A MODULAR LIFECYCLE SERVICE APPROACH

APPLICABLE TO NON IP OWNED MEDICAL DEVICES

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COMPANY 1
Company suppervisor

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Management summary

Motivation and research goal

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In 2018, COMPANY 1 introduced The Life Cycle and Support (LCS) department. Their main goals: executing repairs and sustaining of the devices in order to relieve design engineers. During the development of the LCS department, the service offering is often overlooked. This means that opportunities for interesting service contracts are overlooked. This caused the need for this research and led to the following research goal**: Design a generic configurable service model, configuration and approach applicable to the series produced medical products COMPANY 1 develops for their customers including guidelines for its implementation and use.**

Research method and Results

To realize this research goal, a literature study has been conducted on service offering, an industry comparison between different companies (Company 2, COMPANY 3, Company 4, Philips Medical and SKIDATA) has been and a design study at COMPANY 1 for a service offering approach has been executed.

Out of the literature and industry comparison followed that a service offering process contains: different steps, which are used as input for the design research. Those steps contain: discuss the topic service with the customer, have service content which can be offered to the customer and use an approach to tailor the service offering, determine the prices and design the service contract. This design research contains three of those topics which are translated in a three-step approach that is designed: (i) an approach on how to offer services, (ii) a service portfolio with the service content COMPANY 1 could offer and (iii) an approach to tailor the service portfolio to each new situation, i.e., the start of a new product development project. The methodology used in this design science research is based on the *Design Science Research Methodology* of Peffers et al. (2007) and the *Framework for Evaluation in Design Science model* of Venable at al. (2016) is used for the validation and evaluation of the models. Case studies, action research and focus groups are used to validate the results of the design study. The case studies executed, are applied on already existing medical devices COMPANY 1 has designed and produced.

(i) Service offering

The first step of the approach is to create awareness for service at the start of product development. To create this awareness, service needs to be discussed during the kick-off meeting of a product development project. By embedding service at this stage, the customer and COMPANY 1 are required to think about service which brings the awareness that is needed. To embed the service in the kick-off meeting, a service infographic has been developed which should be integrated into the presentation COMPANY 1 uses for those meetings.

(ii) Service content

When offering service, it is important to take control on the service products to offer to be able to standardize the service content for customers and monitor and optimize the service offering in the future. In the current situation, COMPANY 1 does not have a service portfolio and only reacts on the service wishes customers bring in, which causes a wide variety of service products and contracts. In this design study, a service portfolio is developed which COMPANY 1 can use to take control of the service offering. The portfolio exists of three different blocks, the core of the portfolio is the service packages block shifting from silver services to platinum services. The other two blocks contain advice services and different kind of training that can be offered in case the customer wants to take control and execute the service himself.

(iii) Tailoring service portfolio

Because COMPANY 1 develops and produces many different devices for different kind of customers, it is not always possible to offer the same service content. Guidelines and tailoring per device and customer are needed to guarantee that COMPANY 1 is able to execute the service committed and gain profit out of service. Two decision trees have been developed to guide COMPANY 1 in offering the right service. There is a need to design two decision trees because the perspective from both the customer and the device could differ and

conflict with each other. By using both trees COMPANY 1 should be able to execute the service offered and does not have to take high financial risks in the service it offers.

Conclusions and further research

The three-step approach developed in this research is a good first step for COMPANY 1 to gain knowledge about offering service. This process, which was overlooked during the introduction of the Life Cycle Support department is deepened, in this research. The literature study and industry comparison realized a process overview of the steps that need to be taken to execute service offering. Three of those has been integrated into the design study done in this research. (i) The service offering: the awareness for service by customer and COMPANY 1 must be created during the start of new product development. In this study, an approach and service infographic is designed to create the awareness needed. (ii) The service content: a generic service portfolio with service content that COMPANY 1 could offer is designed. (iii) The tailoring of the service to offer: Two decision trees have developed to guide COMPANY 1 in the service offering. COMPANY 1 develops different medical products whit almost no overlap for different customers with different service expectations. The two decision trees are developed from those two perspectives to reduce the risk for COMPANY 1 to offer service which cannot be executed or risks of offering a service product that does bring a big financial loss for COMPANY 1.

The validation of the three designed steps has been done by using action research, focus groups and a case study. Action research and focus groups are used for the validation of the first step (creating awareness for service offering). Focus group, action research and case study are used for the validation of the other two steps. The case study shows that both, the designed portfolio approach and the designed decision trees can be applied to multiple medical product designs and different kind of customers under the circumstances at COMPANY 1. However, the testing is limited as there is no case study applied on to be developed medical devices. Due to the throughput time a total product development process takes. Such a real-life study is needed to be sure that this approach is also working for future projects. According to the focus groups validations, one of the internal focus groups at COMPANY 1 did not succeed to validate the decision trees. The members did not have enough time for this research project to complete the focus group validation. Instead, an in-depth discussions about the decision trees is done with the service coordinator at COMPANY 1 to complete the validation in another way.

Further actions proposed for COMPANY 1 are: firstly to apply case studies on a real-life case preferably on medical devices. Secondly, new research in the field of service pricing and contracting towards determining service prices based on the service portfolio and translating the outcome of the service offering into a service contract is needed. Thirdly, an approach to determine the exact prices for (customer and device) specific service offering could be developed in further research. Finally, in the field of contracting, it is interesting to find out if it is possible to automatically generate service contracts based on the service portfolio.

Preface

I proudly present you my master's thesis, which is the result of less than a year of research. This thesis is written in order to graduate from the master Industrial Engineering and Management at the University of Twente. Meaning that this thesis marks the end of my life as a student, after eight years, which feel more like three or four years.

I thank my supervisors for the University of Twente, Jos van Hillergersberg and Jan Braaksma for guiding me through the process of writing a thesis. The discussions and your advice during our sessions were useful and helped me to realize this research.

Throughout all my years as a student, my parents supported me for which I am grateful and want to thank them. I also thank all my friends I met during my study in Enschede, for all the good times we had and will have in the future.

Enschede August 2019
Pim Cornelissen

Contents

Chapter 1: Introduction

In this chapter, the research is introduced. In Section 1.1 the organization COMPANY 1 is explained and their ambition to become more proactive in the field of service offering. Section 1.2 pays attention to the project context of this research. Section 1.3 defines from literature perspective the servitization trend which is going on. Section 1.4 elaborates on the research objective of this study where Section1.5 explains the research goal. Section 1.6 zooms in on the research approach used in this study and Section 1.7 gives a preview of the designed artefact in this study.

1.1: Organization

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Figure 1 COMPANY 1 development timeline

1.2: Project context COMPANY 1

COMPANY 1 has made the step to production and is able to deliver finished products to the customer. The next phase is to get more control over the total product lifecycle and integrating after-sales and supporting customers during the using phase of the product. A lot of actions has taken place in order to do so. A new Life Cycle and Support (LCS) department has been created a year ago in order to improve the quality of service by organising the service and support at a central place within COMPANY 1. New service staff members were hired, existing employees have been retrained and a service tool has been developed. Step by step the LCS department is taking over the service and support questions COMPANY 1 receives from the customers. But (and that is where this research project pops up) at the start of a product development request lifecycle management and support is not always on the table jet. It is not always clear what COMPANY 1 can offer, how to price the service products, which processes should start from the moment the first products are delivered and so on.
This research will help in the transition of servitization.

1.3: Project context literature

The trend of servitization is still going on. But in the literature there are few and relatively old examples according to economic success in the adaptation of servitization. Especially business case implementation seems something that does not come up within the different research areas in servitization. Literature reviews have been done like Bains et al. (2009) Reim et al. (2014) in order to categorize servitization, to try to get clear definitions of concepts like, servitization, product service system etc. But most of these scientific papers ask for more research according to implementation of servitization, quantitate methods, guidelines, tools and techniques that enable businesses to adopt servitization (Baines et al. 2007) (Bains et al. 2009) (Garrido et al. 2018).

1.4: Research Objective

The research objective is to help COMPANY 1 in the servitization transition by designing a generic three-step approach that helps COMPANY 1 to: **Bring service to the conversation table**, helps in **determining what services to offer** and **which part of the portfolio to offer in which situation**. This within de scope of medical devices designed for customers where COMPANY 1 is not the IP owner.

1.5: Research Goal

Now the objective is clear the goal and the research questions are formulated here. The goal of this research is:

Design a generic configurable service model, configuration and approach applicable to the series produced medical products COMPANY 1 develops for their customers including guidelines for its implementation and use.

The research questions that should be answered are divided into two subsets. The first subset of questions are general questions that need to be answered to have a clear understanding of different concepts. The second set contains questions that are answered from three perspectives, a **theoretical**, **industry** and **COMPANY 1** perspective. In this research a literature study has been done, in-depth interviews at some B2B companies, papers, web resources have been checked and, the design study at COMPANY 1 has been done.

The **general** questions to realize the research goal:

- What is service?
- What is the current situation at COMPANY 1?
- What is COMPANY 1's service ambition?

The questions below are answered from different aspects: **Theoretical**, **industry** and **COMPANY 1** perspective.

- What steps does a service offering process consist of?
- How to create awareness for service offering?
- What content does a service portfolio contain?
- How can a service portfolio be made flexible?
- How to determine which service to offer?

1.6: Research approach

In this research Design Science Research the methodology of Peffers et al. (2007) is used. Based literature search with search terms as: Design Science Research methodology, Peffers et al (2007) came out as a reliable well-suited approach for this research. The six-step approach is explained in chapter two. Because Peffers et al. (2007) have a little lack of in-depth evaluation approach. A new literature search has been executed with search terms as evaluation design science. This brought the framework for evaluations in design science research of Venable et al (2016) as added evaluation model to the model of Peffers et al. (2007).

In this research desk research, explorative interviews at COMPANY 1 have been done and in-depth interviews at other B2B companies in order to see how other companies do approach the field of service offering. The service model or artefact to be designed has been iteratively evaluated and improved based on the new insights that came up during the research.

1.7: The to be designed artefact

Because it is difficult to have a clear understanding of the artefact to be developed here in this paragraph an explanation of the to be designed artefact and the need or reason why to develop the artefact is given. Later on, in this report in chapter three, we will come back on this paragraph and the design of the artefact. A clear understanding of the artefact before reading the design approach and methodology (chapter 2) will help the reader to better understand how the methodology is used.

From the first paragraphs of this chapter, we know that COMPANY 1 has made the step from designing devices to production of those designed devices (assembly of products) and recently

started with the Lifecycle Support department. The main drive was to relief the design engineers who got broken products back at the table. This internal focus and need for the LCS department resulted in a lack of outside focus. No attention was paid to the service offering, when and how to discuss this topic with the customer, the content of the service to offer and a selection approach to determine when to offer which part of the service portfolio. That is where the need and the design for the artefact of this design research come from. The to be designed artefact is an approach for offering service, contains a modular model with service content to offer and a selection approach that can be used to determine which part of the service portfolio to offer when. This including guidelines for implementation and use. The scope of products in this research are in series produced medical devices.

Chapter 2: Design approach/ methodology

In this chapter, the research methodology is explained. Section 2.1 explains the academic field of design science and Section 1.2 elaborates on the Design science approach which is used in this research, the methodology of Peffers et al. (2007) is explained for the artefact design and the model of Venable et al. (2016) is used to evaluate the designed artefact.

2.1: Design science

As mentioned in chapter one, this research contains the development of a service package and approach Artefact in order to improve the way of service offering at COMPANY 1. When designing an artefact a DSRM approach is needed. A literature study for a suited research approach/methodology is done, literature search with search terms as: Design Science Research methodology is executed. Here the model of Peffers et al. (2007) was selected based on the citations of their paper and the fit whit the design study done in this research. However, the evaluation part of Peffers et al. (2007) could use some more extension. For that reason a new search for an evaluation approach is executed. This brought the framework for evaluation design science (FEDS) of Venable et al. (2016) in this study which will be used for the evaluation of the artefact design. The next sections in this chapter will explain both approaches.

2.2: Design science approach

Peffers et al. (2007) developed a DSRM process for design science because Design Science Research (DSR) is not part of the dominant Information Systems (IS) research culture, no DSR model exist. Without one, it may be difficult for researchers to evaluate a designed artefact or even to distinguish it from practice activities such as consulting. Their model exists of six different phases that are explained here.

Design science creates and evaluates artefacts intended to solve identified organizational problems. It involves a rigorous process to design artefacts to solve observed problems, to make research contributions, to evaluate the design, and to communicate the results to appropriate audiences. Such artefacts may include constructs, models methods and instantiations. They may also include social innovations or new properties of technical, social or informational resources. In short, these definitions include any designed object with an embedded solution to an understood research problem.

Hevner et al. (2004) developed seven guidelines that describe the characteristics of well carried out research. Most important of these is that research must produce an artefact created to address a problem. Further, the artefact should be relevant to the solutions of an unsolved and important business problem. Its utility, quality and efficacy must be rigorously evaluated. The research should represent a verifiable contribution and rigour must be applied in both the development of the artefact and its evaluation. The development of the artefact should be a search process that draws from existing theories and knowledge to come up with a solution to a defined problem. Finally, the research must be effectively communicated to appropriate audiences.

The principles and practice rules for DSRM are only two out of the three characteristics of a methodology the missing part is a procedure that provides a generally accepted process for carrying it out. Peffers et al. (2007) had the overall objective to develop a methodology for DSR in IS. The design of the conceptual process will seek to meet three objectives: it will provide a nominal process for the conduct of DSR, build upon prior literature about DSR in IS and reference disciplines, and provide researchers with a mental model or template for a structure for research outputs.

Peffers et al. (2007) came up with a model that can be found in Figure 2 *DSRM model Peffers et al. (2007)*.

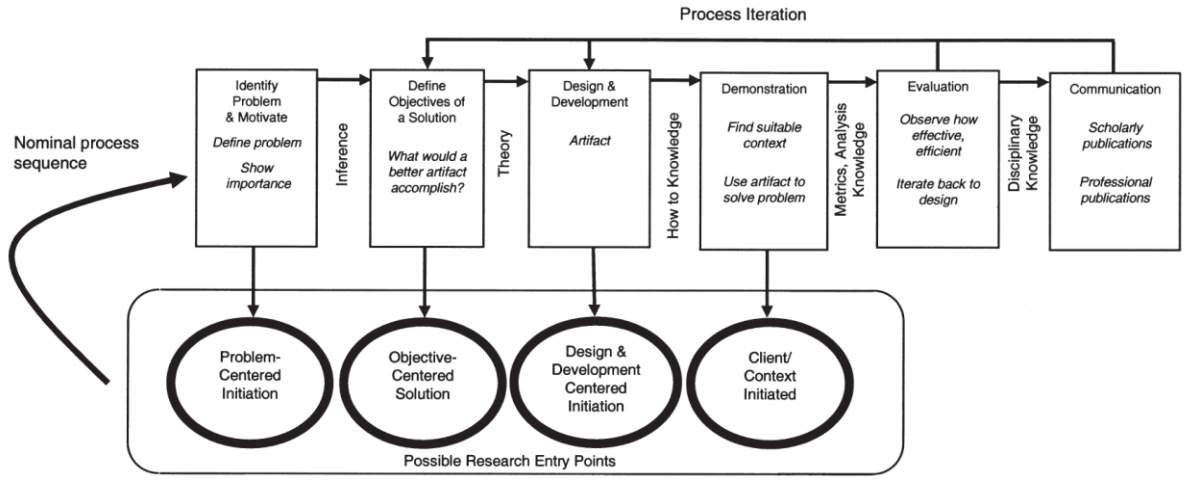

Figure 2 DSRM model Peffers et al. (2007)

This model contains six steps which are explained here. The first activity is problem identification and motivation. Here the specific research problem and the value of the solutions are defined. Because the problem definition is used to design the artefact, it may be useful to atomize the problem conceptually so that the solutions can capture its complexity. Justifying the value of a solution accomplishes two things: it motivates the researcher and the audience to pursue the solution and to accept the results and it helps to understand the reasoning associated with the researcher's understanding of the problem. Resources required for this activity include knowledge of the state of the problem and the importance of its solution.

Activity two is to define the objectives for a solution. Determine the objectives of a solution from the problem definitions and knowledge of what is possible and feasible. The objectives can be quantitative (terms in which a desirable solution would be better than current ones) or qualitative (a description of how a new artefact is expected to support solutions to problems not hitherto addressed). The objectives should be inferred rationally from the problem specifications. Resources required for this include knowledge of the state of problems and current solutions, if any, and their efficacy.

Third the design and development. Here the artefact is created. Artefacts are potentially constructs, models, methods, instantiations or new properties of technical, social, and or informational resources. Conceptually, a design research artefact can be any designed object in which a research contribution is embedded in the design. This activity includes determining the artefacts' desired functionality, its architecture and the creation of the actual artefact. Resources required for moving from objectives to design and development include knowledge of theory that can be brought to bear in a solution.

Fourth is demonstration. Here the use of the artefact is demonstrated to solve one or more instances of the problem. This could involve its use in experimentation, simulations, case study, and proof or other appropriate activity. Resources required for the demonstration include effective knowledge of how to use the artefact to solve the problem.

The fifth activity is evaluation, the artefact is observed and measured how well it performances and supports a solution to the problem. This activity involves comparing the objectives of a solution to actual observed results from use of the artefact in the demonstration. It requires knowledge of

relevant metrics and analysis techniques. Depending on the nature of the problem venue and the artefact, evaluation could take many forms. It could include items such as a comparison of the artefacts functionality with the solution objectives from activity two, objective quantities performance measures such as budgets or items produced, the results of satisfaction surveys, client feedback, or simulations. It could include quantifiable measures of system performance, such as response time or availability. Conceptually, such evaluation could include any appropriate empirical evidence or logical proof. At the end of this activity, the researcher can decide whether to iterate back to activity 3 to try to improve the effectiveness of the artefact or to continue on to communications and leave further improvement to subsequent projects. The nature of the research venue may dictate whether such iteration is feasible or not.

