the set of minimum requirements. It turns out that the selection depends on the perspective and position of the interviewee. This shows the different interests the interviewees has in the USV. For example, the customer of the project has a particular interest in a product that can use its sensory for surveys.
- This also shows that the interest between the company is twofold. Some let their selection depend more on the project than others, causing more requirements to be included.

Similarities between the interviewees their opinion on how and when the developer and the market try to reach each other.

- Everyone, except one engineer, involved in the project first wants to deliver the MVP.

Differences between the interviewees their opinion on how and when the developer and the market try to reach each other.

- The potential customer would like to have an influence on the design early in the process. However, the company first wants to develop a proven product.
- According to the organizational advisor validating the idea and important design choices with other potential customers would be important.
- The company learns about market needs, necessary for follow-up options, but also knowledge of the market would be of added value for the end product of the project.

Protocol for workshop

This appendix describes the protocol and reasoning behind the protocol.

Introduction of the workshop
At the start of each interview, the objectives must be explained, and the structure of the workshop must be proposed.

Protocol opening (5 min):

- Welcome
- Explanation of the objectives
- Explanation of the structure of the workshop
- Inform the participants why this workshop is important for the research
- Ask approval to record and use data from the interview

First part of the workshop
The first part of the workshop validates the conclusions drawn from the selections of requirements and functionalities from the interviews. The first part ensures the first objective to be reached.

Protocol for the first part (10 min):

- Show the main research questions of the research
- Introduce the discussion
- Hand over table 6.1
- Question: What can be concluded from the interview results?
- After the discussion time, ask to fill in the first question of the workshop form (see appendix)

Second part of the workshop
The second part of the workshop validates the including of knowledge in framework 2.0. The second part ensures the second objective to be reached.

Protocol for the second part (10 min):

- Introduce the discussion
- Hand over the conclusions drawn from interviews
- Question: What is necessary to derive to a set of functionalities that should be included in the platform?
- If the discussion is difficult to get started, the following questions can be asked:
    - When will you collect information from the market?
    - Knowing the company has the ambition to transition from project to product platform, is collecting information from the market essential at the start of the project?
- After the discussion time, ask to fill in the second of the workshop form (see appendix)

Second part of the workshop
The second part of the workshop validates the including of knowledge in framework 2.0. The second part ensures the second objective to be reached.

Protocol for the third part (10 min):

- Explain the outline of framework 2.0
- Question: Do you agree with the following parts of the framework are essential for determining a right set of functionalities for the platform?
    - The inclusion of going to the market at the start of the project?
    - The distinction of phases?
    - The relation between the MVP and the platform?
- After the discussion time, ask to fill in the third question of the workshop form (see appendix)

Closing the workshop

A summation of the main points of the workshop is formulated, and participants are asked to validate the summation. If something is missing, the participants will be asked to write it as a recommendation on the workshop form. The workshop is concluded with a word of thanks and an invitation to perceive the results will be provided.

Protocol for closing the interview (5 min):

- Summation of the main points
- Time for the last remark by the participants.
- Word of thanks and invitation to perceive the results of the research.

Required materials

- Powerpoint with results and paper with results
- Workshop form
- Memo paper
- Pens and pencils

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Workshop form

Question 1
According to you, what can be concluded from the interview results?

Question 2
Knowing the conclusions of the interviews and knowing the company has the ambition to transition from project to product platform, is collecting information from the market essential at the start of the project?

Question 3
Do you have comments or do you think something is missing in framework 2.0? (Please describe them as recommendations for follow-up research)

Workshop form results

Question 1: According to you, what can be concluded from the interview results?		
#	Participant	Answer
1	Manager	- Inconsistency between chosen requirements within the developing team. - Overlap among the selection of customers - Mismatches between developer and customers, for example the requirement "CE" - Only two requirements are selected by all of the interviewees
2	Industrial designer	- The vessel that we are developing is reasonable aligned with the customer his whishes.
3	Engineer	Interviewees tend to interpret the question differently. "Bore minimum functionalities of a platform versus use-case specific product for a specific field of application. Hard to draw other conclusions than "The role colours the response significantly".