The last sixth step is communication. Here the problem and its importance, the artefact, its utility and novelty, the rigour of its design, and its effectiveness are communicated to researchers and other relevant audiences such as practising professionals, when appropriate. In scholar research publications, researches might use the structure of this process to structure the paper, just as the nominal structure of an empirical research process is a comment structure for empirical research papers. Communications require knowledge of the disciplinary culture.

In this research, the steps five and six of Peffers et al. (2007) has been replaced by the Framework for Evaluation in Design Science by Venable et al. (2016) we will elaborate on this approach in the Section 2.2.1

2.2.1: DSR Evaluation approach

In their paper, a framework for evaluation in design science research Venable et al. (2016) explains their framework for evaluation in design science. It consists of four steps: 1) explicate the goals of the evaluations, 2) choose the evaluation strategy or strategies, 3) determine the properties to evaluate, 4) design the individual evaluations episodes. (Venable et al., 2016) (Venable et al., 2012)

Evaluation in the literature done by Venable et al. (2016) identifies the two most important categories of evaluations as formative vs summative evaluations, and ex-ante vs ex-post evaluations. Ex-post evaluation is evaluation of an instantiated artefact (i.e. an instantiation) and ex-ante evaluation is evaluation of a un-instantiated artefact, such as a design or model. (Venable et al., 2012)

Framework for evaluation in design science research:
Venable et al. (2016) developed a framework for evaluations in design science research (FEDS), which is designed in an analytical way by looking at different classifications of extant evaluation methods and relating them to the goals of evaluations in DSR. The goals are the varying objectives while evaluations methods are the means. The framework provides a way to support evaluation research design decisions by creating a bridge between the evaluations goals and evolution strategies. Two important aspects or dimensions are the functional purpose of the evaluation (formative or summative), then why to evaluate and the paradigm of the evaluations (artificial or naturalistic). These two dimensions are the basis of the FEDS.

Dimension 1 functional purpose of the evaluation, this dimension is a continuum between formative a summative evaluations. The formative purpose is to help improve the outcomes of the process under evaluation. Summative evaluations are to judge the extent that the outcomes match expectations. Towards the formative end evaluations must provide a basis for successful action. Towards the summative end evaluations must create a consistent interpretation across shard meanings.

The second dimension Venable et al. (2016) use in their FEDS is the distinction between artificial and naturalistic evaluation. Artificial is nearly always used to test design hypotheses and has the main goal of proving or disproving the design theory and or utility of the designed artefact. The artificial evaluation includes laboratory experiments, simulations, criteria-based analysis, theoretical arguments, and mathematical proofs. Naturalistic evaluations explore the performance of a solution technology in its real environment. Naturalistic methods typically include case studies, field studies, field experiments, surveys, ethnography, phenomenology, hermeneutic methods, and action research. Naturalistic evaluations can be costly and difficult where artificial evaluations fail to adhere to one or more of the three realities, unreal users, unreal systems or unreal problems and therefore may not correspond to the real use in Figure 3 *FEDS (Framework for evaluation in Design Science) with evaluation strategies (Venable et al., 2016)* framework can be found

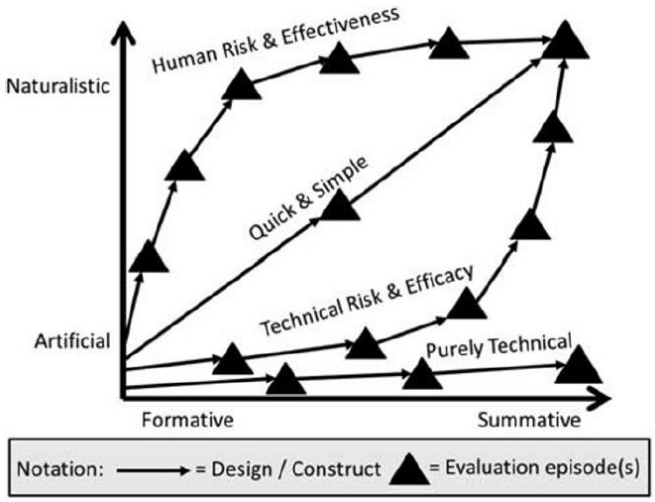

Figure 3 FEDS (Framework for evaluation in Design Science) with evaluation strategies (Venable et al., 2016)

2.2.2: Evaluations strategies

Venable et al. (2016) defined four different possible strategies. The strategies include the quick and simple strategy, the human risk and effectiveness evaluations strategy, the technical risk and efficacy evaluation strategy and the purely technical artefact strategy. The FEDS in Figure 3 *FEDS (Framework for evaluation in Design Science) with evaluation strategies (Venable et al., 2016)* shows these different strategies. Here the triangles show the evaluations episodes or where the evaluations occur in the strategy. The number of triangles and their placement along any particular strategy's trajectory are indicative only; they may and should vary according to the needs of a particular DSR project. Below the different strategies are explained.

The quick and simple strategy is as the names do expect a little formative, progresses quickly to summative and more naturalistic evolutions. The trajectory of these strategies includes relatively few evolutions episodes. It could occur that only one summative evaluation at the end of the project. This strategy is low cost and encourages quick project conclusion, but may not be reasonable in the face of various design risk.

The Human risk and effectiveness evaluation strategy emphasises formative evaluations early in the process, possibly with artificial, formative evaluations early in the process, but progressing quickly to more naturalistic formative evaluations. Near the end of this strategy, more summative evaluations are engaged, which focus on rigorous evaluations of the effectiveness of the artefact. This means that the utility or benefits of the artefact will continue to accrue. Even when the artefact is placed in

operation in real organisational situations and over the long run, despite the complications of human and social difficulties of adoption and use.

The technical risk and efficiency evaluations strategy emphasizes artificial formative evaluations iteratively early in the process but progressively moving towards summative artificial evaluations. Artificial summative evaluations are used to rigorously determine the efficacy of the artefact which means that the utility or benefits derived from the use of the artefact are due to the artefact, not due to other factors. Near the end of this strategy, more naturalistic evaluations are engaged.

The purely technical strategy is used when an artefact is purely technical, without human users, or planned deployment with users is so far removed from what is developed to make naturalistic evaluation irrelevant. This strategy is similar to the quick and simple strategies, but favours artificial over naturalistic evaluations throughout the process, as naturalistic strategies are irrelevant to purely technical artefacts or when planned deployment with users is far in the future.
Table 2 *The four different DES evaluation strategies (Venable et al., 2016)* summarises the relevant circumstances when to select which of the four strategies

Table 1 Circumstances for selecting a relevant DSR evaluation strategy

DSR evaluation strategies	*Circumstance selection criteria*
Quick & Simple	If small and simple construction of design, with low social and technical risk and uncertainty
Human Risk & Effectiveness	If the major design risk is social or user oriented *and/or* If it is relatively cheap to evaluate with real users in their real context *and/or* If a critical goal of the evaluation is to rigorously establish that the utility/benefit will continue in real situations and over the long run
Technical Risk & Efficacy	If the major design risk is technically oriented *and/or* If it is prohibitively expensive to evaluate with real users and real systems in the real setting and/or If a critical goal of the evaluation is to rigorously establish that the utility/benefit is due to the artefact, not something else
Purely Technical Artefact	If artefact is purely technical (no social aspects) or artefact use will be well in future and not today

Table 2 The four different DES evaluation strategies (Venable et al., 2016)

2.2.3: Strategy choice process for DSR

Based on the framework with the different strategies, the question arises on how to select the right strategy. Venable et al. (2012) have designed a four-step approach which helps in selecting the right strategy for a DSR project. First, explicate the goals of the evaluations, second choose the evaluation strategy or strategies, third determine the properties to evaluation and forth design the individual evaluations episodes.

Explicate goals

Step one explicate the goals has been analysed by Venable et al. (2016), they found four different goal categories, Rigour, Uncertainty and risk reduction, Ethics and Efficiency. Depending on the project the importance of the different goals will differ.

Rigour has two senses. First efficiency, here the focus is on the outcome of the artefact and only the artefact, not some confounding independent variable or circumstance. The second sense is effectiveness, here the goal is that the artefact instantiation works in a real situation.
Artificial evaluations will likely be the most appropriate for the efficacy goal while naturalistic evaluations more suit the effectiveness goal. Uncertainty and risk reduction, formative evaluation is important when design uncertainties are significant and is a key way to reduce risks. Risks may be identified as human social/use risks and technical risk (the risk that the technology cannot be made to function). Formative evaluations should be conducted as early as practicable in an evaluations trajectory or strategy. Identifying difficulties and areas for improvement as early as possible so as to influence and improve the design of the artefact supports the development of a higher quality. Summative evaluation is the best way to ensure the rigour that reduces risks.

Efficiency, this balances the above mentioned goals against the resources that are available. Formative evaluation can reduce cost by evaluating before incurring the cost of installation and theory specification in a prudent way. The naturalistic evaluation takes longer and is more costly than artificial evaluations. Specific methods of evaluations are less costly, with non-empirical (which are artificial) evaluation methods often have large savings.

To guide the identification, analysis and priorities of all the requirements or goals for the evaluation portion Venable et al. (2012) developed seven steps to follow:

a) Determine what the evaluands are/is. Will they be concepts, models, methods, instantiations, and/or design theories?
b) Determine the nature of the artefact (s)/evaluand(s). Is (are) the artefact (s) to be produced a product, process, or both? Is (are) the artefact (s) to be produced purely technical or socio-technical? Will it (they) be safety-critical or not?
c) Determine what properties you will/need to evaluate. Which of these (and/or other aspects) will you evaluate? Do you need to evaluate utility/effectiveness, efficiency, efficacy, ethicality, or some other quality aspect (and which aspects)?
d) Determine the goal/purpose of the evaluation. Will you evaluate single/main artefact against goals? Do you need to compare the developed artefact against with other, extant artefact s? Do you need to evaluate the developed artefact (s) for side effects or undesired consequences (especially if safety-critical)?
e) Identify and analyze the constraints in the research environment. What resources are available – time, people, budget, research site, etc.? What resources are in short supply and must be used sparingly?
f) Consider the required rigour of the evaluation. How rigorous must the evaluation be? Can it be just a preliminary evaluation or is detailed and rigorous evaluation required? Can some parts of the evaluation be done following the conclusion of the project?
g) Prioritize the above contextual factors to determine which aspects are essential, more important, less important, nice to have, and irrelevant. This will help in addressing conflicts between different evaluation design goals.

In this research, a quick analysis of the goals based on the steps above is executed to support the decision-making according to the best-fitted strategy or combinations of strategies applied in the evaluation execution.

2.2.4: Choosing a strategy or strategies

There are four considerations that need to take into account in order to decide which strategy or strategies a DRS project will fit. First the type of design risk (social or technically), second the costs of the evaluating in the real setting relative to the resources of the project, third figure out if the

artefact being developed is purely technical and if the need for the design is urgent or more future related. Last the difference between small and simple constructions versus large and complex ones.

Evaluate and prioritise design risks, when the major design risk is social or user-oriented a Human Risk & effectiveness strategy could fit. But when the major risk is technology focussed for example if a certain technology will work or not. A technical risk and efficiency strategy could fit better and starts with laboratory experiments then a human risk and effectiveness strategy may buy some speed for money to clarify boundaries of the technology seems a good start.

The costs of evaluation with real users and real systems relative to the resources available in the project do affect the decision for a certain strategy. For example, if it is relative cheap to have real users in their real context a Human risk and Effectiveness strategy fits well. A novice researcher may have enough time with real users but limited development or other resources available. In this case, it may be best to evaluate the design using a simple and cheap prototype first. When on the other and time is limited and enough money available the human risk and effectiveness strategy can buy some speed for example by investing in a usability lab. If it is too expensive to evaluate with real users and real systems in terms of money, health or life, then a technical risk and efficacy strategy may fit.

If a design is simple and small or complex and large determines to allow for the evaluation process. Here small and simple designs ask for a quick and simple strategy and complex and large projects need to look more in-depth on the other 3 considerations.

In order to guide the selection of the strategy to use Venable et al. (2012) developed a strategy selection framework, based on a two by two matrix. Naturalistic vs artificial and ex-ante vs ex-post guidelines have been formulated. Looking at the criteria in both white portions relating to a single dimension and the blue areas relating to a single quadrant. The criteria statements that match the contextual features of your DSR project will determine which quadrant(s) applies(y) most or are most needed. It may well be that more than one quadrant applies, indicating the need for a hybrid Methods evaluation design (Venable et al., 2012) the overview can be found in Figure 4 *selection framework evaluation strategy*.

DSR Evaluation Strategy Selection Framework		Ex Ante	Ex Post
		•Formative •Lower build cost •Faster •Evaluate design, partial prototype, or full prototype •Less risk to participants (during evaluation) •Higher risk of false positive	•Summative •Higher build cost •Slower •Evaluate instantiation •Higher risk to participants (during evaluation) •Lower risk of false positive
Naturalistic	•Many diverse stakeholders •Substantial conflict •Socio-technical artifacts •Higher cost •Longer time - slower •Organizational access needed •Artifact effectiveness evaluation •Desired Rigor: "Proof of the Pudding" •Higher risk to participants •Lower risk of false positive – safety critical systems	•Real users, real problem, and somewhat unreal system •Low-medium cost •Medium speed •Low risk to participants •Higher risk of false positive	•Real users, real problem, and real system •Highest Cost •Highest risk to participants •Best evaluation of effectiveness •Identification of side effects •Lowest risk of false positive – safety critical systems
Artificial	•Few similar stakeholders •Little or no conflict •Purely technical artifacts •Lower cost •Less time - faster •Desired Rigor: Control of Variables •Artifact efficacy evaluation •Less risk during evaluation •Higher risk of false positive	•Unreal Users, Problem, and/or System •Lowest Cost •Fastest •Lowest risk to participants •Highest risk of false positive re. effectiveness	•Real system, unreal problem and possibly unreal users •Medium-high cost •Medium speed •Low-medium risk to participants

Figure 4 Selection framework evaluation strategy Venable et al. (2012)

Determine the properties to evaluate

Next in the strategy formulations is to define what to evaluate. Defining the features, goals and requirements of the artefact that are to be subject to evaluations. Venable et al. (2012) have developed a four-step heuristic for choosing evaluation properties.

Step 1) frame of potential artefacts is to explicate the goals of the evaluation. Step 2) is to determine a strategy or strategies for the evaluation, step 3) determine the properties to evaluate and last step 4) develop the individual evaluation episodes (the triangles from Figure 3).

To guide the selection of an appropriate evaluation method or methods that align with the chosen strategies of Figure 5 *DSR evaluation strategy selection framework (Veable et al., 2012)* has defined a framework to select appropriate evaluation methods. Those can be found in Figure 5 *DSR evaluation strategy selection framework (Veable et al., 2012)*

DSR Evaluation Method Selection Framework	Ex Ante	Ex Post
Naturalistic	•Action Research •Focus Group	•Action Research •Case Study •Focus Group •Participant Observation •Ethnography •Phenomenology •Survey (qualitative or quantitative)
Artificial	•Mathematical or Logical Proof •Criteria-Based Evaluation •Lab Experiment •Computer Simulation	•Mathematical or Logical Proof •Lab Experiment •Role Playing Simulation •Computer Simulation •Field Experiment

Figure 5 DSR evaluation method selection framework

Design the individual evaluation episodes

When the strategy or strategies are clear, the methods are chosen and the decision has been made what properties to evaluate of the artefact the next step is to design the evaluation episodes. Based on the FEDS (see Figure 3) a rough idea about the number of episodes is there. Still, an approach is needed for designing individual episodes. First, the constraints in the environment need to be clear, what resources are available, time, people budget, research site etc. this determines where to focus on. Categorizing these resources is essential, more important, less important, nice to have and irrelevant is the next step. The last step is to determine the amount of evaluations episodes, when, where and who is doing what.

Chosen evaluation strategy

The designed artefact in this research is of the type “process artefact”. All the steps of the artefact are methods/approaches to guide someone or tell them what to do to accomplish some tasks. Process artefacts are social-technical kind of artefacts. Which means that the human risk & effectiveness evaluation strategy from Venable et al. (2016) suits best for this research. This corresponds with the naturalistic and ex-ante types from Venable et al. (2012). Action research, focus groups and case studies are used in this research to accomplish the evaluation strategy.

Chapter 3: COMPANY 1's current state

In this chapter, the current situation is explained. In Section 3.1 the context of COMPANY 1 is described. Section 3.2 explains the way of working at COMPANY 1 based on the stage-gate model that is used. Section 3.3 zooms in on the service offering process at COMPANY 1 in the current situation. Section 3.4 zooms in on the current organizational structure and place of the LCS department at COMPANY 1 which is responsible for the service execution. Section 3.5 provides background information on the consequences of service due to medical regulation. Section 3.6 provides a conclusion about the current situation at COMPANY 1 and Section 3.7 combines the conclusion of Section 3.6 whit the input from Chapter 2 into the objectives the designed artefact of this research should bring.