Question 2: Knowing the conclusions of the interviews and knowing the company has the ambition to transition from project to product platform, is collecting information from the market essential at the start of the project?		
#	Participant	Answer
1	Manager	Yes
2	Industrial designer	- Yes - The market –> input for the project. - Test prototypes and evaluate functionalities and performances with the customer
3	Engineer	Yes. The results of this information defines the broader potential fields of application. Market research –> a lot of demand –> scalable project Market research –> not a lot of demand –> less potential than above

Question 3: Do you have comments or do you think something is missing in framework 2.0? (Please describe them as recommendations for follow-up research)		
#	Participant	Answer
1	Manager	- Now the model includes the decision-making of what should be included in the platform, and the model can be extended by the development planning of the platform and products. - In the model the MVP is described as a point in time. However, it might be interesting to see how the model would be if these are visualized as a process. - More details about the activities of the lines that are drawn would increase the applicability.
2	Industrial designer	- Market review results in evaluation of price versus functionalities - More details can be added in the model - It would be interesting to investigate the duration of the phases.
3	Engineer	Vertical axis, maybe this can be defined? When does DM1 takes place? What should be covered or required? More details on DM2 might be interesting.

Table H.1: Results of the workshop

Case study research discussion

Identificating TP and DP mechanisms in the case study

A proposition can be described how the relations of TP and DP mechanisms are related to the case study. First, the customer and the company started a conversation. In the subsequent process, the company identifies the pain points; these pain points can be seen as *DP*. Next, an idea or concept will be developed in which estimates about solutions for the pain points are made. These estimates are *TP* influences. If the customer expects the concept sufficiently solves the pain points, then a *DP* influence results in specifying their needs to start a first project phase. In the first project phase again estimates about the realization of the MVP are made, again these are *TP* influences. After the company gained enough knowledge to transition from project to platform level, the product that will be developed can be seen as 80% of the development of the 'whole product.' The last 20% necessarily will be developed in cooperation with the customer and therefore can be seen as a *DP* influence. This proposition shows that a balance is being sought between the two mechanisms. According to the company, for a project, this balance works, so this must be included in the framework.

Bifurcating or balancing TP and DP mechanisms

While writing the previous paragraph, there is tried to bifurcate TP and DP mechanisms. However, as can be seen from the description, both mechanisms constantly alternate. The more the company works together with the customer, the more there is alternation and the less it can be seen as bifurcation. That it should not be seen as bifurcation is also suggested in literature (Di Stefano et al., 2012). However, how this should be balanced was not yet described. It might be the case that balancing these mechanisms means continuously develop together with the customer. Now, a definition of balancing TP and DP mechanisms can be formulated as the following: "When market parties and technology developers work together on a technological wanted solution." As the company indicates that it has difficulties meeting the market needs, it means that the right balance may not have been found yet. Another difficulty lies in still balancing TP and DP mechanisms while scaling to product platform strategy.

Proposition of a strategy to deal with TP and DP mechanisms in the transition from project to product platform

As stated before, in project-level, a balance between TP and DP is organized. In Fig. I.1 this is shown with both an orange coloured TP mechanism as a blue coloured DP mechanism. Furthermore, the figure shows how the field of tension between a high-tech company and the market can be visualized. A new product development process is shown between both the company and the market. In which the commercialization strategies are in relation to the customers of a specific market segment. These customers all have a certain DP influence on the set of functionalities, as figure I.1 shows with the blue arrows. A subsequent commercialization step can be to define a market segment and use a TP mechanism to show the relevance of a certain (or part of essential) technology. If a customer is interested, a balance can be found by incorporating additional needs in further product development. This lead to a DP mechanism, a company can develop its product, including these needs by decisions in product functionalities (see Fig. I.1) and again commercialize this product to the customers. In this way, a balance between TP and DP mechanisms like a company has in a client-driven development project can be translated to a balance for a product platform together with a niche market.
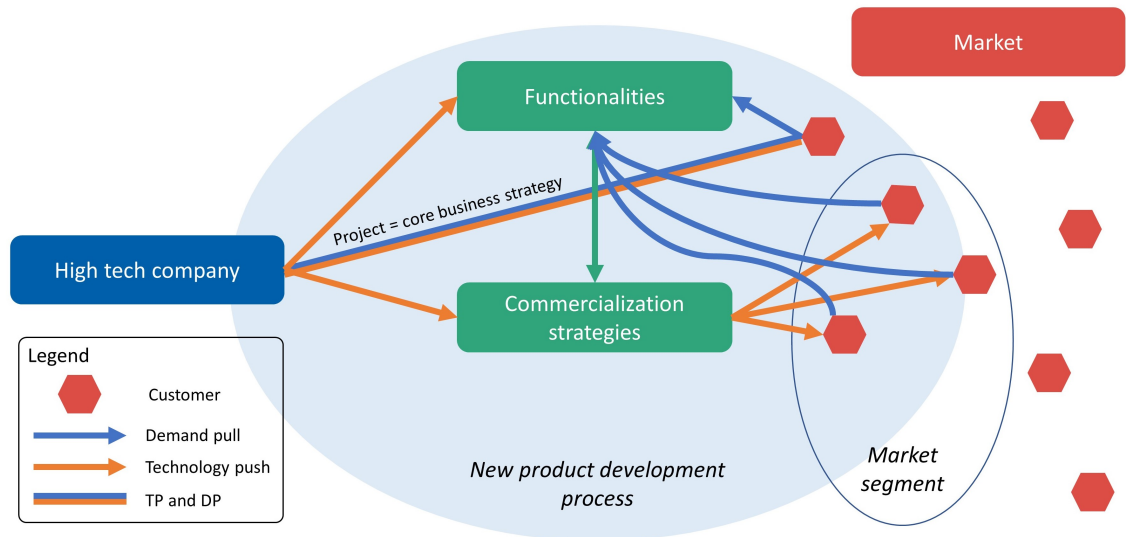
Figure I.1: A proposition of the relations of TP and DP mechanisms in a new product development process. Based on the process as observed in the case study and developed from the perspective of functionality and commercialization strategy decisions.

Proposition of the product development process of a company together with a niche market

If it is assumed, that a company has enough knowledge of a certain technology that the company is in a position to develop a product that can meet the needs of a niche market, then the following proposition can be described, which is also visualized in Fig. I.2. The knowledge of a certain technology a company can be translated to unique selling points if these compete to other market alternatives. The figure describes that next to that, a unique selling market should be defined, for which the unique selling points are relevant. A unique selling market can be defined as a market segment in which unique selling points of a developing company meet the actual needs of the customers from the market segment. What can be seen furthermore, are the relations between the competitor, the high tech company and the niche market. The blue lines describe how the high tech company and the market parties from the niche market segment balance TP and DP mechanisms by working together in developing a new product.
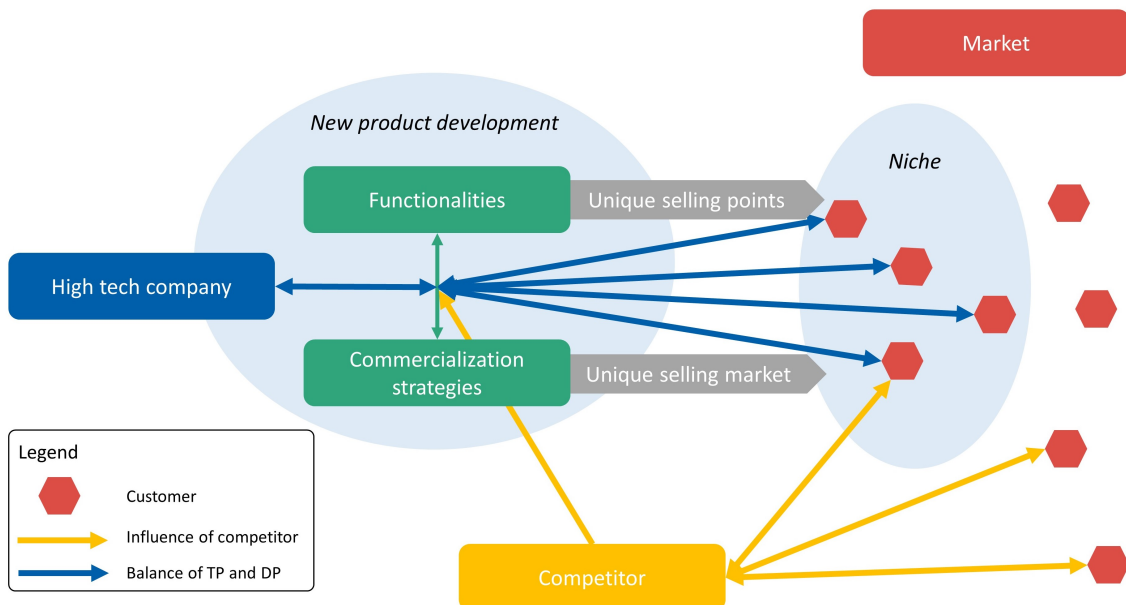

Figure I.2: Based on the product development process as observed in the case study a proposition of the relation between competitiveness and the company their functionality decisions and commercialization strategies are visualized.

Understanding the what and why behind the transition process

During the case study research, the main problem is the transition process from project to product platform level the company has to organize. The question is, why is this transition process a problem? Is it because the company does not know what to organize or does the company not know how to organize? In other words, is it about the implementation, or is it about what should be implemented? This question is also asked about the company. The answer was: "first we need to know what we should implement and why before we implement the process in our organization."