3.1 COMPANY 1 context

confidential

3.2: Stage-gate model

COMPANY 1 works according to the well know stage-gate model Cooper (1990) from the development of the product to the production. See Figure 6 *Stage gate model at COMPANY 1 (COMPANY 1, 2016.)*

confidential

Figure 6 Stage gate model at COMPANY 1 ***(confidential, 2016)***

confidential

3.3: Service offering process

Roughly a year ago the start has been made of a service department within COMPANY 1, this so-called Lifecycle Support department. The LCS department has been created in order to relief design engineers with repairs of broken products. The design engineers were asked every time a broken product came in, where it was unclear what the problem was. Most of the time these engineers are already working on new projects and products to develop. Because the reason to set up the LCS department was internally focused at the start of the department not many service agreements where developed and agreed on. If they were developed, it was in a reaction to customer demand. If the customer asked for service they brought in their wishes and COMPANY 1 sees if they can agree on those and develops a specific service level agreement for that specific customer. Some customers explicit ask for service and come with their service request. But most of the customers forget the service conversation. For that reason, most products COMPANY 1 produces have no service contract. Service repairs are based on a recalculation of the made working hours and materials used. First COMPANY 1 makes an analysis of the problem, sends a quote based on the analysis and wait for approval before repairing the product. Because of the lack of an agreement, there are no clear response times, therefore customers try to push the LSC department to work faster. This makes it difficult for the department, the customer who tends to asks for the most attention get shorter response times, while not paying for those shorter response times. Setting up Service Level Agreements (SLA's) that contain priority rules can help the service department to get less pressure from the customers.

3.3.1: Current SLA content

Some major customers of COMPANY 1 at this moment have a SLA. This, in order to guarantee their service levels. Currently, COMPANY 1 is, as introduced earlier reactive, according to what the customer wants and evaluates internally if COMPANY 1 should agree on the customer request or

not. This leads to different service levels agreements. At this moment in time, three different kinds of service level agreements exist. While in total 4 SLA's have been signed or almost signed. Where today COMPANY 1 is able to hold the overview of the current SLA types, this could bring problems for the future in case the service offering approach will not change.

A first SLA is a SLA compared to a service contract for cars, with the half-year and yearly planned minor and major maintenance. There has been agreed that the customer does small maintenance and product inspection every half year. This must be done in the way COMPANY 1 explained in the maintenance training guidebook. Besides the small maintenance, COMPANY 1 handles yearly major maintenance. The customer needs to bring in the product to COMPANY 1 and COMPANY 1 handles the maintenance. It is possible for the customer to get a loaner device during the maintenance but they have to pay every time they want to make use of this option. Additionally, the customer can bring in a broken product which is repaired separately from the major maintenance.

The second kind of SLA is one where a list is generated with common repairs, those repairs get a standard fixed price so when a broken product comes in COMPANY 1 does an analysis to determine the problem, is it a known breakdown that is communicated to the customer and the costs are known. Is the cause of the breakdown new, than COMPANY 1 makes and estimation and communicates a rough quote. Based on the used time and material the real price is set. When the specific breakdown has occurred more often the fixed price is determined. And at the end of the year, this price is added to the price list.

The third type of SLA is one where small maintenance is done by the customer of COMPANY 1 and if that is not possible they swap the whole system and send a loner-device. The SLA contains an agreement on the number of loaner-devices the customer has and the price the customer pays for a loaner device. Because those devices will not be used often and the customer of COMPANY 1 is not allowed to sell them. A reduced price for those devices is agreed.

3.4: The organizational structure according to service and the LCS department.

As mentioned COMPANY 1 is divided into different subsidiaries. COMPANY 1, or COMPANY 1, is the part of COMPANY 1 that is responsible for the development of the products. COMPANY 1 Production, or COMPANY 1, is responsible for the production of the developed products. The employees from the Lifecycle Support department, or LCS, work formally in the COMPANY 1 subsidiary but the projects they run are COMPANY 1 projects, the profit or loss that is made on the service operations are booked on the subsidiary COMPANY 1. The non-commercial hours worked by the employees of the LCS department are booked on the subsidiary COMPANY 1 (because the department is part of that subsidiary. Non-commercial hours are inefficiency, or overhead, that cannot be invoiced to the customer, department meetings or for example improvement projects run within the department. Here you could think for the LCS department of hours working on the development of the service tool they use. In this way, the COMPANY 1 has the benefit of the LCS department where COMPANY 1 only end up with the cost. There is an intercompany (within the total COMPANY 1 group holding) cash flow from the subsidiary COMPANY 1 to COMPANY 1 for the worked hours on COMPANY 1 projects of the LCS department employees. Because this cash flow is structural and not incidental it creates extra work but does not bring any added value.

In the world of service, everyone is speaking about lines of support. The first line is the direct contact with the end-user of the product to explain the issue. This line tries to solve the problem. When they are not able to solve the problem the issue is escalated to the second line of support. Here a more in-depth analyse is done in order to solve the problem. In case the second line support is not able to solve the problem they can escalate as well to the third level of support. This is where no further escalation is possible.

COMPANY 1 does not offer first-line support, the reason for this is that the IP and the product are not owned by COMPANY 1. Most of the time the customer of COMPANY 1 sells the product to the end-user of the product. For that reason, COMPANY 1 does not have contact and no contract about service with the end-user. It is up to the customer of COMPANY 1 what services they offer to their customers, therefore, there is no interest for COMPANY 1 to offer the first line support to the end-user of the products. COMPANY 1 offers however second, third and fourth line of support. Second-line support is done by a service engineer who can escalate to third line support which is a sustaining engineer who can escalate to fourth line support which is a product development team.

3.5: Consequences for service due to medical regulations

Due to the fact that the scope of this research contains medical devices, there is some legislation which needs to be followed according to the service offered for that kind of products. Different regulations and the ISO 13485 (ISO, 2016) brings constraints according to service. This paragraph will explain those constraints.

First of all, a company needs to have the ISO 13485 registration. ISO stands for International Organization for Standardization. ISO is an independent, non-governmental international organization with a membership of 164 national standards bodies. International Standards give world-class specifications for products, services and systems, to ensure quality, safety and efficiency. They are instrumental in facilitating international trade. The ISO 13485 certificate is needed to handle medical devices and forces companies to have proper quality management systems and requirements for regulatory purposes. The 13485 ISO norm specifies requirements for a quality management system that can be used by an organization involved in one or more stage of the lifecycle of a medical device, including design, development, production, storage, distribution, installation, servicing, final decommissioning and disposal of medical devices (ISO, 2016). For service, this means that all the service actions are only allowed to be done by trained and certified personnel. COMPANY 1 trains their personnel during the production phase so service engineers can directly start working when service orders arrive at COMPANY 1. In case the customer of COMPANY 1 wants to offer the service their own they need to get trained. Because of the medical ISO 13458, COMPANY 1 has a quality management system that needs to be used for service as well. This means that all the service actions that are done need to be documented and saved. When a problem occurs that is new for COMPANY 1 an investigation is needed to be sure no patient risk will occur due to the defect. At the same time, a solution needs to be developed and documented, this solution approach is the way how in the future this specific problem is solved. In the ISO 13485 is stated that at least must be in the quality system according to complaint handling. The organization shall document procedures for timely complaint handing in accordance with applicable regulatory requirements. These procedures shall include at minimum requirements and responsibilities for:

a) receiving and recording information;
b) evaluating information to determine if the feedback constitutes a complaint;
c) investigating complaints;
d) determining the need to report the information to the appropriate regulatory authorities;
e) handling of the complaint-related product;
f) determining the need to initiate corrections or corrective actions.

If any complaint is not investigated, justification shall be documented. Any correction or corrective action resulting from the complaint handling process shall be documented. If an investigation determines activities outside the organization contributed to the complaint, the relevant information shall be exchanged between the organization and the external party involved (ISO, 2016).

3.6: Conclusion Current state at COMPANY 1

The current situation at COMPANY 1 according to service for the medical serial products can be described as reactive. Never has COMPANY 1 taken the lead in order to bring service on the conversation table. COMPANY 1 reacts on what a specific customer wants and sees case by case what COMPANY 1 is able of and whatnot. No real structure is available according to the service offering, way of bringing in the service conversation, what kind of services to offer and even the way prices are set for the service is not structured. This way of working at COMPANY 1 could lead to problems in the future, when the number of SLA type's keeps going up it becomes difficult to keep control and holding overview on the service offering, the risk both financially and the ability to execute the service will be more difficult, the stress on the LCS department increases and service opportunities could be overlooked.

3.7: Translating the problem identification and motivations into the objectives for solutions the artefact should bring

The conclusions of the current state are the input for the objectives of the solution the artefact should bring. In chapter one, the goals of this research are mentioned and the previous paragraph in this chapter brings the conclusion about the current situation and the shortcomings there are. This combined brings the objectives of a solution. The gap of a commercial responsible person for the service creates the lack of focus there is within COMPANY 1. This lack can be fixed by the development of an artefact that contains a modular service portfolio that can be used for multiple projects (within the scope of this research, serial medical produced devices). This artefact should bring more awareness by customer and the sales employees (project manager at COMPANY 1 and COMPANY 1 plus the managing director of COMPANY 1) according to service, it should contain a clear overview of the services COMPANY 1 is able and allowed by law to offer and in the end it should contain guidelines when and how to use this artefact and it must bring COMPANY 1 in control for the service offering. With this translation the second step of the Peffers et al. (2007) model has been made, an objective of the solution the artefact should bring is given. In the next chapter a comparison research is done in order to see how other companies approach too service, and what the scientific world has written about the way service should be provided to make it success full. This is the input for the third step of Peffers et al. (2007); the Design and Development of the artefact. Below a bullet point overview of the high-level design objectives for the three-step approach can be found, each step with its own high-level goal. In chapter 5 where the design of the three different steps is explained, detailed design objectives per step will be substantiate.

- Create awareness for customer and COMPANY 1 about service.
- Bring COMPANY 1 in control by pro-active service offering.
- The service model should be generic and usable for different customer groups within the medical business unit at COMPANY 1.

Chapter 4: service models and relating approaches

This chapter explores the literature, and industry for existing service approaches that could be used in the COMPANY 1 situation. Section 4.1 contains a literature study on the potential benefit and challenges of service offering. Section 4.2 explores literature about service pricing methods. Section 4.3 contains an industry and company comparison on how different companies approach their service offering processes and approaches. Section 4.4 combines the studies of section 4.1, 4.2 and the comparison of 4.3 and analyses if there are fits whit the COMPANY 1 service offering scope in this research. This corresponds with the first information gathering for the design approach of the artefact according to Peffers et al. (2007)

4.1: Literature study

In the literature study, the databases of Scopus and Web of Science have been used to find relevant literature. Search terms for the methodology used in this research contain: Design Science research, evaluation design science, model evaluation, artefact design. For the content of this study research terms as: servitization, aftermarket sales, service approach, service offering, service pricing, performance-based contracting, product service combination, service provider, service supply chain. Based on the number of citations in the databases, abstracts of papers have been read to find a certain match with this study. The relevant papers found will be explained in the next sections.

In the western economies, service contains a big part from the total economy and is still rising for several years now. Not only full-service providers but especially manufacturing companies develop expand their service intensity. The CBS in the Netherlands recognizes these trend numbers shows that the part services contain the total economy is still growing today (Van, van Dalen, & Notten, 2017). In research, Vandermerwe and Rada were the first that published a scientific paper about this trend and came up with the term servitization at the late eighties.

Services are performed rather than produces and are essentially intangible (Rada & Vandermerwe, 1988). But the substitution between goods and services is there. For example, yesterday's barber services are today's electronic razor but as well the other way around all products produce services and service companies buy goods to produces services (airlines buys planes in order to sell flight tickets).

After Rada et al. (1988), it took some time before the servitization topic was adopted in research, Reim at al. (2014) has done a literature study that has been published in 2014. This paper shows that since 2003 this topic gains some research interest. Based on the different type of journals that published papers they have seen that many research backgrounds start getting interested. This makes it difficult to come up with standardized definitions. Different area's use different names. Servitization, industrial product-service system, product service system, service-dominant logic, functional sales product bundling etc. All terms which target the same content, service offering for product manufactures.

Manufacturers can base their competitive strategies on services, and the process through which this is achieved is commonly known as servitization (Neely, 2008). It can be approached in various ways. Some manufacturers simply add more and more individual services to complement their product offerings, while others develop bespoke, long-term and intimate offerings with a few strategic customers. When changing the mindset from product manufacturer to service provider companies exploit their own design and production competencies to deliver and improve their customer's business processes. Last mend services are called advanced services. Bains and Lightfoot (2012) divide services in their book made to serve in three categories Lightfoot et al. (2012). Base,

intermediate and advanced services. The Figure 7 *servitization model Made to serve (Lightfoot et al., 2013)* shows the relation between these service types and how a transition of services who supports products to services that support customers corresponding with moving from base to advanced services.

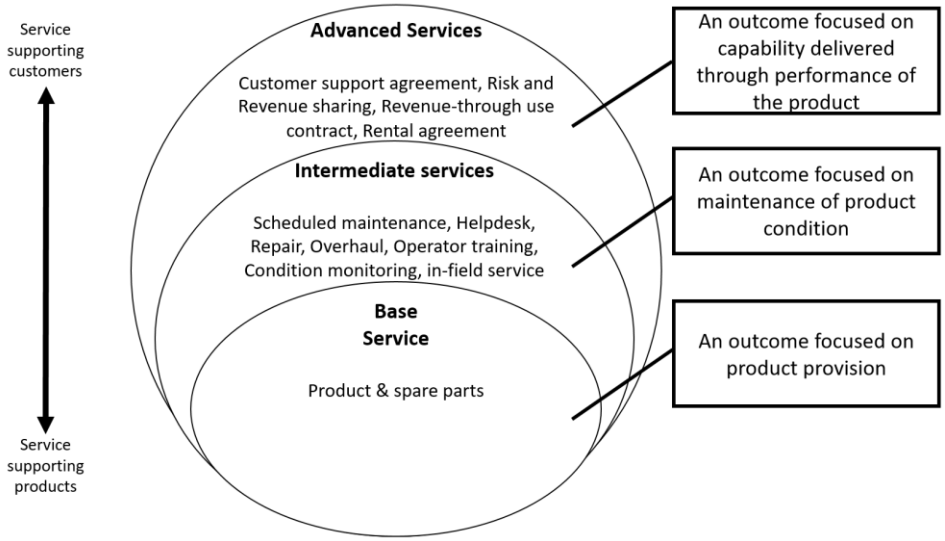

Figure 7 servitization model Made to serve (Lightfoot et al., 2013)

Figure 7 shows the servitization transition where manufacture changes the goal of service from service to support the produced products to services that support the customer. For this last goal often the product itself is integrated into the service offered. A good example is the power by the hour Rolls Royce offers. Here the customers do not buy an aircraft engine but buy available hour's powers. Performance agreements are made, when Rolls Royce meets them they get paid and in case they are not able to reach them penalties occur for them.

4.1.1 Winning in the aftermarket

"Winning the aftermarket" is a paper written by Morris A. Cohen et al (2006). They explain in their paper how to approach the aftermarket or service market. They developed a six-step approach to use when developing your services. First, you need to identify which products you want to cover service for. Second, a service portfolio needs to be developed. Third, business models to support the service products need to be designed, fourth you need to modify after-sales organization structure. Fit the after-sales service supply chain needs to be designed and six and the last step is to keep track of the performance and evaluate with the use of benchmarking and customer feedback.

4.1.2: Potential and benefit of aftersales services

In a lot of western countries companies sees a high potential of earning money with service or after-sales. The, for example, the automobile, industrial machinery, and information technology industries have sold so many products that the aftermarket has become four to five times larger than the original equipment business. In the United State, roughly 8% of the annual gross domestic products is earned from services.

Despite the service market charms most organization squander its potential. They perceive after-sales services to be a necessary evil and behave as though big business to business service contracts, small business to consumer warranties and everything in between were a needless expense. That is

mainly because service offering/ after-sales support is notoriously difficult to manage, and only companies that provide services efficiently can make money from them.

Although original equipment manufacturers carry, on average 10% of annual sales as spares, most do not get the best out of those assets. Some OEMs are content to let independent service providers cater to customers. Indeed third-party vendors have become so price competitive that OEMs lose most of the aftermarket the moment the initial warranty period ends.

Customers do not expect the product to be perfect, but they do expect manufacturers to fix things quickly when they break down. Not surprisingly customers are usually unhappy with the quality of the after-sales support.

Companies can benefit from several strategic ways by focusing on after-sales services. Providing support generates a low-risk revenue stream over a long period of time. In general the longer the life of the asset the more opportunities companies will find down the line. Also increasing sales of parts and service-related products cost businesses far less than finding new customers, though they can successfully cross-sell and up-sell only if the support they offer satisfies existing customers. The after services can be a differentiator as well. Being on par with your rivals in performance, price and quality gets you into the game; after sales, services can win you the game. Finally, when businesses provide aftermarket support, they gain a deep understanding of customers' technologies, processes, and plans. Often knowledge that competitors cannot easily acquire.

4.1.3: Aftermarket challenges

It is not surprising that companies find it tough to compete in the service market. Across industries delivering after-sales services is more complex than manufacturing products. When delivering service products, executives have to deploy parts, people and equipment at more locations than they do to make products. An after-service network has to support all the goods a company has sold in the past as well as those it currently makes. Each generation of the product has different parts and vendors, which makes the service network more complex. The service personnel has to be trained with all kinds of different technical skills. Moreover, the service networks operate in an unpredictable and inconsistent marketplace because of demands for repair crop up unexpectedly and sporadically. On top of that companies have to handle the return, repair and disposal of failed components.

Cohen et al. (2006) say based on more than two decades of studying after-sales service networks that in order to make progress and win in the aftermarket executives need to recognize that after-sales service is a commitment companies make to respond within a specific time frame to the customer's need for support. This definition has three important managerial implications. First companies must approach the promises they make as products that they design, price, produce and deliver to customers in order to generate revenue. There are companies focussing on the reliability of the product and for that reason offering services for free in order to deliver reliability as high as possible. Second companies must design a portfolio of service products. Different customers have different service needs even though they may own the same product. For example, a mainframe computer in a stock exchange fails vs a mainframe computer in a library. The consequences of failing or impact of failing to differ which results in a different service need. Service needs to vary at different times. For example, a grounded aircraft means more to the army during a war then it does during the course of a training exercise. So OEM's must design service products that satisfy different segments, and price them according to the customer's willingness to pay. In addition, service products need to be based on customers focussed metrics such as machine uptime. Not based on internally focused metric such as the part-fill rate. Third, companies should visualize a distinctive aftersales service supply chain that delivers service product to customers through a network of

resources: materials (parts), people (engineers, call centre staff, depot and warehouse staff etc.) and infrastructure. The service supply chain differs from the manufacturing supply chain. Both consist of entities and assets linked by the flow of materials, information and money. But service supply chains handle more SKU (stock-keeping units), deliver people, parts and infrastructure rather than just raw materials or finished products and contend with reverse flows of failed parts. Still the surface similarities between the two supply chains drive management decisions, and that creates inefficient after-sales service supply chains. In Table 3 *differences between manufacture and service supply chains (Cohen et al., 2006)* an overview of the differences between the two supply chains can be found.

Two Chains Compared

Companies neglect after-sales services supply chains because they're tougher to manage than manufacturing supply chains. Their performance suffers by comparison, too.

PARAMETER	MANUFACTURING SUPPLY CHAIN	AFTER-SALES SERVICES SUPPLY CHAIN
Nature of demand	Predictable, can be forecast	Always unpredictable, sporadic
Required response	Standard, can be scheduled	ASAP (same day or next day)
Number of SKUs	Limited	15 to 20 times more
Product portfolio	Largely homogeneous	Always heterogeneous
Delivery network	Depends on nature of product; multiple networks necessary	Single network, capable of delivering different service products
Inventory management aim	Maximize velocity of resources	Pre-position resources
Reverse logistics	Doesn't handle	Handles return, repair, and disposal of failed components
Performance metric	Fill rate	Product availability (uptime)
Inventory turns (The more the better)	Six to 50 a year	One to four a year

Table 3 differences between manufacture and service supply chains (Cohen et al., 2006)

Cohen at al. (2006) suggests that one crucial distinction between the two kinds of supply chains should differentiate the operating philosophies applied to them. Demand for service is fulfilled through physical assets such as spare parts, repair depots, and field engineers. Unlike factories, businesses cannot produce services in advance of demand. They can manufacture service only when an unpredictable event such as a product failure triggers a need. Even when an event is predictable, for example, scheduled maintenance. The need for parts or engineers is not easy to forecast. Unlike in product manufacturing, companies must deploy physical resources in advance of events to respond with the speed promised to customers, and they use up those resources when they cope with demands for support.

Based on the dynamic of the service network In order to manage the service networks Cohen et al. (2006) have developed a six-step for managing service networks. First an identification which products to cover service for, second a portfolio of service products needs to be developed, business models need to be selected for the service portfolio, the aftersales organizational structure needs to be modified, the after service supply chain needs to be developed and the last step the performance needs to be monitored on a continuous basis.

Identify the products to cover service

The first step is to determine which products to offer services and which not. For example, Kodak supports its digital cameras but not its disposables. Many pc manufacturers discontinue support for products they have stopped manufacturing. Some businesses choose to service complimentary

products as well as their own. Others may support competing products in addition to their own to generate economies of scale from the service technologies they have developed.
Before companies decide to provide service for products they do not manufacture, they must determine whether they can generate synergies in the process. They must ask themselves: Do the assets and skills that we would need to service all those products have anything in common? Do customers really want a one-stop service provider? How critical supports to retraining customers? Will we dilute our brand if we service rival products?

Design a portfolio of service products

To design a portfolio of service products businesses need to analyse the parameters that govern aftersales support from the customers' viewpoint as well as from their own. On the one hand, customers measure a service provider's performance by the amount of time it takes to restore a failed product. They have to weigh the levels of response they need against the prices they are willing to pay. On the other hand, to respond quickly to breakdowns, manufacturers have to locate spare parts close to customers and invest in larger stockpiles. The faster the response that manufacturers promise, the higher their cost is. Thus instead of segmenting customers by sales volumes, geography, or technological capabilities, companies must create a variety of service that meets customers' needs and willingness to pay. Service products usually range from those that are fast and expensive (platinum services, as they are commonly known) to those that are slow and economic (silver services).

Developing too few or too many service products reduces quality levels van profits. Many companies provide a one size fits all product, which often increases costs. There are examples of companies who almost went bankrupt because of offering one size fits all. The price is often too low and at some point in time, the work gets too much which results in using other than service personnel to help with service which causes problems somewhere else in the company. On the other hand, developing customized products for every customer or product would prohibitive because of the delivery cost. Companies should develop service products that maximize synergies between the resources required to provide the services.

Use multiple business models

Business can support service product by deploying one or more business models at the same time. When customers' want low levels of service, companies can use an ad-hock business model, which allow customers to pay per use. When products functioning is critical, a performance-based model can be used. Here customers pay for services according to the way products perform. In general, business models differ by product ownership. Table 4 *different service business models (Cohen et al., 2006)* shows an overview of different business models and the differences between them.

SERVICE PRIORITY	BUSINESS MODEL	TERMS	EXAMPLE	PRODUCT OWNER
None	Disposal	Dispose of products when they fail or need to be upgraded	Razor blades	Consumer
Low	Ad hoc	Pay for support as needed	TVs	Consumer
Medium-high	Warranty	Pay fixed price as needed	PCs	Consumer
Medium-high	Lease	Pay fixed price for a fixed time; option to buy product	Vehicles	Manufacturer; leasing company
High	Cost-plus	Pay fixed price based on cost and prenegotiated margin	Construction	Customer
Very high	Performance based	Pay based on product's performance	Aircraft	Customer
Very high	Power by the hour	Pay for services used	Aircraft engines	Manufacturer; service provider

Table 4 different service business models (Cohen et al., 2006)

The business models go from conventional ownership-based models to performance-based models for customers that do not own the products they use. The business model a company chooses is important because it drives the incentives of all the players in the services supply chain: manufacturer, service providers, logistics provider and customer. When customers pay manufacturers for the parts and services they provide to keep products working, for example, a conflict of interest arises. Suppliers would like to sell more spare parts and services, but customers would like to minimize costs. Performance-based models usually align incentives better than ownership-based ones because customers compensate service providers according to the output they deliver.

The suitability of a business model sometimes depends on the nature of the product and in some cases, businesses may use different models for the same asset at various stages of its lifecycle. The U.S. Department of defence uses a cost-plus service model when it purchases new equipment because it cannot predict failure rates. As the product is used more and more, the agency demands performance-based service contracts. When the uncertainty about maintenance cost diminishes the Department of defence asks for a fixed price service contract.

Determine the after-sales organizational structure

Most companies do not pay much attention to the way after-sales services are organized. Consequently, the products division is often nominally responsible for products that are covered by warranties, but the service department, which sells post-warranty services, actually delivers warranty related support. This overlap leads to organizational tension. For example, if the products division wants to extend the period of the initial warranty, the services department will object because it will lose revenues in the process. Since companies us the same stockpiles of spare parts to provide both warranty related and non-warranty related services, it is not clear who is responsible for the inventory carrying the cost.

To manage the after services business effectively, most companies require skills and knowledge they do not yet possess. For instance, suppliers must know exactly how their products create value for

customers, which means greater interaction between manufacturers and customers as well as new technological capabilities. Changes in strategy might also involve nudging the sales organization away from selling products at the best possible prices and toward generating income from services over a long period of time.

Create an after-sales services supply chain

Companies must match the supply of resources with demand. The right materials, people and infrastructure have to be delivered to the right place within an agreed-upon time at the lowest possible cost. It is difficult to decide which resources to deploy and where to deploy them because both spares and locations are hierarchical. There is a pecking order to parts and places that complicates stocking decisions. The places vary from far away from the customer in the central depot to as close as possible at the customer's site. This principle counts as well for the breakdown of the spare parts, you can put complete end products on stock, modules, sub-modules or parts of the product. The further the stock is kept from the customer, the slower the company can respond. Since companies cannot easily forecast the demand for resources for service, they must develop demand probability distributions and make allocation decisions after calculating the trade-offs of stocking different resources at different locations.

Companies can use the same materials and human resources to support different service products. An engine can serve as the replacement for a premium service contract as well as for a standard service contract. In the services business, an asset is an asset, regardless of who uses it. The problem though is the free ride phenomenon: the manufacturer may sometimes allocate a spare part held to serve the needs of a premium customer to a lower-paying customer simply because the later demand occurred first. Alternatively, a manager may divide the available resources equally between the two customers, thereby giving the premium customer a lower than promised priority and the standard buyer a higher than a promised priority. To cover this kind of problems businesses can use prioritization rules. First divide the service chain allocates the available inventory of a spare part on a first come first serve principle until the stock levels drop to a threshold level. Below that level, the network will reserve the inventory only for higher-paying customers, and lower-paying customers must wait their turn. Another approach would be for the service network to satisfy demand from a premium customer for a failed product, say, a 30 GB hard drive by providing a better product, such as a 60 GB hard drive. In that case, the company would pool risk across products through substitution even as it ensured a higher degree of service for that customer. In the PC industry, the benefits of using new drives as spares are greater than the costs of stocking inventories of old drives, since the price of hard drives can fall rapidly.

When it is clear where to stock what resources firms can calculate the cost of responding to breakdowns. Then they can create a range of service products, from platinum to silver see Figure 8 *Creating service products (Cohen et al., 2006)*.

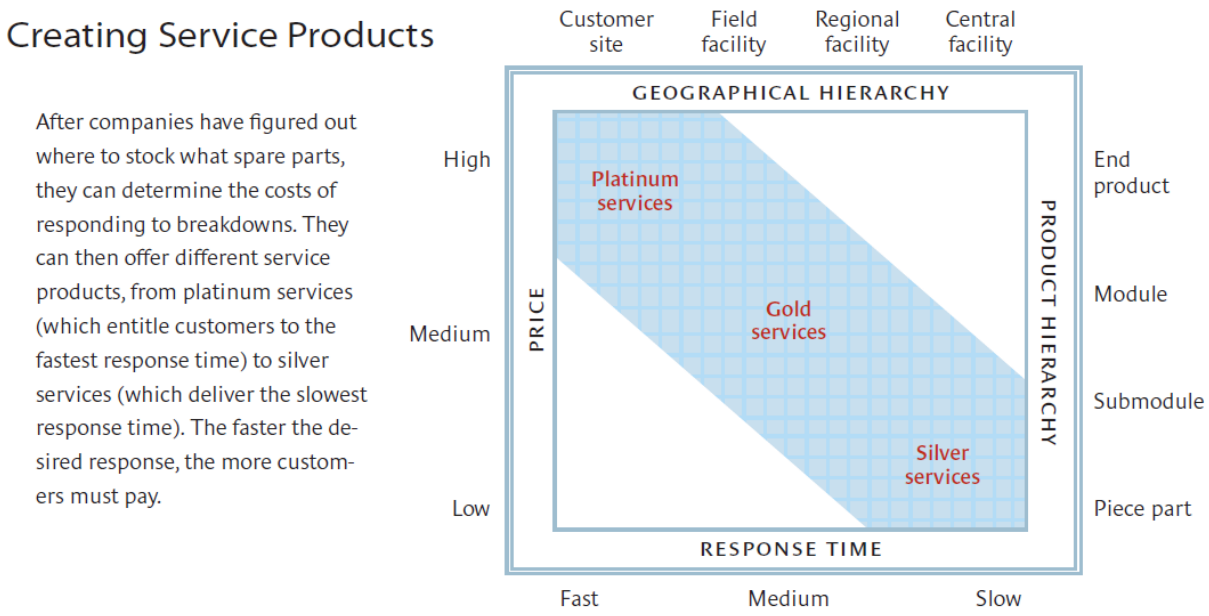

Figure 8 Creating service products (Cohen et al., 2006)

The business strategies, product technologies and information about product failure rate which drive many businesses allocations decisions, will change over time. As a result, executives must sense shifts in the environment and respond with forecasts that allow them to reposition resources. Given the complexity involved in managing service assets, companies should break the decision-making process into three planning periods, at the most immediate level of planning (days), companies should worry about repositioning decisions such as replenishment, allocations and transhipment of resources. At the next level, (weeks or months) managers should address the strategic positioning of material, human and knowledge resources. At the furthest level of planning (years) companies must make decisions about the services strategy.

Monitor performance

Monitoring performance can be internally focused and externally focused. Monitoring customer metrics such as waiting time for technical assistance, diagnosis and part delivery can help to get insights on how efficiently a company creates value for its customers. Internally focused metrics such as fill rates and parts obsolescence costs can quantify the way companies use their service assets.

Besides keeping track of technology that may force changes in service strategies can help to improve services. Wireless two-way communication is a technology that can help to improve services for example. On the other hand, do companies keep track of the development other companies make, this can be rivals but does not necessary needs to be so.

4.2: Literature study on pricing methods

Another aspect of service is how the price in the service portfolio. Avlonitis and Indounas (2005) have done research on pricing objectives and methods in the service sector. A comprehensive review of the literature on pricing. Of services identified twelve pricing methods falling into three large categories namely cost-based, competition-based and demand-based Avlonitis and Indounas (2005). In the next paragraph, those twelve methods are explained.

4.2.1: Cost based methods

The cost-based methods contain, cost-plus, target return, break-even analysis, contribution analysis, and marginal pricing. Here those are explained.

- Cost-plus model: here a profit margin is added on the service average cost. This margin is a percentage of the cost.
- Target return pricing: the price is determined at the point that yields the firm's target rate of return on investment.
- Break-even analysis: the price is determined at the point where revenues total equals the total costs.
- Contribution analysis: a deviation from the breakeven analysis, where only the direct cost of a product or service are taken into account.
- Marginal pricing: the price is set below total and variable cost so as to cover only marginal costs.

4.2.2: Competition based pricing methods

The competition-based methods contain, pricing similar to competitors, pricing above competitors, pricing below competitors and pricing according to the dominant price in the market. These methods are easy to handle. The price of the service/product is either, copied, set above or set below the price of a selected competitor or group of competitors. The other way is just following the market leader and copying their price.

4.2.3: Demand-based pricing

The demand-based pricing methods contain perceived value pricing, value pricing or pricing according to the customer's needs.

Perceived value pricing: the price is based on the customer's perceptions of the value, where the brand plays a major role, for example, Rolls Royce praises their cars high while probably a Volkswagen car perforce better, the perception of the customer is the exclusiveness of the Rolls Royce car where customers wants to pay for.

- Value pricing: a fairly low price is set for a high-quality service.
- Pricing according to the customer's needs: the price is set so as to satisfy the customer's needs.

4.3: Other companies in service offering and servitization

The servitization transition and its approach differ per company there for that reason it is interesting to see what is going on in different companies when starting with servitization yourself. In this research, a collaboration with Company 2, COMPANY 3 and Company 4 has been made to help each other in the servitization transition. This paragraph will explain how the different companies approach service, the service offering and the transition some of them are making in servitization.

4.3.1: Company 2

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4.3.2: COMPANY 3

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Table 6 service portfolio COMPANY 3

4.3.3: Company 4

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4.3.4: SkIDATA

SKIDATA provides hardware and software for access solutions & visitor management. Some examples are mountain destinations, vehicle access management, amusement parks, from barriers and columns, automated payment machines as well as the SKIDATA tools for reporting, control and monitoring. SKIDATA has a modular service contract. They have divided their service options into different modules. Figure 10 *service portfolio SKIdata (SKIDATA, 2019)* shows an overview of the different modules.

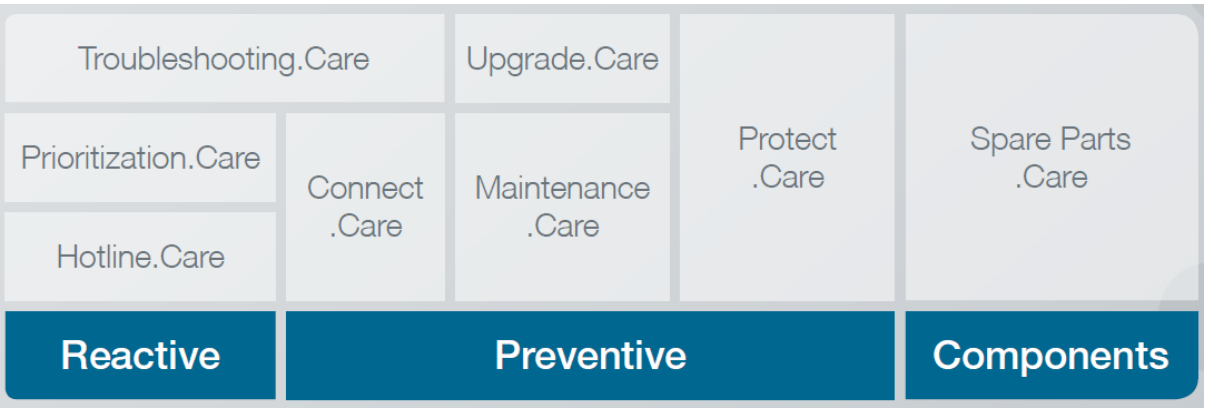

Figure 10 service portfolio SKIdata (skidata expert services, 2019)

These different modules are divided into different packages, so within a module, it is possible to choose as a customer what you want. Table 7 *service content SKIDATA (SKIDATA, 2017)* shows an overview of the different modules.