Linking the difficulties the high tech company has to a propositional solution described as a protocol

Based on as well this question and the subquestions derived from the case study research, which can be found in section 3.2.4 and the visualization of Fig. I.1 a propositional protocol can be formulated: "First, find during a client-driven project phase essential technology in the product that can cover almost all essential parts from the 80%, this is the point in time when you should scale to program level (Q1). Choose a market segment in which the essential functionalities are most suitable and validate your product. (Q4) Then talk with the customers, gather all information needed to know which functionalities are wanted by this market segment and are essential to include in the 80%. (Q2) Then there is one point in the timeline, in which you decide on both the set of functionalities that are necessary to cover the 80% and still make it adaptable to all customers and other markets and also the commercialization strategy how you can reach all these customers in this market segment. (Q3 and Q4). Keep the partner in the program until you need the backing of him, commercially to the lowest cost possible."

Balancing TP and DP during the transition, linked with decisions on functionalities and commercialization strategies

A proposition can be formulated that the balance of TP and DP will have to be held during the transition process from project to scalable product platform. A major difficulty is to keep the connection with the market, instead of developing together with one customer other market parties should also be taken into account in the development process. If we stick to the definition that commercialization is the whole of connecting with market parties, then defining who and how big the target market is, will be the first step in the commercialization process. Also, the starting point of the transition process from project to scalable product platform. The company should understand that at this moment of defining your target market segment, the required functionalities to meet the needs of this specific market segment should be defined or estimated. Then this is the time to balance TP and DP again. Market parties often have difficulties in specifying their needs upfront, estimating their needs and working together towards a base product during the development process is therefore important, as it is also important in project level to design together with the customer. This base product, therefore, consists of essential technology (USP) for these specific market segment (USM). Because it is a business-to-business market, the base product is not the end product. For every customer, the latest part has to be customized. In other words, decisions on functionalities and commercialization strategies should be made together. From the current knowledge gained in projects, unique selling point should be defined together with unique selling markets. Develop a base product together with the market parties ensures that TP and DP mechanisms remain balanced. Balancing TP and DP mechanisms at this point enables a company to capitalize on both technology and demand.

Literature discussion

This appendix discusses the theory for this research. This results in interpretations and propositions that might differ from existing literature, and can be seen as an addition to the conclusions drawn from the literature study. This chapter consists of three paragraphs, each of them belonging to the macro, meso and micro level like described in this research. Each paragraph consists of multiple paragraphs describing different discussion points.

J.1. Discussion macro level literature

Identifying the phase of the technology of the case study

From the case study research, there is learnt that the technology of the case is in the market adaptation phase because next to a few competitors the company is trying to establish a new standard as described in paragraph 3.3.4. Figure 4.4 shows that this belongs to the market adaptation phase. What can be learned from this table is that one of the market mechanisms during the market adaptation phase is "Finding the best product-market combinations based on the technology". This characterization matches the question the company has regarding its functionality decisions that are required for a successful product diffusion. Thus, the transition from project to product platform, which is the subject of this research, is also in the market adaptation phase. The goal of this transition process is to make the company ready for a breakthrough market introduction which, if it succeeds, could be seen as the market stabilization phase.

The link with TP and DP mechanisms

The focus of this research is narrowed down to TP and DP mechanisms. The link between TP and DP mechanisms and literature from Ortt and Schoormans (2004) can be found in Fig. 4.4; the market situation and market adaptation phase combination "finding the best product-market combinations based on the technology" (Ortt and Schoormans, 2004, p. 299). The company has gained knowledge of new technology during a project and now is the time to find product-market combinations. This process is defined in this research as the transition from project to scalable product platform.

The search for the right product-market combination can also be seen as another indication that the transition process from a project to a scalable product of the case study is in the market adaptation phase is.

Links between factors necessary for large-scale diffusion mentioned in literature and factors emerged in the case study research

Knowledge of technology and *knowlegde of application* are both mentioned by literature as factors and barriers of large-scale diffusion. In the case study research turned out that the company uses client-driven development as a business strategy. The projects deliver not only money per worked hour, but also *knowledge of technology* and *knowledge of the application.*

Defining who the *customers* are is yet a difficulty for the company regarding the technology that is researched in the case study. This is primarily due to the business-to-business relation the company has with its customers and the co-development process the company has with its client during a project. This project is also the process in which the company increases its knowledge of technology. The company learns how to be relevant for the client, but has difficulty in translating this relevance to a specific customer segment.

The *new high-tech product* for the case study is the unmanned surface vessel, to which is looked on the level of 'functionalities' as is defined the first element of the three that following Ortt et al. (2013) can be distinguished. That this factor is important is clear for the company in the case; this appears from the first interviews that the most difficulty is seen in the functionality decisions. As a strategy to learn what functionalities make the product relevant for the market a lead user niche strategy is used, which will be discussed

later in this chapter.