Module*	Short service description	Basic	Extended	Premium	Premium Plus
Hotline.Care	Contact SKIDATA within standard office hours on working days	•	•	•	•
	Basic amount of troubleshooting included		•	•	•
	Contact SKIDATA outside standard office hours on working days		•	•	•
	Contact SKIDATA on weekends and public holidays			•	•
	Contact SKIDATA 24/7				•
Prioritization.Care	Standard interaction times (reaction, on-site, resolve)	•	•	•	•
	Fast interaction times with prioritization		•	•	•
	Faster interaction times with prioritization			•	•
	Fastest interaction times with prioritization				•
Troubleshooting.Care	Basic amount of troubleshooting according to Hotline.Care	•	•	•	•
	Helpdesk/remote working time for troubleshooting included		•	•	•
	On-site working time for troubleshooting included			•	•
	Travel expenses for troubleshooting included (excl. flights)				•
Module*	Short service description	Basic	Extended	Premium	Premium Plus
Connect.Care	On-demand remote connection	•	•	•	•
	Static, high security remote connection		•	•	•
	Standard remote monitoring			•	•
	Individual remote monitoring				•
Maintenance.Care	Regularly scheduled maintenance consultation	•	•	•	•
	Hardware maintenance [Level 1, Level 2]		•		•
	Software maintenance [Level 1, Level 2]			•	•
Upgrade.Care	Information about the latest software and hardware	•	•	•	n/a
	Latest software release including installation		•	•	n/a
	Cyclic IT Hardware exchange			•	n/a
Protect.Care	Initial basic security check according to security guideline	•	n/a	n/a	n/a
	Anti-Virus as a service	•	n/a	n/a	n/a
Spare Parts.Care	Provide spare parts within a defined time	•	•	•	•
	Exchange in advance		•	•	•
	Spare parts (excl. wear parts) included			•	•
	Wear parts included				•

Table 7 service content SKIDATA (SKIDATA, 2017)

The division is made between basic, extended, premium and premium plus. The options increase when a customer moves more towards premium plus.

4.3.5: Philips medical:

At Philips, they have a separated service business unit who is responsible for the profit and losses of the service Philips wide. The Philips Medical business does contain service employees as well. This results in a complex matrix structure according to the organization of service within Philips. But the Figures are good. The revenues according to service for Philips Medical are roughly 25% on average of the total revenue from a product group within Philips Medical (so the average only includes the medical products and services). Roughly 80% of all Medical customers do have a service agreement. Philips has developed a fixed fee service price. Independent on the number of repairs, minor, major, unscheduled maintenance or unexpected breakdowns Philips Medical fixes it all for the agreed yearly fixed fee where roughly 80% of all the customers have that kind of agreement. Philips is able to handle this kind of contracts because of the volume of products they produce. The amount of products sold is high enough to divide the risk of the service cost over the products and still earning money out of it. On the other hand, the customers are happy to have the certainty about the cost they will have in the future so they can make their financial planning and do not need to reserve

unexpected service cost.
Because of the fixed fee, Philips can earn more money when the design of the product is more robust. For that reason, service is already during the design phase of the product an important theme. The development of remote service or remote monitoring of the products has been increased in the Philips products this because some problems can be helped from a distance now which decreases the service cost for Philips which does the service profit rise.

Besides this kind of contract Philips Medical is developing some kind of technology state of the art contract. The idea is that customers who agree on such a contract buys a product and when Philips Medical releases a version 2.0 of the same product the customer can swap their current product for a small fee for the newly released product, in this way the customer keeps working with state of the art products and technology while not having big investments. Philips Medical Takes back the used products from the customer and sells them as refurbished products in a lower market segment. In this way, customers who do not have enough money for buying new products can become the owner of a product that before was notable for them to use. In this way Philips is able to get products out of the service contract when they get old, old products have a higher risk of failing which brings more cost for Philips. It did not become clear how and what kind of service Philips Medical is offering for the refurbished products in the lower market segments. This information is based on an interview between the researcher of this project and a Sr. Global Product Manager – IGTD at Philips Medical and the site of Philips Medical (Philips-Healthcare, 2019).

4.4: Companies comparison and literature study combined with the current situation at COMPANY 1 applied for COMPANY 1

The approach of Cohen at al. (2006) is a nice six-step approach for the development of after-sales services. Here not all the steps are applicable to COMPANY 1 but some of them create nice guidelines that can be used in the design and development of the artefact.

Step one the identification of which products to cover service for. For example in the case of COMPANY 1 when it is not possible to send a product by mail back to COMPANY 1 it quickly becomes risky to offer repairs. Because of the freedom of the customer who can decide to sell the product too whom they want the cost for sending a service engineer to the broken product comes unexpected for COMPANY 1 which makes it difficult to price the service, at the same time the planning and occupation of the service engineers becomes quickly complex and risky and it is more beneficial for the end-user and COMPANY 1's customer if he or she handles the repair themselves because the cost for letting COMPANY 1 handles the repairs become fast high. For that reason, in such a situation, it is better to offer the customer of COMPANY 1 service training where the customer gets trained in order to handle the service them self. This example shows that it is wise to bring in some guideline questions that need to be answered before offering the service to the customer. Which corresponds with the first step of Cohen at al. (2006).

Step two of Cohen et al. (2006) is already mentioned in the conclusion of the previous chapter. Create a portfolio to be able to offer all the customers of Medical serial produced products. This helps to get awareness by the customer that they need to think about service and helps COMPANY 1 in the offering. It is an approach that has been used a lot in practice, most of the companies discussed in this chapter work with a different service portfolio where it is up to the customer to choose till what amount of service he or she wants. Except for Philips Medical, but the way they offer their service is not possible to handle for COMPANY 1, this because of the production volumes Philips produces are high which decreases the financial risk and becomes some kind of insurance company according to service. The COMPANY 1 situation is different first of all COMPANY 1 is not

the IP owner and legal manufacturer of the product and does not sell products to end customers so COMPANY 1 does not have any control in the market introduction of products, even the development of a 2.0 version is not in control of COMPANY 1. Second, the volumes COMPANY 1 produces are low for that reason the financial risk of using a service approach such as Philips Medical becomes for COMPANY 1 high.
Based on the literature and the company comparison an approach of using, silver, gold, platinum and maybe a fourth category is used in the design of the artefact. Most of the companies' use a matrix structure different rows contains the different service offerings where the columns explain what the customer gets at every different service level (silver, gold platinum etc.). When using those different rows or service blocks (the different rows of the mentioned matrix) it becomes quickly clear that point three of Cohen et al. (2006) select the right and probably multiple business or pricing model. Because a pricing model for a service helpdesk differs from the repair offering service block. The current organizational structure of service (step four of Cohen et al. (2006)) at COMPANY 1 could have some improvements, as mentioned in chapter 3 the financial streams flow not according to a logic way. This because the LCS department is part of the COMPANY 1 subsidiary while primary working for COMPANY 1. Because this cash flow is structural and not incidental it creates extra work but does not bring any added value. For that reason, a recommendation of moving the LCS department from COMPANY 1 to COMPANY 1 seems logic advice. A future plan could be to create a separate service business unit which contains the employees of the LCS. But because the LCS department is at this moment of time small and not able to handle all the responsibilities that pop u when becoming a business unit. This transition of the service organization is part of step four of Cohen at al. (2006) about the step modify the after-sales organizational structure.

The development of the supply chain according to COMPANY 1 is not a real issue and does not have that high attention. This because COMPANY 1 only works on repairs at the COMPANY 1 site and forces the customer to send the products back to COMPANY 1 or take the decision to handle the service themselves, of course is the supply chain coordination important over the long run for example when products are not produced anymore but service still must be delivered but this topic goes way out of the scope of this research and will not be considered.

4.4.1: Applied evaluation strategy

The literature study and company comparison has brought insights for this research and help the design guidelines that improve the design of the artefact. This is part of the FEDS of Venable et al. (2016) the evaluations strategy that is used in this research is close to human risk & effectiveness. Iteratively meetings with COMPANY 3, Company 4 and Company 2 has been done where the development of the artefact has been presented and evaluated. In this way, the knowledge from other companies is embedded in the artefact design. While those companies quite differ from the situation at COMPANY 1 (all own the product IP, sell the products hem self to end customers, does not produce medical devices etc.) still it is possible to gain knowledge about the way they approach service. But internal evaluations and action research with the researcher is needed because the design is developed to be used at COMPANY 1 for the specified medical serial products it is important that internal reviews take place as well for that reason often at the LCS department meeting (every two weeks) the development of the artefact is evaluated. Even at senior management level, an evaluation meeting has been held here the managing director of COMPANY 1, the managing director of COMPANY 1, Business Unit Manager Medical, and the group leader LCS was present in these meetings. The kind of reviews that are done is a combination of artificial reviews (the literature study) and naturalistic evaluations which are the interviews and company comparison and the evaluations with some of the companies who are spoken to.

Action research, focus groups, case studies, best practices from the literature and the different companies are used to evaluate if the design is on the right track or that new knowledge can improve the artefact and the design process. Based on the evaluation insights has been generated which has improved the artefact design. In the end, the artefact has been tested in order to see how well the artefact did performer. Unfortunately, it was not possible to use and discuss the artefact with real customers of COMPANY 1. For that reason a test tool is developed in order to see how the artefact performs, this test tool exists of two decision trees, one customer-focused and one product-focused.

Chapter 5: Three-step approach artefact Design

In this chapter, the design of the "Three-step approach" artefact is explained. Each of the three steps has its own section in the chapter. Where in section 5.1 the service offering process is designed by the development of a service infographic in combination with the service offering process. Section 5.2 contains the design of the service portfolio. Here elaboration on the different parts of the portfolio will be explained, the service packages, training and advice services and a quick first assessment in the field of service pricing methods is done. Section 5.3 contains the design of the service tailoring. Here two decisions trees are designed which guides COMPANY 1 in tailoring the service offering for each specific device and customer. The tree sections combined of the chapter result in the total designed three-step approach in this research.

5.1: Design Step one: The service offering process

The first step is to create awareness for the service offering process. During the Kick-off meeting of a new product development project (see Figure 11 *Current stage-gate model COMPANY 1*) the project manager of COMPANY 1 must bring on a high-level service on the table. That must be done in two ways, first, the stage-gate model, the way of working within COMPANY 1, must be showed and explained. This often already happens but the service gates are not included in the model which can be seen in Figure 11 *Current stage-gate model COMPANY 1*.

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Figure 11 Current stage-gate model COMPANY 1

Currently, there is a project running to extend the stage-gate model with service gates. It will take a while before this project is finished, the current steps made show that the new model developed is a fully internally focussed model and overview. In that kind of Figures, it is often clear for the employees within the company what has been drawn on paper. But when a customer sees such a picture it is often complex and hard to understand. For that reason another more high level and customer focussed infographic is developed in order to inform the customer about the options and capabilities COMPANY 1 contains to support the customer after and during the production phase. No highly in-depth internal overview but a high level clearly overview of the approach and way of working at COMPANY 1.

The first design is an extension of the stage-gate model from Figure 11. The idea is that by adding extra service gates the topic service finds its way in the kick-off meeting of a product development process. The second iteration was done in order to make clear at which gate the service processes start at COMPANY 1 so the customer gains the feeling of how COMPANY 1 approaches service. The third and last iteration is done to make the infographic more customer focussed. The first two iterations were based on the internal COMPANY 1 processes, in order to understand those processes knowledge of COMPANY 1 is needed which is something customers does not have. To make the infographic more accessible for the customer to understand a more high-level view is designed which brings enough input to start the conversation on the topic service without making it to complex. The design iterations of this infographic can be found in appendix 3. The result of the different iterations is placed in Figure 12 *New service infographic*.

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Figure 12 New service infographic

The idea of this infographic is that the customer knows there is a service phase after production and that COMPANY 1 can support the customer if they want. Figure 12 *New service infographic* is made in a circle or a closed-loop to show that COMPANY 1 is a partner for the long term and the future. The different service options COMPANY 1 offers could help the customer to develop the product and sees when it is necessary to start development for a version 2.0 which is a competence of COMPANY 1. The input during the support phase combined with the market insights from the customer brings the right time and commercial profit. COMPANY 1 can support on the technical side based on the knowledge gathered during support and sustaining phase where the customer has the knowledge on the market side.

After the Kick-off the COMPANY 1 project (development of the product) will start, during the alpha design, the design for service needs to be started, so here a rough idea about the services that the customer requires needs to be clear, for that reason it is wise to let the project manager from COMPANY 1 who will take over from COMPANY 1 after a while meet the customer upfront so the customer has an idea and contact person for questions about production and service and knows he needs to think about service as well. When moving on through the development gates, the industrialization phase is reached. This is the moment that the project leader from COMPANY 1 transfers the project to the project leader of COMPANY 1. The negotiation about the product transfer price is done. This is the moment the service portfolio of COMPANY 1 needs to be put on the table again, and the decision needs to be made what services the customer wants that can be put in the SLA. The main advantage is here the COMPANY 1 standard is the starting point of discussing the service. This result that everyone within COMPANY 1 speaks the same language and knows what a silver service package contains. Where in the past COMPANY 1 was reactive to hear what the customer wants, they send over their preferences of a Service Level Agreement which was evaluated by COMPANY 1 where a negotiation starts. In this way, the customer standard was used in the service negotiation which brought COMPANY 1 a lot of work and unclearness. The legal department needs to check and make up every single customer-specific SLA and the number of different contracts grows fast which makes the work for the LSC department unclear because of all the differences in the contracts.

With this design of the service offering process and the infographic, the first pillar of this research is completed. The way of service offering is clear now. The second pillar contains the service portfolio, what COMPANY 1 could offer their customers, this be explained in the next paragraph

5.2: Design Step two: Service portfolio COMPANY 1

Multiple sources' have been used in order to determine what services COMPANY 1 could offer, papers from the literature study and the results from the company comparison where Company 2, COMPANY 3, Philips Medical, Company 4 and SKIDATA has been analysed. Internally the current service offered and those from the past has been evaluated. Different brainstorms are organized with employees from the LCS department, the managing director of COMPANY 1, the managing director of COMPANY 1 Enschede and the business unit manager medical systems. The goal of the brainstorms: to figure out what other extra service options COMPANY 1 could fit in the future.

Besides the internal evaluations and brainstorms. External literature, the service comparison of the other companies and discussions during a multi-company project about service have been held in order to see what kind of services companies could offer. That knowledge from outside has been evaluated inside COMPANY 1 to see what could fit.

This resulted in three different service categories. Service packages, training and advice service here the service levels contain the service activities. In case no service could be offered the training services is used (or when the customer asks for training) and additionally it is possible to request for

the different advice services that COMPANY 1 can offer. The main idea is that the service packages are used to determine the service level for the customer.

The service packages contain calibration, repair, helpdesk, spare parts and standby service by different level of engineers (sustaining or design). The training category contains first-line support, maintenance and trains the trainer training. The advice category contains: obsolescence, trend analysis, upgrade advice and root cause analysis. Below per service category, a description of the service is explained. The types of services integrated into the service packages are all generic to use for all kind of products, and does not need any IP ownership to execute them. Further the training could be offered because COMPANY 1 has knowledge about the product and service which they can transfer to the customer if he wants. In the end the advice services are added to be able to support the customer in the long run if he wants and keep knowledge and advice for product improvement for the customer.

5.2.1: Service packages

In this paragraph, an explanation is given for the service packages pillar of the service portfolio. In general, an explanation is given per category within the packages after which the differences per service level is explained. The service packages combined result in the three different service levels to offer (silver, gold and platinum).

5.2.2: Training

In this paragraph, an explanation is given of the different kind of training that COMPANY 1 can offer. The main idea for the training is that in case the customer does not want to outsource service to COMPANY 1 the customer still can benefit from the technical knowledge COMPANY 1 has. Besides this brings the option to execute the service because of the medical devices service engineers needs to be certified that they are allowed to execute repair and maintenance operations on a certain medical device. Still, in case, the customer wants to outsource the service to COMPANY 1 it could be wise to ask COMPANY 1 to support by a first-line support training where the helpdesk employees from the customer get trained by COMPANY 1 in order to have product knowledge that can be used when an end-user is calling for help. Below the different kind of training is explained.

First-line support training: the customer always hades the first support them self, they sell the product to the end customer so they are the contact. COMPANY 1 can develop training for the customer to train their helpdesk employees in order to help the end-user with simple questions. So the customer of COMPANY 1 has some know-how of the product and can help the end-user with some questions. When it gets to complex the customer can contact the helpdesk at COMPANY 1.

User training: The customer sells the product to end-users for that reason it is often necessary to show end-users a demo of the product. Because COMPANY 1 has developed the product they are able to teach the customer how to use the device and shows the capabilities of the product.

Maintenance training: When the customer wants to handle repairs self they need to be trained, it is not allowed by law to handle a repair on a medical device without being a certified service engineer for that specific device. COMPANY 1 can arrange a training so the customer can get certified.

Train the trainer training: when the customer wants more control and be able to train more service employees to handle service repairs a train the trainer training could bring an outcome. COMPANY 1 trains employees to be able to train and certify other employees. In this way, the customer can expand the service employees who are able to execute service repairs.

5.2.3: Advice

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Table 8 Service packages

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Table 9 Training offering

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Table 10 Optional advice services

5.2.4: Summary service packages

In this paragraph, the three different service packages are explained; the silver, gold and platinum level.

First the **silver level,** this is the lowest and cheapest service level COMPANY 1 offers (except the training that COMPANY 1 can offer in case a customer does not want to outsource service to COMPANY 1). The repairs take long times, the helpdesk is not specialized for the product,

The **gold level is** some more expensive as the silver level and does offer some more options. Most important to mention is that in case customer and COMPANY 1 agree that there is a patient risk if the product breaks down that COMPANY 1 is allowed to execute an inept root cause analysis no matter what and on the cost of the customer. This is done because of medical risks that can occur and the responsibility COMPANY 1 wants to take because when such a critical breakdown occurs there cannot be any waiting time before COMPANY 1 is allowed to execute the root cause analysis to the financial responsibility should be clear upfront. Besides the customer gets a guarantee that for 4 hours a week (which cannot be brought to the next week) of sustaining engineers or product owner. Those employees at COMPANY 1 are good skilled and trained to handle the specific product during the usability phase of the product. For the help desk and the availability guarantee of the sustaining engineers, the customer pays a quarterly fixed fee. The other parts of these packages are invoiced when used. So financially there are some parts with a fixed price which brings the customer more insights in the future service cost and gives the customer the option to make future financial planning.