Defining on which factors the company has influence
In Fig. 4.5, a distinguishment is made in core and influencing factors. The left-sided box lists the factors that have an influencing effect of the diffusion. The right-sided box has a core effect of the diffusion. However, there could also be argued that a distinction in factors on which the company has influence is relevant for a company perspective of this research. Figure J.1 shows the adjustment to the figure from Ortt et al. (2013). This figure shows the distinction of company factors and circumstantial factors, and also the distinction between influencing factors on and core factors important for the development of new high tech products.
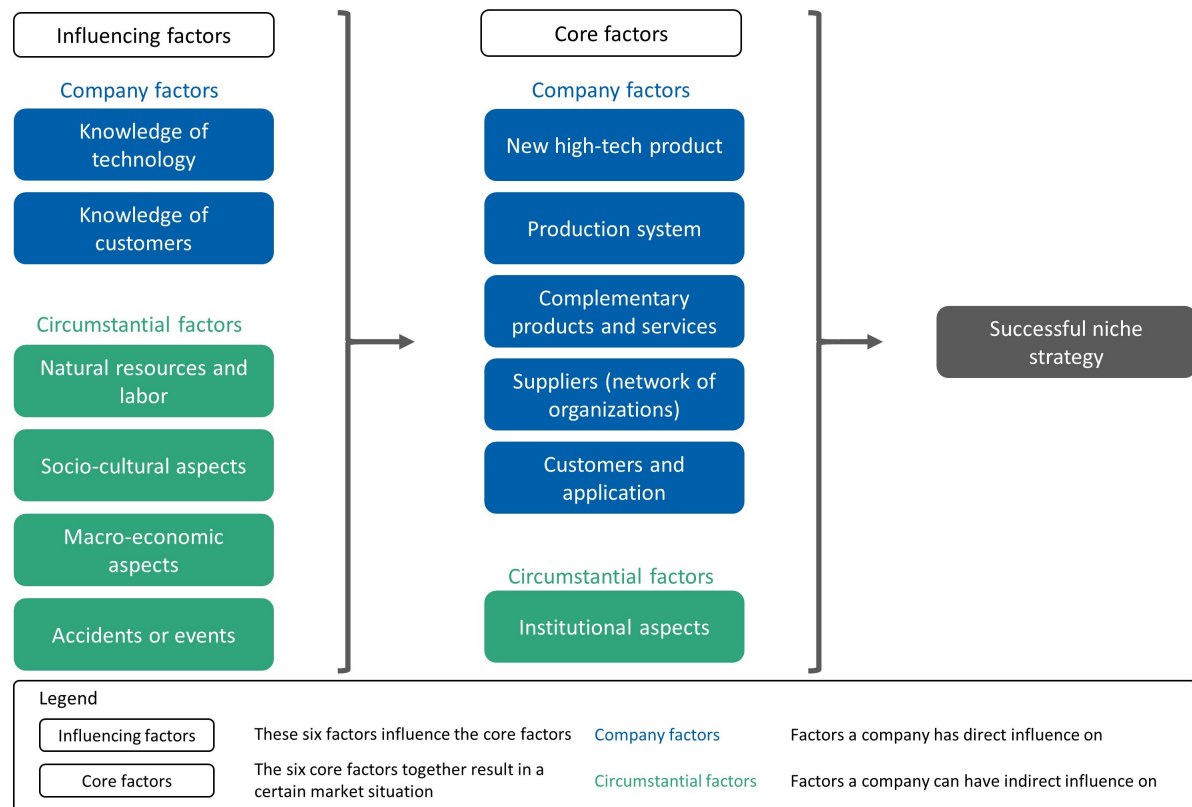
Influencing factors		Core factors	
Company factors		**Company factors**	
Knowledge of technology		New high-tech product	
Knowledge of customers		Production system	
Circumstantial factors		Complementary products and services	
Natural resources and labor		Suppliers (network of organizations)	Successful niche strategy
Socio-cultural aspects		Customers and application	
Macro-economic aspects		**Circumstantial factors**	
Accidents or events		Institutional aspects	

Legend

Influencing factors	These six factors influence the core factors	Company factors	Factors a company has direct influence on
Core factors	The six core factors together result in a certain market situation	Circumstantial factors	Factors a company can have indirect influence on

Figure J.1: Adjusted figure of factors important for the development and large-scale diffusion of new high-tech products (Ortt et al., 2013)

Importance of knowledge of technology and knowledge of application
In all market situations that are mentioned in Table 4.3 the situation starts with *knowledge of the technology* or *knowledge of the application* is lacking. This could mean that only the factors of which the company has a direct influence on and are of input of the other six factors (as is shown in Fig. J.1) define which niche strategy is required. A company if failing in the factors *knowledge of the technology* or *knowledge of the application* will see the result in one or more of the following factors: *new high-tech product, production system, complementary products and services, suppliers* or *customers*. With *customers* is, for example, meant that the technology was not aligned with the 'wants' of the customer segment.

Knowledge of customers
In literature by Ortt et al. (2013) is described that "the availability of customers means that a market application for the product is identified, that customer segments for these applications exist and that the customers are knowledgeable about the product and its use and are willing and able to pay for an adoption." If this statement is critically viewed, there can be identified that TP mechanisms lay behind it. First, a product is developed, and afterwards, the right customers' segment should be available. However, there can be argued that to create a new high tech product also knowledge of the market, including knowledge of the needs of

customer segmentation (in short knowledge of customers), is needed. This knowledge, like the knowledge of the technology and knowledge of application, can also be seen as an influencing factor. Meaning, the model might be adapted by the inclusion of a factor called knowledge of customers, which is a company factor and influencing factor.

Lead user niche strategy
The lead user niche strategy, which can be found in table 4.3, could be in some cases, not a strategy to start large-scale diffusion, but can also indicate a project on its own. During the case study research, there is found that the company has a business strategy client-driven development. This results in projects in which the company takes the lead, but works together with the client to a technological solution for their problem. This client can, therefore, be seen as an innovator or lead user as described by Ortt et al. (2013). However, it might be in this case that the lead user niche strategy was not a strategy to make the technology ready for large-scale diffusion. The approach of the company is rather the other way around with these kinds of projects. The company sells projects, and when the technology developed during a project has enough relevance, the scalability of the product will be researched.

Two propositions can be described in which the question and the current strategy are included.

1. The first proposition is that a project is a lead user niche strategy in the market adaptation phase of which the company knows up front that it is not the strategy that will succeed to let the product diffuse. Thus a second niche strategy will be necessary, and the question is how the company should transition towards the execution of a secondary niche strategy.
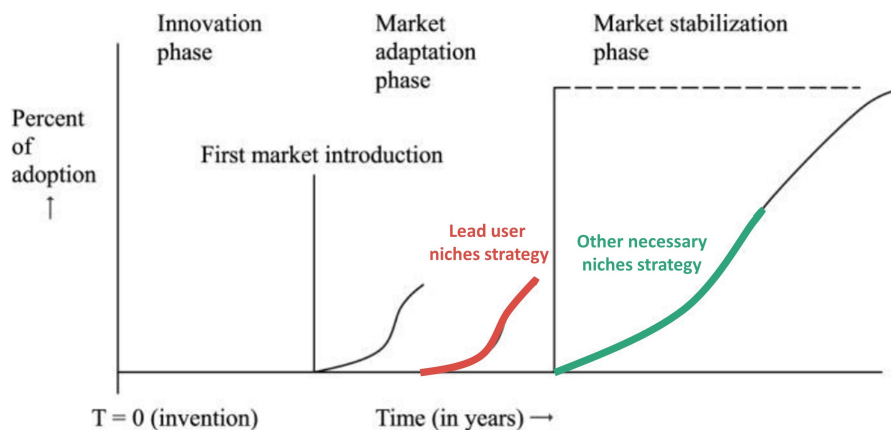

Figure J.2: Adjusted figure of market adoption pattern to visualize proposition 1: Another niche strategy is necessary after the lead user niche strategy to let the new product diffuse (Ortt and Schoormans, 2004)

2. A secondary proposition is that lead user niche strategy is a right strategy to let the product diffuse to the mainstream market, but the company has difficulties in identifying or estimating if their product is good enough to diffuse from this niche strategy towards the mainstream market.

It can be argued that the first proposition is more plausible because the company is now acquiring knowledge about technology but still has to translate it into a product that meets the needs of the mainstream market. And on the other hand, if a product is developed during a project phase that is good enough to meet the needs the customers of the mainstream market, then it may be that no second niche strategy is needed.

J.2. Discussion meso level literature
The link between theory from Ortt and Schoormans (2004) and Moore (2014)
The link between the market adaptation phase (Ortt and Schoormans, 2004) and the literature from Moore (2014) can be defined as during the market adaptation phase the innovators, and early adopters are served, and the company is preparing to the market stabilization phase by preparing to serve the early majority.