The **platinum level** is the most advanced level of service levels. The repair and response times are short, COMPANY 1 takes responsibility to plan the calibration, the spare parts are handled by COMPANY 1, and the most technically skilled people will help the customer and are guaranteed to be available for four hours a week. A fixed quarterly fee is paid by the customer for the help desk, calibration, spare parts and the availability of the design engineers. The other parts are invoiced when used by the customer. This level brings compared to the gold level more insights into the service cost for the customer which makes the prediction for their financial planning more realistic because more of the

Service package differences

As mentioned it is important to create a clear overview of the service portfolio COMPANY 1 could offer and therefore make a distinction between the different packages. The levels are as mentioned divided into three different levels plus the level of no service, in that case, COMPANY 1 can always offer the customer training to help the customer to be able to handle the service themselves. The other levels, silver, gold and platinum. Need to get their own characteristics. There the differences are made based on two main characteristics. Those are time/priority and quality of their service. For the time this contains, response times for the help desk and repair times. The quality of the service is connected to the technical level of the helpdesk and the substantiation of the root cause of a certain breakdown. Because the time and substantiation will differ per developed product it is not possible to state strict time buckets or level of analysis but a relative relation between those levels does exist.

It is important when to formulate the platinum level first because this is the most advanced level that is offered. According to quality, here you could state that for root cause analyse the development team of the products needs to handle the analyse for platinum, where for gold level a sustaining engineer handles the analyse where for silver the service engineer handles it. For the helpdesk or a non-technical employee is allowed to response (sliver), or a service coordinator (gold) or just one specific service coordinator who has in-depth technical knowledge of the product. The times are related, when the shortest time is known for platinum, the golden times can be 150% where the silver times can be 200% of the platinum service times (this relation is used in the portfolio of Table 8 *Service packages*). In this way, there is a clear distinction between the three service levels. An overview can be found in Table 11 *Service level characteristics*. service is included in the fixed prices.

Table 11 Service level characteristics

5.2.5: Pricing methods

In this paragraph, the last pillar of this research is explained. The pricing methods applicable to the service portfolio. The pricing approaches for the different service options and levels are discussed. The literature study, comparison of the other companies and the current service offering and pricing methods that are used in the service offering and the selling process of the product development process at COMPANY 1 has been input for the pricing methods applicable to the service portfolio. First, a general recap on the input is given after which the different service pillars (service packages, training and advice services) is explained separately.

General pricing fit for COMPANY 1

The different kind of models that have been found in the literature Avlonitis and Indounas (2005) does not all fit COMPANY 1 and the service products of COMPANY 1, especially the competition based methods do not fit well. In principal COMPANY 1 is the only service provider the customer could ask to handle service. If the customer does not want to outsource service to COMPANY 1 but to another company employees of that company needs to get trained by COMPANY 1, this because we are talking about medical devices where the law is strict about who is allowed to execute service or support operations. The demand-based pricing methods fit some better, for example, the pricing according to the customers' needs could use full, with the separation between the three different service levels in the service portfolio it could be possible to price service at three different levels where the customer could choose which one does fit him the best. Some of the cost-based models do fit COMPANY 1 as well. In the product development COMPANY 1 uses commercial tariffs for working hours of the engineers working on the project, this is already some kind of cost-plus model, it could easily fit in the service model as well. But the other in literature found cost-based models does not fit. This because support issues differ a lot between products and repairs for that reason determining a target return price method is difficult to use. This same problem occurs for the marginal pricing method. Break-even is nice to know but there is a goal to make some fair profit out of service. For the same reason contribution analysis fells of. Below an explanation per service activities is given.

Training: all the training is developed and get a fixed fee, this is based on the time the training takes and the complexity of the training plus a small part that is integrated into the fixed fee for the development of the training. Upfront the shelf life for the certificate that the participants that

successfully complete get is determined based, in this way COMPANY 1 can make estimations on the number of training they will deploy in the coming time.

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Table 12 COMPANY 1 price method fit

5.3: Design step three: Service Tailoring

This section will elaborate on the way of tailoring the service portfolio. This contains the development of two decision trees which helps as guidelines for tailoring the service portfolio for a different product and type of customers. The cause of the decision trees development. The reasoning behind the development of two different trees, the customer focussed and device focussed decision tree and concludes with a high-level first step towards conclusions and evaluation. This will be used as input for Chapter 6 which contains the evaluation of the total three-step designed artefact

5.3.1: Decision tree cause

In this research, it was not possible to get in contact with customers of COMPANY 1. This in combination with the throughput time of a product development process (which takes some years) makes it impossible to test the service portfolio in a real-life case. For that reason, another approach has been chosen. Two decision trees have been developed which can be used to create an overview of how to use the service portfolio and when to offer what kind of services. An example of NASA (2008) is used as a reference input for the development of the decision trees.

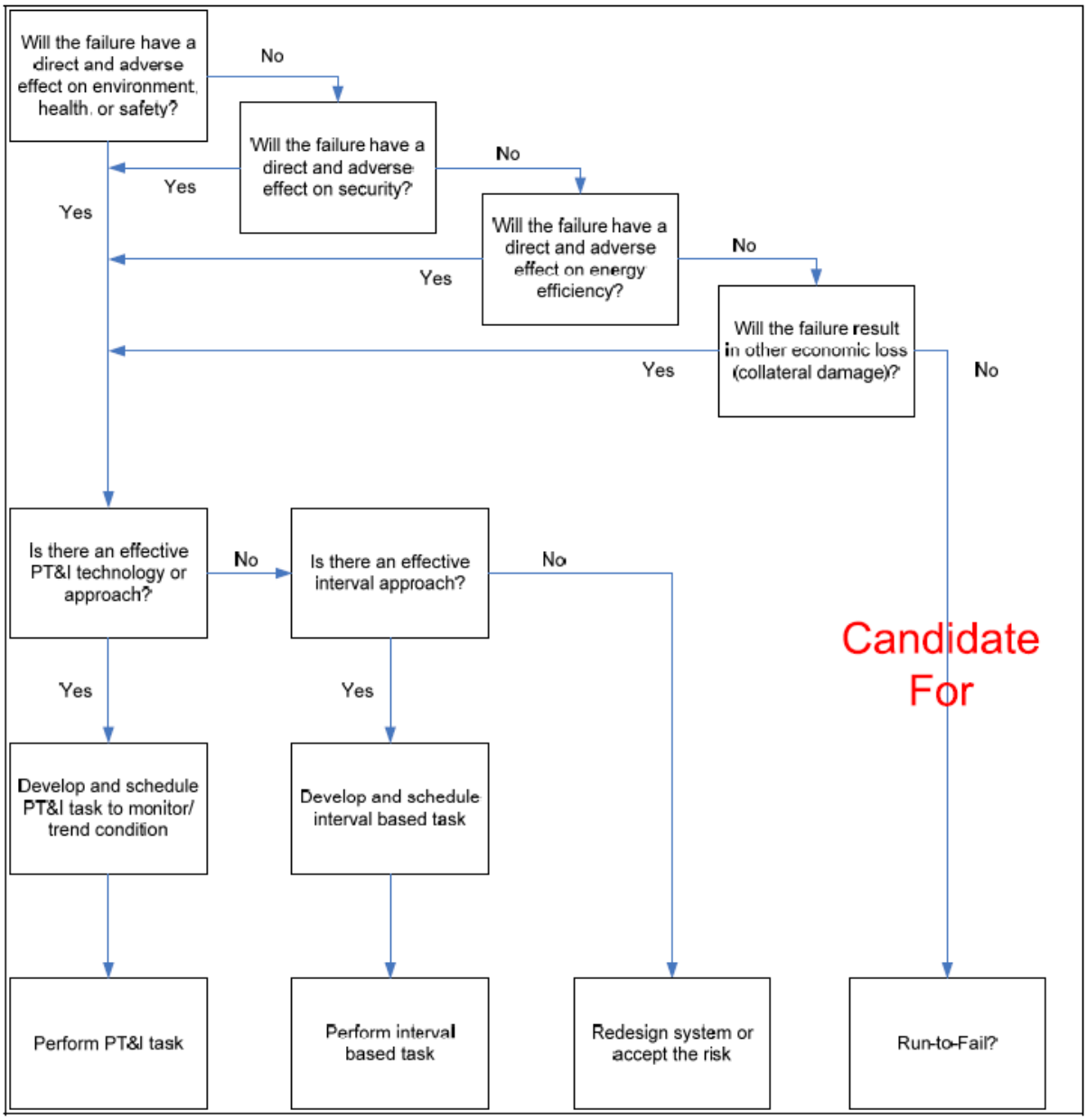

Figure 13 NASA RCM logic tree (NASA, 2008)

NASA has developed a clear accessible logic tree for their Reliability-Centered Maintenance, or RCM, approach, as can be seen in Figure 13 *NASA RCM logic tree (NASA, 2008)*. The aim is to develop a comparable, in the sense of the accessibility, logic tree for the service levels developed in this research.

During the development of the decision tree for the service portfolio, it became clear that there are two approaches to develop the tree which both can lead to another outcome. The tree can be developed based on customer characteristics and it can be developed based on the product characteristics. Because both approaches can lead to different service levels, the decision has been made to formulate two decision trees that can be combined.

The first step and approach used to develop both service decision trees were to create decision levels where different service levels are excluded from the offer. Extra iterations have been made which brought new opportunities, those can be found in the production volume that is added in the product-focused tree. This is an enabler for low price products to sign up a gold service level. The

bank guarantee for service that can be offered by start-ups in the customer focussed tree is an enabler for gold and platinum service levels for start-ups. With this approach, the decision trees have been developed from two ways, first by exclusion service levels and after that an iteration to include service levels on different places in the trees to guarantee a well-founded approach and development of those trees. In the next paragraph, the customer focussed decision tree is explained per decision level.

5.3.2: Customer focussed decision tree

The customer-focused decision tree distinguishes three different levels. First, the laws and regulations in the selling countries of the customer, second the size of the company and third the customer type of culture. This tree and levels have been developed in collaborations with two sales employees of Subsidiaries from COMPANY 1 that sell their own medical device all over the world. Their insights have been used to develop the decision tree. Below the three different levels are explained which is combined in the decision tree at the end of this paragraph.

The laws and regulations this decision level is focused on the import duties countries ask for medical devices that will enter the country. Some countries ask for import duties from 50% to 70% of the new value of a device. You should think of Mexico, Brazil and Argentina. Because COMPANY 1 is repairing all the products in the Netherlands at their office's repairs and calibrations become expensive for customers/end users. For that reason this is a service killer, when offering no service it is still an option to offer the customer training so they can handle repairs them self. In Table 13 *Service decision law and regulations* an overview of the consequences for this decision level can be found.

The second level of the decision tree is about company size. In principle, there are three sizes of companies where COMPANY 1 is doing business with. Start-up, SME and big companies. For service, the decision has been made to bring back those three options to two by combining the SME and big companies to one group. This has been done because for service there exist a risk for COMPANY 1 according to start-ups because they have never done a market introduction before and will phase a lot of new problems they most of the time did not expect. For that reason, it should be smart to offer no platinum service level for the start-up group. When they have convinced and have shown COMPANY 1 they are able to handle the market introduction and become a stable company there can be reconsidered to offer a platinum service level. Because SME and big companies already have faced a market introduction before and are more stable companies there the platinum service level can be offered straight away. In Table 14 *Service decision company size* an overview of the consequences for this decision level can be found.

The last decision level for the customer-focused decision tree is the customer's culture type. Based on interviews with the sales employees three kinds of culture types have been formulated. There are cost focussed cultures, no focus and quality-focused. The cost and quality focussed can be seen as outliers which do need a different approach. Most of the cultures around the world fit in the no focus category. Cost focussed cultures are for example the cultures of China and India. Those cultures see service just as extra costs and are most of the time not willing to pay for service and do not see added value in service offering. On the other hand, quality-focused cultures want a high level of quality. In-depth root cause analyses are expected when a device needs a repair, those quality-focused cultures want to know for sure that those problems will not occur at the other products in the field. For those cultures, you must think of Japan and Germany. For that reason, the quality-

focused cultures do not get a silver package offer where the cost focussed cultures do not get a platinum package. In Table 15 *Service decision culture type* an overview of the consequences for this decision level can be found.

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As mentioned above the first iteration of the tree is made based on criteria to exclude service levels per node in the tree. Next, an iteration has been done by looking at service enablers to see where in the tree service levels can be added in case an enabler is around. In this tree one enabler has been found. A bank grantee for service by a start-up. In case a start-up is able to hand over a bank guarantee to COMPANY 1 the financial risk for COMPANY 1 is reduced which opens the opportunities to offer more expensive service levels. The result of the decision tree can be found in Figure 14 *Customer-focused decision tree*.

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Figure 14 Customer-focused decision tree

The outcome of the tree results in five different service offering packages, shifting from not offering service to offer all the four service levels. This tree is a nice guideline to use and evaluate if the offering of a service package should be considered or not, but because cultures are no exact science it could be that another outcome in some cases fits better, for example, according to China and India as cost focussed cultures, from those countries, has been asked for high quality and root cause analyses some customers asked for more compared to German customers for example. This because when the medical device is patient critical and could bring the patient to live in danger in case of failing the root cause investigation becomes interesting as well for those countries. In order to take away that kind of problems, a second tree has been developed more focussed on the product characteristics of the to be developed medical device. This tree with different levels is explained in the next paragraph.

5.3.3: Product focussed decision tree

The product-focused decision tree contains decision variables for the service offering that can be used in order to guide the service offering based on characteristics of the product that is developed. The levels of this tree are the product size, the product price, the risk level if a product fails and the complexity of service execution.

The first level of the tree is about the size of the product, this is a direct link to the possibility of shipping the product. In case the product is too big to ship by mail COMPANY 1 is not able to offer service besides training the customer. Because COMPANY 1 handles all the service at COMPANY 1 sites. Besides COMPANY 1 has no influence on the places where the customer will sell the product. In Table 16 *Service decision product size* an overview of the service offering can be found for this level.

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The second level of the product-related decision tree has to deal with the product price. Here a distinguish has been made between, low, medium and high prices where the tipping point between low and medium is set on €2000 and between medium and high €5000. Those prices are set based on the cost service will bring, in case of a cheap product, it quickly becomes from an economic point of view wiser to by a new product instead of repairing the broken one. This results in the following service offering options shown in Table 17 *Service decision product price*.

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The consequences of a failing product are the third level. Here the patient risk is key. When the risk for the patient occurs due to a breakdown of the product a deep root cause analyse is needed in order to be sure a recall of the products in the field is needed or not. For that reason in case the product is critical for the patient the service level offered should be on a high level.

It could occur that in some cases due to other levels in the tree the high platinum service level will not be offered by the decision tree. When this occurs COMPANY 1 needs to be remembered that it is wise to pick up the discussion and find out with the customer if an in-depth root cause analysis should be added to the service contract and in what conditions. In Table 18 *Service decision product failing consequences,* an overview of the service offering can be found for this level. Besides, it could occur that due to other causes than patient risk service forms a high priority for service. Often this priority is availability focussed (instead of the patient risk which is quality focussed). In that case, the response times are important which has a direct link with the high service levels. So the cause of the high priority service is different but they result in the same packages.

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The last level of this decision tree is the level of complexity that is expected for service, in this case, the serviceability is evaluated, when it takes a lot of time to disassemble the product you know upfront the service is time-consuming and becomes expensive. In that case, the customer must be willing to invest in service. For that reason, the silver package, in that case, will not be offered in order to trigger the customer to make a good decision. In Table 19 *Service decision service complexity* an overview of the service offering can be found for this level

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The four levels combined will result in the decision tree that can be found in Figure 15 *Product-focused decision tree.*

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Figure 15 Product-focused decision tree

In total three results in six different service offering packages shifting from not offering service to offer all the four service levels on the left-hand side when resulting in non-shipping options all the service offering except for training, the customer is immediately killed. For that reason here you can jump directly to the end result No service. The third and fourth level of this decision tree can be swapped resulting in another service offering. When or patient risks occurs or the service is complex you can immediately see in all the columns where to go.

This tree is a guideline to use and evaluate if the offering of a service package should be considered or not, but because not all the products are the same and there are always grey areas and some of the tree levels need their decision based on the feeling people to have about the customer expectations which makes it difficult to draw solid conclusions as the decision tree represents.

5.3.4: High-level evaluation service tree

In order to investigate if the decisions trees aid in identifying the right service options, an evaluation is carried out below three medical devices have been used as input for a decision-making process

supported by the designed decision trees. Additionally, the outcomes have been compared to the current service situation.

A big German customer has asked COMPANY 1 to develop a part for their brain surgery tool. Here on the customer site, the result of service offering will come to No service, gold or platinum offering. Because the selling countries of the product does not have high import duties, the customer is a big company and the German culture is quality-focused.

On the product site, the same service offering pops up. Here shipping the device is possible, the product price is high and the service is complex. Because of the complexness, there is no need for information about patient risk. In the tree, you can see patient risk can be switched with the complexity of the product without coming to another result. This brings the decision tree to the same outcome as the tree for the customer. After evaluating the negotiation and seeing the first service request which was based on the service level agreement they use for other products they sell to end customers it was clear here was asked for gold or platinum service level. Here because the product is a submodule the customer wants to have extra products so they can quickly swap parts, which reduces the response time for the end customer. At the same time, they ask for a high level of root cause analyses.