The USV in the revised technology adoption life cycle
The customer of the project can be seen as an early adopter. However, some of the characteristics match the
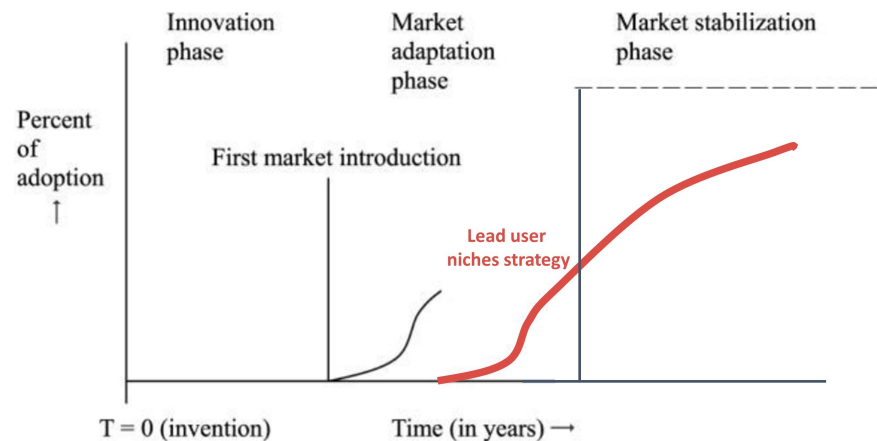
Figure J.3: Adjusted figure of market adoption pattern to visualize proposition 2: The lead user niche strategy can lead to a diffusion of the product to the mainstream market in the case the product is good enough to meet the needs of the customers of the mainstream market. (Ortt and Schoormans, 2004)

definition of an innovator meets the characteristics of the client that the company is doing a project for. The co-development process, as is mentioned by Moore (2014), matches the process the company has with the customer. Major decisions are made together, estimations are made, and feedback moments are planned to steer the development process to the right outcome for the technology to be relevant for the customer. And there it is, the customer has accepted the project because the goal is to have a strategic advantage with the product. This is the major difference between an innovator and an early adopter. Next, it becomes clear that the technology is right before 'crossing the chasm'.

Defining a market
As mentioned in theory description of Moore (2014), if there is referred to market, there is, for example, meant that the market for footballs reaches as well as Africa and The Netherlands. Therefore a market can be defined as all established or potential market segments for a product or service.

Market-driven approach
Having a market-driven approach is essential, according to Moore (2014). However, it is explained as satisfying a specific set of customer their buying objectives. There can be argued that this is not market-driven 'enough'. First, a product is developed, and references should be made, and next to that, a market segment is searched of which their needs and wants to match the relevance of the product. Although this could also be the other way around. As soon as a company has enough technical knowledge to be potentially relevant, then it can decide which market segment to go for, and identify what relevance they need in a product. Together with an early adopter, the product can be developed in such a way it meets their strategic goals, but also includes essential value to meet the needs of the chosen market segment.

Timing
Creative market segmentation is the first step in whole product management. However, the moment a company is ready for this step can be discussed. By Moore (2014), it is argued that this moment is after the generic product is developed and proved by early adoptions. However, there could also be argued that the right moment is when a company is sure to have enough knowledge of technology. Searching for the right market segment is then the first step, after which the generic product can be build while already knowing the needs of the customers from the market segment. In the following, this will be elaborated.

Furthermore, the moment of initial target market segmentation might be done earlier in the process. Before finishing the generic product in an early-market development process a market segment can already be chosen, in this way, the needs of the market segment already can be taken into the development process of a generic process, and so a better match can be sought for all parties. The important notion of taking into account is that the client which you the company is doing a project for will have to be satisfied in all the steps that the company considers. Moreover, from the moment the knowledge of technology is enough, the project and the initial target market segment can be done in parallel. By doing this in parallel, a company can get more time to prepare the crossing. Deciding when the knowledge of technology is enough can be hard; how-

ever, in some cases, it can be concrete. For example, if a company succeeds in patenting certain technology.

Defining the battle versus defining the balance

"Focus the competition within the market segment established by your must-have value proposition, which is the combination of the target customer, product offering and the compelling reason to buy that establishes your primary reason for being. (Moore, 2014, p. 194)" Can also be interpreted as: define the balance (the compelling reason to buy), by defining the technology (the product offering) and the demand, consisting of the market segment and their needs (target customer with their must-have value proposition). What is also included in the battle by Moore (2014) is the competition, which should be defined next to the combination of the target customer, product offering and the compelling reason to buy.

The mindset

If looked to literature from Moore (2014), the book is written from the perspective of people that have an attitude that includes a technology-driven strategy (Moore, 2014, p. 238). The tipping point to start thinking about the market segmentation is described to be after the general product is developed. The book of Moore (2014) is written from a TP perspective but, at the end of the book, a paragraph of the emerging discipline of whole product development is written in which is stated that whole product R&D starts at market segmentation. It can be interpreted that whole product development starts by understanding the market and clearly understanding the needs of the market and the market segmentation. This could be interpreted that the book is written from a TP perspective, and the importance of the demand perspective is mentioned.

Critically considered, the attitude of the people of the company that wants to cross the chasm is not enough taken into account but can be seen as the main problem. People wanting to cross the chasm think from the perspective of the company they are working for, they want to earn money and keep the company healthy, from a company perspective, this is understandable (Moore, 2014). However, having the courage to think from the customer, the market segment, and to create added technological value for customer needs, which is essential for developing a whole product, starts with another mindset; a needs-driven mindset. With the following statement, Moore (2014) describes that it is essential that all people of the company form a unity: "One of the most important lessons about crossing the chasm is that the task ultimately requires achieving an unusual degree of company unity during the crossing period" (Moore, 2014, p. 8). Furthermore, Moore (2014) describes that "the consequences of being sales-driven during the chasm period are fatal" (Moore, 2014, p. 82). Although Moore (2014) addresses the importance of forming a unity and not being sales driven, he does not combine both statements towards a certain attitude that is necessary. Having this mindset makes choices easier because every choice that a company makes can depend on what the customers needs.

It can be challenging to estimate what the customer wants, and this question often arises after the moment a company found an interesting idea. Assumed a company has a client-driven development core strategy, the following proposition, which differs from Moore (2014) his view in the early change of mindset, can be described: An interesting idea can arise during an early-market project, when an organization learns how to use this, it can be defined as knowledge of technology, a definition mentioned by Ortt et al. (2013). After the point in time, this knowledge of technology is appropriated, a 'customer-need-driven' company-wide attitude is necessary. Now, the question can arise if this knowledge can be used to meet the needs of other customers than the initial client from an early-market project. This is the moment a market segment should be chosen according to the principles described by Moore (2014). After that, in close collaboration with customers a balance between their needs (demand) and the development of a whole product (technology) including essential technology of which only the company knows to take advantage of should be found.

The moment of the organizational transition

The following is described by Moore (2014): "As the shape of the mainstream market emerges, when the needs of this market can be increasingly identified through market research and customer interviews, then the whole product manager steps into the title that she has had all along on her business card, product marketing manager" (Moore, 2014, p. 233). Next, there is described that "during the early market, it is important to be product-driven a to give strong powers to the product manager" (Moore, 2014, p. 233). However, there can be discussed this transition from product manager to product marketing manager, thereby suggesting to go from product-driven to market-driven approach is too late if the shape of the mainstream market emerges. The reason for this is the shift from product-driven development (when learning knowledge of technology in early-market development in projects) to market-driven development (when defining the right market seg-

ments for which the company has sufficient knowledge to design a relevant product) would be a process that comes before the emergence of a mainstream market. One of the suggested new jobs by Moore (2014) can therefore also be criticized. The whole product manager, with its dual role of product manager before the chasm and product marketing manager after the chasm, is not precisely what a company needs. A whole product depends on the market needs and therefore, opposite of what Moore (2014) describes, it is crucial to step into the new role of whole product manager early in the market development process. This enables the company to develop the right whole product based on the needs of the market segment that are identified by the target market segment manager.

J.3. Discussion micro level literature

Product-driven approach

There is mentioned that people working on development projects tend to believe there is true value in the innovations that they are developing, it seems that they at least overestimate its value (Lubik et al., 2013, p. 22). In the case study research, engineers would prefer to think in terms of technological feasibility than in terms of customer requirements.

Shift in market orientation

According to literature from Lubik et al. (2013), finding a first partner is one of the main events that ensure the orientation to be shifted to a DP orientation. This is also discussed after the case study research findings.

Initial market estimations

Instead of learning the market needs, there is described that in historical cases, firms tend to rely on prior experience or instinct during the process of product development (Lubik et al., 2013, p. 22). This is also encouraged by the findings in the case study research that is done for this study.

Start-ups versus established firms

Literature from Lubik et al. (2013) describes that start-ups have more difficulty with finding a balance between TP and DP orientation than established firms. According to Lubik et al. (2013), this is due to the limited personnel, and financial resources start-ups often have. If this is considered critically, there can be argued that this is shortfalling. It might be the case that historical cases describe this behaviour, but that does not conclude that there is no alternative. There is stated that the balance between TP and DP orientations is ideal for established firms (Lubik et al., 2013, p. 23). Then ideally start-ups also try to find in a way a balance between TP and DP orientations. The company of the case study research can best be described as a start-up 100% owned by another established firm. This unique combination can take away the barriers of having limited resources in personnel and finance.

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