The second example is Hemics, a start-up in the Netherlands where COMPANY 1 has done the development for their Rheumatoid Arthritis scanner. They have customers in the Netherlands. According to the customer-focused design tree, Hemics should get the offer of no, silver or gold service option. According to the product focussed tree the product is able to ship, the price is in the middle category, and there is no high patient risk when the product brakes down but the service is complex. This results in a service offering of no service or gold service. At this moment of time Hemics handles first line support by them self, Hemics employees have been trained to handle standard repairs, when it becomes more complex COMPANY 1 handles the repairs, here Hemics is on a gold level interested in the root cause of the break downs.

Third COMPANY 1 is producing the ScopeControl, an endoscope tester. This is a test and measurement device developed by DOVIDEQ medical to verify the quality of rigid endoscopes and securing quality assurance. COMPANY 1 has not done the development of this device.

DOVIDEQ is a SME company in the Netherlands where it is not known for COMPANY 1 where the product is sold. This results for the no, gold platinum option on the customer-focused tree. The product price is in the middle range, shipping is possible, not patient high risk occurs in case of a breakdown, and the service is not complex. This results in a no, silver, gold offer from the product-focused tree. At this moment of time, COMPANY 1 is offering second line support and does not have had many repair request. DOVIDEQ wants to handle as many services as possible on their own. Because of the second line support the service COMPANY 1 offers becomes complex and DOVIDEQ is like Hemices interested to know the root cause. So the current situations look most like a gold service level.

5.3.5: Tree node evaluation decisions trees

In this paragraph, both types of trees are evaluated on all the nodes they contain. First, the customer-focused tree is evaluated after which the product-focused tree will get its attention.

Customer-focused decision tree

The first layer of the customer tree is about the selling area of the customer and the import duties that countries have. Because COMPANY 1 handles the repairs in the Netherlands the customer needs to send back the product. In the case of countries as Mexico, Argentina, Colombia and for

example Brazil the import duties go up to 50-70% of the brand new product value which makes this an absolute service offering killer. This level in the tree works pretty well, none of the customers who sell in countries with high import duties wants the kind of service that is COMPANY 1 able to offer. For that reason, in this case, the offering of training is the only option to offer. Most of the time it is not possible for COMPANY 1 to set-up a service centre in those countries because the selling volume is often too low and the risk for COMPANY 1 that the customer starts selling in other countries. For example, Brazil and Argentina are no friends so when COMPANY 1 has a service hub in one of both this does not solve the problem for the other neighbour country.

The second layer of the tree is about the size of the customer, which is divided into start-ups and SME/big companies. Here this difference has been made because start-ups bring uncertainties, the market introduction is new for them and a big investment in the development of the product has been made which causes a risk for COMPANY 1 for offering an expensive platinum service level. Because a start-up first needs to prove that they are able to sell products and earning money to be sure for COMPANY 1 that there is no risk of a bankruptcy of the customer. For that reason, the service enabler service bank guarantee has been added in this level which allows start-ups to go through the service options the same way as SME and Big companies. In this level not always the bank guarantee is asked by the sales because in some cases that push pressure on the customer relation especially when the negotiation is still going for the production of the product. In those cases, a decision is made based on the estimation of the salesmen at COMPANY 1 if it should be wise to offer higher levels of service. But by mentioning this option in the tree the businessmen get remembered to not overlook this aspect during the offering of service by COMPANY 1.

The last level is about the cultural background of the customer, this is the softest level of the decision tree. Overall the German and Japanese culture are quality-focused which means that they expect inept root cause analysis when a product brakes down. On the other hand, the Indian and Chinese culture sees service as cost and wants to have as cheap as possible only necessary repairs of the product. For that reason, the cultures are splits up in three levels, cost-focused, no focus and quality-focused. While this is generally thought there are already examples of Chinese customers who asked for more in-depth root cause than common German customers. So here the cultural and customer knowledge that project leader of COMPANY 1 has should be used to determine the type of culture that fits the customer. In that way, it could be possible to offer a Chinese customer a gold of platinum service contract. This level does not work that well in this sense but because COMPANY 1 is dealing with customers from all over the world it is wise to integrate the customer culture in this tree. Because the way of approaching and the expectations of customers differ all over the world as mentioned for Germany and China. But there needs always a human estimation to be sure that the service levels offered does fit the customers. Because there are examples of Chinese companies who have higher expectations than some German companies. When COMPANY 1, in that case, offers just low service focused levels this brakes down the image and the expectations of the customer. So it is wise to integrate the customer culture but just guiding based on the country where the customer comes from seems not the optimal way of approaching.

Tree integration options

After both service trees have been developed it has been tried to integrate the customer focussed tree with the product-focused tree. After some iterations and trial versions of the integration, it became clear that the difference in scope and focus of our customer is not in line with the kind of product that is developed. It is compared to a stakeholder map that can be made from different stakeholders for the same situation resulting in different solutions and priorities. In those cases, it is good to know the different perspectives to see where the similarities occur and where the

differences are in order to determine your approach. In that way, both perspectives from the customer and the product should be taken in to account.

Product-focused tree

The first layer in the product-focused tree is about the possibility of shipping the product due to the size and/or the price of shipping. Because COMPANY 1 executes all the service activities intern the products needs to be shipped. In case that is not possible, it should be wise to train the customer so they can handle the service their own. This because there is a risk for COMPANY 1 when going to a customer while not having control over where the products are sold. This layer is clear and a true service killer.

Next, we come up by the product price, divided in three categories low (<2000) middle (2000-5000) and high (>5000) price. Here the extension has been made that in case the production volume is high enough for low price products that this enables a more advanced service level and the low price product follows the flow of the middle price products, the same counts for the middle price products compared to the high price products. The reason behind the categories is that it quickly becomes financial, not interesting to execute a repair in those cases the customer could better buy a new product for the low price products and that for the middle price products it becomes interesting to offer more high-level service increase the production volumes goes up. So high-level service agreements are not needed for low price products. But due to the helpdesk and the standby services from the higher service levels, those levels becomes interesting when the production volumes increase. This level in the tree is a good guidance for the service levels. But when time is passing the price levels and the productions volume numbers needs to be evaluated in order to see if the estimation which has been made now still fits over some time.

Patient risk is the next level here we speak about the consequences for the patient when the product breaks down. Do you only loos the data of measurement or is the risk there that patient could die because respiratory systems fall out. When a patient risk occurs there is no option to offer a low-level service agreement because this requires a high level of service that is not included in the silver level. In the first hand, it seems weird to offer no service in case of patient risk but because of the combinations made in the tree based on the levels up, there is no option for COMPANY 1 to take the responsibility at this level.

The complexity of the service is an estimation about the afford necessary to execute service operation, this is about time and knowledge. In case the service is estimated as complex this means that it is not beneficial for COMPANY 1 to offer a low level of service so at least a gold level should be offered. Here it is difficult to make a good estimation upfront. But it does bring in the need to ask the employees of the LCS department to review the designed product and make an estimation about the complexity. In this way, they become responsible and help to give their input which service level COMPANY 1 should offer to the customer. In this level, some opinion rises sometimes one says this is a complex service product where another says that it is easy to execute the service this makes it hard to execute this tree level in a good way.

Chapter 6: Model validation

In this chapter, the validation of the in chapter 4 introduced three-step approach is discussed. A recap to the framework for evaluations in design science research is made where the strategy, strategy selection and the evaluation method of chapter 2 is given after which the evaluations executed is explained. Section 6.1 repeats the methodology used for the evaluation and Section 6.2 explains the execution of the design evaluation.

6.1: Evaluation background

The type of artefact that is designed in this research as a process artefact. Because all the three steps are methods/approaches to guide someone or tell them what to do to accomplish some task. Because the artefact is a process artefact this implies that it is a socio-technical artefact. The human risk & effectiveness evaluation strategy from Venable et al. (2016) explained in chapter 2 is the strategy that fits the characteristics of the designed three-step approach.

As mentioned in chapter 2 there are five classes of evaluations methods with 12 specific methods in those classes (observations methods, analytical methods, experimental methods, testing methods and descriptive methods). Hevner et al. (2004) do not provide guidance on method selection or evaluation design Venable et al. (2012) does. Their four-step approach: (1) analyse of the context of; the evaluations; this step exists of seven sup steps. (a) determine what the evaluation is, (b) determine the nature of the artefact, (c) determine the properties needed to evaluate, (d) determine the goal of the evaluation, (e) identify and analyse the constraints in the research environment, (f) consider the required rigour of the evaluation and (g) prioritize the steps a till f to determine which aspects are essential. (2) Match the needed contextual factors to the criteria from *Figure Selection framework evaluation strategy* (in chapter two), (3) select the appropriate evaluations method(s) from those listed in the selected corresponding quadrant(s) in Figure 5 *DSR evaluation method selection framework* (in chapter two) and (4) design the DSR evaluation in detail. This approach is used for each of the three-step models that have been developed in the research. In the next paragraphs contains the evaluation per designed step. first, the seven steps for the context analyse of the evaluation will be discussed, a match with the DSR evaluation strategy selection framework will make, the selection of the DSR evaluation method selection framework will be made and the last step the DSR evaluation in detail where the outcome of the evaluations will be discussed.

6.2: Evaluation execution

Step 1) analyses of the context of the evaluations

There are some steps generic for all the steps in the three-step approach. Those will be once explained here. In the next paragraph, the specific parts per step of the designed artefact will be explained.

b) All the three steps contain a social-technical artefact as mentioned in section 7.1 all the steps are process artefacts, methods/approaches

d) Here a combination is needed, first the part on itself needs to be evaluated and the total three-step approach needs to be evaluated where the synergy of the three steps should get the attention.

e) Databases with research papers able to use, the researcher invested time, there is no money and some limited time of stakeholders and field experts is be used.

f) Depending on the scope and willingness of COMPANY 1 to continue on this research the rigour of the evaluation is determined. In case COMPANY 1 wants to take the next steps all the risk should be covered and rigorous evaluations are needed, in case COMPANY 1 does not want to

continue a high-level approach can be used. From an academic perspective, it is important to develop a rigorous evaluation. But only for the service content and the tailoring of the service portfolio. Form academic perspective the service offering step is less imported which means a high-level evaluation suits for this step.

g) This part will be discarded from the approach. In this research, only the aspects that have been executed will be mentioned so a prioritizing is not needed. In the chapter limitations and further research, we come back on the nice to have for the future.

6.2.1: (i) Service offering

Step 1) analyses of the context of the evaluations

a) In the service offering part a process combined whit a service infographic has been designed.

c) The effectiveness, the integration in the current process and presentation of the kick-off meeting and the quality of the designed artefacts.

Step 2) match the needed contextual factors to the criteria of *'DSR Evaluation Strategy Selection Framework'*
The designed artefact is of a naturalistic and ex-ante type. Generally, this implies: low building cost is needed, real users, problem and system are involved, many stakeholders, the artefact is socio-technical, there is a long time horizon needed to realize and implement the artefact.

Step 3) Select appropriate evaluation method(s)
Action research and a focus group will be used to evaluate the first part of the three-step approach, this is in line with the previous steps. The outcome of step two: a naturalistic and ex-ante type of artefact results in Figure 5 *DSR evaluation method selection framework* out chapter 2 in an evaluation of the type focus group and action research.

Step 4) Design the DSR evaluation in detail.
The infographic that has been developed by the use of action research, tighter with an industrial design engineer at COMPANY 1 the layout has been designed. In the appendix, the different design outcomes can be found.

The focus group used to evaluate the results of the action research did exist of different experts at COMPANY 1. Here a Project manager from COMPANY 1, manager director COMPANY 1 Enschede, manager director COMPANY 1, group leader LCS and Business unit manager medical systems and for the layout involved. The experts gain the result of the action research and discussed if and how they could use the approach behind the infographic and if they were willing to integrate the infographic in the kick-off meeting. Due to some iterations, multiple session's with the focus group has been organized.
A first idea to integrate the service approach in the stage-gate model has been rejected by the focus group, because the integration of the extra service gates should take to long for this research to realize. For that reason, a separate infographic was designed.

In the second iteration of the action research, the industrial design engineer advised integrating some parts of the current stage-gate model in the infographic so the customer can see where all the steps come from. Because COMPANY 1 expresses itself as a partner the closed-loop was used in the infographic. And to keep an eye on the general COMPANY 1 style, for that last reason the blue form the COMPANY 1 house style is used in the infographic.

Back to the focus group, they agreed that the approach could be useful but on its own, not useful to embed and integrate into the kick-off meeting. Their argument: When integrating service in the kick-off meeting the total service process including service products, pricing and contracting needs to be in place first. Otherwise, service will be discussed while COMPANY 1 is not able to continue on this theme in the next phases, service products content, pricing and contracting. In case those steps are in place at COMPANY 1 the willingness of integrating the infographic is committed by the higher management at COMPANY 1.

6.2.2: (ii) Service content

Step 1) analyses of the context of the evaluations

a) The service portfolio is a product artefact which is part of the total service offering process. Which makes it a social-technical artefact.

c) The integrality of the service portfolio, the fit whit the service situation at COMPANY 1 in de medical business unit and the quality of the service portfolio.

Step 2) match the needed contextual factors to the criteria of *'DSR Evaluation Strategy Selection Framework'*
The designed artefact is of a naturalistic and ex-ante type. Generally, this implies: low building cost is needed, real users, problem and system are involved, many stakeholders, the artefact is socio-technical, there is a long time horizon needed to realize and implement the artefact.

Step 3) Select appropriate evaluation method(s)
Action research, a focus group and case studies will be used to evaluate the first part of the three-step approach. The action research and focus group are in line with the previous steps. The outcome of step two: a naturalistic and ex-ante type of artefact results in Figure 5 *DSR evaluation method selection framework* of chapter 2 in an evaluation of the type focus group and action research. However, the case studies do not fit in the quadrant of the naturalistic and ex-ante type still the need for those case studies is there. It was not possible to execute a test on a real-life case due to the time of a development process which outranges the time available for this research. For that reason, the case studies introduced to test the portfolio on existing medical devices sold by COMPANY 1.

Step 4) Design the DSR evaluation in detail.
The service portfolio has been developed by the use of action research and two different focus groups. After which the portfolio (in combination with the guide decision trees from step three) is applied to some existing medical devices COMPANY 1 has produced in order to see how the portfolio did perform i.e. the case studies.

One of the focus groups during this research was internal at COMPANY 1 and did contain: the group leader of the LCS department, manager director COMPANY 1 Enschede and the Business unit manager medical systems. The outside focus group did contain service experts from Company 2 and COMPANY 3. From Company 2 three different product managers' services with up to 40 years of experience in the field of service. From COMPANY 3 the new Director aftermarket and services were involved.

The action research that took place was done by the researcher and supported by the service coordinator at COMPANY 1. it was used to develop the portfolio. Based on models found in literature, the current services executed by COMPANY 1 and service models from other companies the first conclusions were: use service packages and be clear what to offer in which package. This input and the current service execution at COMPANY 1 is translated to a first service portfolio which

has been brought to the outside focus group. Feedback was to use a more customer focus and if the possible end-user focus in developing the service portfolio. In case you are able to create value for the end-user, you immediately create value for the customer of COMPANY 1. The product manager service from Company 2 advice to integrate training and additional service in the portfolio which customers could add on the service package they prefer. The last advice was tailoring of the service portfolio and an approach on how to tailor the portfolio to specific customers. The experts concluded that the content (the different rows in the portfolio) did contain the core needed in a service portfolio. Because the experts do not have enough knowledge about COMPANY 1 they were not able to give advice on the exact content per service row for the different packages.

The additional service and training were added to the service portfolio, with action research the service packages were more tailored to the COMPANY 1 (here the research gained a lot of help from the service coordinator) and a first step of the tailoring for different customers was made.
The results were brought to the inside focus group. They liked the idea of the different packages and training but were not all convinced on the additional services. It was difficult to gain more feedback due to the fact that after the first meeting the news appeared that the managing director of COMPANY 1 Productions contract was not extended which dropped the priority of some of the focus group members. This lack of substantiated feedback by the internal focus group brings doubts about the willingness of COMPANY 1 to continue with the portfolio. To continue the research and gain in some way the feedback from within COMPANY 1 the service coordinator at DECON is asked and inept discussions about the portfolio took place with him. Main improvements made were more different types of training. Extra training types were added because the service coordinator gains the need for that from different customers.

The feedback was gathered, which brought some changes to the additional services. After which case studies have been executed with the portfolio applied to existing products (those studies has been done in combination with the decision trees from step 3). Main results here were that the fit of the portfolio is there and the portfolio is working for multiple devices. The results of the cases were in line with current service contracts or when that was not the case they are inline whit the wishes of the project managers responsible for those product lines in the ideal situation, for example, the ViveO2 had this result. In appendix 4 the more inept analysis can be found.

6.2.3: (iii) Tailoring service portfolio

Step 1) analyses of the contest of the evaluations

b) The guiding decision trees are a product artefact which is part of the total service offering process. Those trees will be used as guidelines for the employees who will work with them. This makes it a social-technical artefact.

d) The quality of the outcome by the decision trees. This means that the outcome of the trees may not bring risk for COMPANY 1 and the trees should be workable. It should not be the case that the employees using them should not often deviate from the result based on their own experience.

Step 2) match the needed contextual factors to the criteria of *'DSR Evaluation Strategy Selection Framework'*
The designed artefact is of a naturalistic and ex-ante type. Generally, this implies: low building cost is needed, real users, problem and system are involved, many stakeholders, the artefact is socio-technical, there is a long time horizon needed to realize and implement the artefact.

Step 3) Select appropriate evaluation method(s)

Action research, a focus group and case studies will be used to evaluate the first part of the three-step approach. The action research and focus group are in line with the previous steps. The outcome of step two: a naturalistic and ex-ante type of artefact results in Figure 5 *DSR evaluation method selection framework* out chapter 2 in an evaluation of the type focus group and action research. However, the case studies do not fit in the quadrant of naturalistic and ex-ante type still the need for those case studies is there. It was not possible to execute a test on a real-life case due to the time of a development process which outranges the time available for this research. For that reason, the case studies are introduced to test the portfolio on existing medical devices sold by COMPANY 1.

Step 4) Design the DSR evaluation in detail.
Based on the input of the outside focus group from step 2 action research has been done to design a decision tree for this action research different sales employees of two Subsidiaries (Finapres and Macawi, both selling their own complex medical device) from COMPANY 1 has been interviewed to gather content for the decision tree for the customer. During the interviews, it became clear that there was not always an overlap between the answers gain from the Macawi compared to those from Finapres. This brought triggers that the kind of device selling could be an important part of the decision tree. A first approach was to integrate the device type combined with the customer perspective in one tree. However, after some iterations, it became clear that it was not possible to integrate both perspectives into one tree due to conflicts that arise. For that reason, two trees were designed, one form customer perspective and one from the device perspective.
Action research was executed by the researcher, by joining meetings for service contracts, joining the LCS department meetings and taking active roles in the different brainstorm meetings. The internal focus group from step 2 has only discussed the first developed decision tree and was convinced that such tailoring should bring benefit but did not come with suggestions for redesign, this causes the need for other input for the validation which has been found by the service coordinator at COMPANY 1 and at the University of Twente discussions about the content. Based on those discussions it became clear that it is not possible to fit both the customer perspective and the device perspective in one decision tree which causes the development of two trees. Because two trees are developed where it could occur that both trees result in a different outcome it became clear that: the trees do guide the employees but not force the employees to strictly follow them. If employees have a substantiated reason for deviation of the results from the trees this should be done, but only after the LCS department has been contacted because they are the ones who execute the service and have the most knowledge and experience with service within COMPANY 1.

The results of both trees combined with the service portfolio from step 2 has been applied in case studies on existing devices. Based on the case studies we see that the decision trees guide in a good way for multiple devices. The results of the cases were in line with current service contracts or when that was not the case they are inline whit the wishes of the project managers responsible for those product lines in the ideal situation, for example, the ViveO2 had this result. In the appendix, the more inept analysis can be found.

Chapter 7: Conclusions and recommendations

This chapter contains conclusions and recommendations. Section 7.1 gives a recap and the general introduced sub-research questions formulated in Chapter 1 and answers them. Section 7.2 elaborates on the sub-research questions whit the focus from, Theoretical, industry and COMPANY 1 perspective to answer them. Section 7.3 combines the results from Section 7.1 and 7.2 to reflect on the research goal that is formulated in Chapter 1. Section 7.4 reflects on this research from a practical COMPANY 1 perspective and Section 7.5 contains a reflection from a more theoretical perspective.

7.1: General questions

The general sub-questions in this research are:

- What is service?
- What is the current situation at COMPANY 1?
- What is COMPANY 1's service ambition?

What is service?

There are many definitions of service, a literature study has been done to formulate the definition used in this research. Service is related to aftersales which contains the sales of services that are executed during the use phase of the developed medical device.

What is the current situation at COMPANY 1?

In the current situation at COMPANY 1, research shows that the service offering process is overlooked, interviews and examples of medical devices without service agreements substantiate this suspicion. The way the LCS department has been created is an important driver in this. The focus during the introduction of this department was to relief the design engineer's who executed service activities. The service offering and what to offer has not been developed yet.

Other COMPANY 1 characteristics according to service which plays a role in this research are mentioned in Table 1 in chapter 1. Most important here, COMPANY 1 is not IP owner of the device, this research scope is on medical devices, the devices are complex, produced in low volumes and the service actions are executed only at COMPANY 1 site.

What is COMPANY 1's service ambition?

The aim of COMPANY 1 is to be a partner for the customer instead of a supplier. For that reason the development from an engineering firm to system supplier who is able to handle production as well has been made, the next logical step is to add service and life cycle management to the competences of COMPANY 1 to become the full partner COMPANY 1 wants to be. This is the result of interviews done with the managing director of COMPANY 1 Enschede and employees of the PR and communication department.

7.2: Theoretical, industry and COMPANY 1 perspective questions

The second set of sub-questions in the research has been approached from three different perspectives, theoretically, from industry and from COMPANY 1 perspective.

- Which steps does a service offering process contain?
- How to create awareness for service offering?
- What content does a service portfolio contain?
- What does a configurable service model contain?
- How to determine which service to offer when?

What steps does a service offering process consist of?

From the literature, the six-step approach for managing service networks from Cohen et al. (2006) is used as input. They define: 1) identify which products to cover, 2) create a portfolio of service

products, 3) select business models to support service products, 4) modify after-sales organizational structures, 5) design and manage an after-sales services supply chain, 6) monitor performance continuously. This approach has triggered to define what service to offer.

In industry, it differs per company which process steps the service offering contains. Different companies have been studied in this research (Company 2, COMPANY 3, Company 4, Philips medical, SKIDATA). Most of them work with a service portfolio where the customer can choose what to buy from that portfolio. Some of the companies fine-tune their portfolio per customer they will approach where others use one standard for all their customers.

For COMPANY 1 there is no standardized service offering process. Service is often overlooked and the LCS department gets confronted with unexpected service request where no service agreements have been signed.

How to create awareness for service?
The awareness for service can possibly be created by integrating the service in the processes and literature advice to create a separate service business unit by making service profit and loss responsible the awareness can be created.

Different companies are studied during this research, (Company 2, COMPANY 3, Company 4, Philips medical, SKIDATA) multiple interviews and focus groups outside of COMPANY 1 has been used in this study. It became clear that different companies have different approaches to create awareness for service. Where COMPANY 3 is creating a new service business unit, for example, Company 2 is breaking down its separate service business unit.

At COMPANY 1 the production and the LCS department together are that small that on the first-hand service should be integrated into COMPANY 1 production. For that reason the awareness for service needs to be created by integrating service in the selling process in the case at the start of a product development service is discussed this will trigger the rest of the processes. During the start of a product development project at COMPANY 1, a presentation during the kick-off meeting with the customer is given to inform the customer where COMPANY 1 is capable of and what their way of working is. This presentation does not contain any content on service but brings a good opportunity to mention this topic at the start of a project. For that reason, an infographic has been developed in this research. Which can be integrated into this presentation in order to embed this topic in the kick-off meeting. The idea about this infographic is that the customer knows there is a service phase after production and COMPANY 1 can support the customer during the usability phase of the device if they want. Figure 12 *New service infographic* is made circular because the different service options COMPANY 1 offers could help the customer to develop the product and sees when it is necessary to start development for a version 2.0 which is a competence of COMPANY 1.

What content does a service portfolio contain?
The literature advice to develop a service portfolio such that the service products meets the support the customers wants wherein case the customer prefers short response times this drives up the prices. Service products range from those that are fast and expensive (platinum services) to those that are slow and economic (silver) Cohen et al. (2006). The number of service products may not be too much and not too few because both reduces the profitability of the service.
In the industry, the companies all offer repairs, spare parts, maintenances, assistance/ helpdesk kind of services.

At COMPANY 1 in the current state repairs and calibrations are the service actions that are executed there seems the ability to develop more service products for COMPANY 1.

How can a service portfolio be made flexible?
The literature does not make a distinction between a service portfolio and a configurable service portfolio. The service products differing from silver till platinum are all mentioned as configurable. This means that the literature picks the focus on companies who have one kind of products that they sell. This does not contribute to the situation COMPANY 1 is in. for COMPANY 1 it is up to the customer what kind of device will be developed the variety in products is enormously which brings the need for a configurable service portfolio. Part of this research is to find out if this approach of silver till platinum service products could fit in a situation as COMPANY 1 is in with the amount of variety in customers and medical devices.

In the industry, it differs again per company what they integrated and if they use a configurable portfolio. Some companies always offer the same set of services for each customer, but some as for example Company 2 first customize their portfolio for a customer.
At COMPANY 1 a configurable service portfolio is needed because COMPANY 1 develops a lot of different devices for a lot of different customers. But in the current state, no service portfolio exists.

How to determine which service to offer?
The main guidelines for the service offering from literature focus on the capability to offer the fast response times corresponding to right prices, in case a company is not able to keep spare parts close by the customer fast response times should not be offered.

At Company 2, they have done a customer segmentation study. There are around 50 allowed possible customers for Company 2 worldwide. Those have been segmented in four different categories. When a customer becomes interested in service Company 2 firstly picks their standard portfolio for the right segment. This portfolio will be fine-tuned more for the specific customer after which negotiation starts which will lead to the agreed service agreement. COMPANY 3 is offering every customer the same service levels and uses agents around the world to guarantee that the response times can be realized.

At COMPANY 1 the current situation does not have a service portfolio and there is no idea when to offer which services. In this research a first generic service portfolio is designed, this full portfolio should not be offered to any customer and for any medical device. Because that brings big financial risks and a possibility that service products are offered which cannot be executed by COMPANY 1. Tailoring of the portfolio is needed. Two guide decision trees are developed to guide and support COMPANY 1 in their decision making what to offer from the portfolio in each situation. For COMPANY 1 there is a need to guide from two perspectives, the customer perspective, and the device perspective. Because the kind of devices that COMPANY 1 develops is broad, the service offering cannot be the same for every device. From the customer perspective the expectations and for example the countries where the products will be sold play an important role in the service offering COMPANY 1 could do.

7.3: Research goal

The answers of the sub-questions were input for the design study realized in this research. The research goal of this study is: **Design a generic configurable service model, configuration and approach applicable to the series produced medical products COMPANY 1 develops for their customers including guidelines for its implementation and use.** The three-step approach that has been designed contains an approach to create awareness for service in step one where the infographic supports, a generic configurable service portfolio has been developed and the decision trees guide how to use the portfolio in specific situations. Those elements contribute to the research goal of this study.

7.4: COMPANY 1 reflection

In Sections 7.1, 7.2 and 7.3 the research sub-questions and the research goal have been discussed. This paragraph contains the conclusions and recommendations from COMPANY 1 point of view and will give recommendation for COMPANY 1 in the future.

The three-step approach developed in this research is a good first step for COMPANY 1 to bring knowledge on service approach. The focus during the introduction of this department was to relief the design engineer's who executed service activities. The service offering and what to offer has not been developed yet.

In order to take steps in the servitization journey a foundation according to service, offering is needed to make next steps towards performance-based kind of contracts. Due to the current situation at COMPANY 1, those steps are not possible in the short term. Besides, because COMPANY 1 does not own the IP of the product, modification on the devices to integrate sensors and Internet of Things, or IoT, technology becomes complicated which brings problems for monitoring the devices what is needed in case of performance-based contracting. A next problem is that the data gathering, in the medical industry laws and regulations, are tight and patient data is not allowed to share. Bedsides the sensors on the devices are not owned by COMPANY 1 so tracking the devices needs to be discussed with the customer who will be the owner of the data. In the end, the fact that the devices developed are on the edge of technical possibilities and no performances data is known upfront. Brings a big financial risk for both COMPANY 1 and the customer because the performances are not known upfront the cost and benefits of the performance-based contracts are not known for both the customer and COMPANY 1. In total, the servitization trend seems not be made for companies like COMPANY 1.

This research is a first step to close that gap that exists at COMPANY 1 in the field of service offering. Still, more development is needed, like a real use case from the start of a development project to completely analyze if all the aspects of the three-step approach work how they should do. After three-step approach guidance in pricing and contracting and a clear role with the responsibility of service offering at COMPANY 1 is needed. The implementation plan (which can be found in the appendix) brings a good first guideline with the first steps to take for COMPANY 1. it explains how COMPANY 1 could use the three-step approach and gives suggestions on where to put which responsibility in the organization and which potential new roles could be created to embed this three-step approach in the organization.

Early involvement in the product design cycle is needed for service offering and while it seems possible to use the generic service portfolio. This portfolio and its guidelines have shown its results in the case study tested on existing products that are being sold by COMPANY 1. The tailoring is needed for each new device and customer that comes up which is supported by the decision trees from this research. The devices and customers of COMPANY 1 all have their own characteristics which bring big financial risks and a possibility that service products are offered which cannot be executed by COMPANY 1 in case service products will be offered that does not match the specific device and customer characteristics. However, the standardized service portfolio is needed to structure the service products and service offering process. This brought the combination of a standardized framework (the service portfolio of step two) which needs to be tailored for each specific situation by the use of the decision trees from step three.

For the future, the main recommendations are to take the next steps in order to bring service more in attention at the start of the product development and start working with the implementation plan. When it will be embedded at the start of the product development the consequences of the made decisions over there will become clear at the start of the product development. Where in the

current situation this was only seen by the LCS department which needs to solve the situations in order to keep a satisfied customer.

Because of the standardization this research brings, a long-run future opportunity for COMPANY 1 is to gather data on service that will arise when using the portfolio, this can be used to measure if the pricing is right and COMPANY 1 is able to execute all the services in the right way. By gathering the data after a while it becomes possible to apply trend analysis in order to improve the portfolio and the prices.

The results of this research is to aim for a lifecycle approach for the development, production, and service of the medical devices. This request a lifecycle way of thinking and handling which suits the service ambition COMPANY 1 has to become more partner of their customers instead of a supplier.

7.5: Academic reflection

This paragraph contains the conclusions and recommendations from an academic point of view. The goal of developing a generic model for service offering where the product aspects are not known upfront in which this research seems to succeed brings a contribution to the academic world. However, a case study started from the developing project until the service execution phase to prove the three-step model does works seems needed to guarantee this conclusion. Additional research on pricing methods will be needed to complete the full-service offering process this content is not in the scope of this research and brings an interesting topic for future studies. Based on the industry compression and the knowledge which has transferred from those companies to COMPANY 1 does suggest that it could be possible to translate this service approach to other industries. Here a logical step seems to translate the three-step approach to other business units within COMPANY 1. But a transfer of this model outside of COMPANY 1 to another company could be an option for future research because such research can show how generable this research for the specific COMPANY 1 situation in the medical business unit is.

Chapter 8: Limitations and further research

In this chapter, the limitations of this research and the several possibilities for interesting future research are discussed. Section 8.1 contains the limitations found during the research and design process of this study and Section 8.2 contains suggestions for further research both from COMPANY 1 and the academic perspective.

8.1: Limitations

During the define, design, demonstrate, evaluation and communication phase of this design science research no customers of COMPANY 1 are be contacted because the researcher was not allowed to get in contact with customers of COMPANY 1. To compensate for this lack of end-user input, field experts from inside COMPANY 1 who have a lot of customer contact is used as validation experts and outside COMPANY 1, experts in the field of service were involved in this research to try to become as close as possible to real customers, since reaching them was not possible. Which means that customers' opinions, expectations, and reactions are not integrated into this research and the three-step approach that has been developed.

The input gain from service experts outside COMPANY 1 is gain from the companies used in the industry comparison study. Here should not be forgotten that those companies are not similar to the situation where COMPANY 1 is acting in. Especially the IP ownership is a difference between COMPANY 1 and the other companies.

Besides the lack of involving customers, another limitation of this research is the limited number of representative cases which could be used. In this research different case studies have been executed on medical devices that are already developed and are being sold by COMPANY 1. The case studies show that the service portfolio is applicable to different medical devices, however, no case studies are done for medical devices that are still in the development phase. While this research suggests to come up with an approach to discuss service before the medical device has been developed.

The first step in of the three-step approach is to create awareness for service at the start of a product development process. The need for this awareness is well defined and substantiated by the literature study done. The outcome of this research and the use of the infographic is a way to create awareness for service. However, there could be more ways to generate the awareness needed which has not been taken into account in this research.

The both decision trees developed can result in different service offering advices, it could occur that the trees conflict, extend on each other or that they do not overlap in their advice. There remains a grey area where human input and discussion will be needed to make the final decision what service to offer. While the both trees guides not always to the same direction still they are useful in the discussion there will be according to the service offering.

In the customer-focused decision tree, customer culture types are mentioned which guide COMPANY 1 to a certain part of the service portfolio that they could offer. Here a distinguish has been made between cost-focused, no focus or quality-focused cultures. Based on the country where the customer comes from he gets his place in one of the three categories. It is a good first step to integrate the cultural background of the customer but this approach can lead easily to mistakes, e.g., there are customers in China who are more quality focussed than German companies. For that reason, it is mentioned in this research that it is always allowed to guide a customer to another category compared to where the country he is from suggests. What is missing, however, is an approach that can be used to put a customer in another category.

8.2: Future research

The conducted research can be seen as a first step to develop a new service approach for COMPANY 1. An approach that can aid in creating awareness for service. Secondly, by identifying options that can be further fine-tuned to specific situations, next steps proposed for COMPANY 1 are in the field of service pricing and contracting. An approach to aid in the pricing for (customer and device) specific service offerings is subject to further research. In the field of contracting it is interesting to find out if it is possible to automatically develop service contracts based on the service portfolio. For the implementation and use of the approach for service mentioned in this research, some next research steps can be done.

In addition, the field of maintenance in healthcare is strictly guided by some regulations and restrictions. Which bring some additional documentation requirements, for example, the Master Record Device, or MRD, that contains the Device History Record, or DHR, and Design History File, or DHF. In the current situation, it is the IP owner's responsibility to update the documentation. It could, therefore, be interesting for COMPANY 1 to analyse if it could bring benefit to take over that responsibility from the customer because COMPANY 1 executes all the service operations and has the knowledge of the devices. Research is needed here because the question arises if COMPANY 1 is able and willing to take these responsibilities, which could be for example the responsibility of a recall of devices.

Finally, an application of the method in other industries should be carried out to research if the theory can be generalized to other sectors. Advised is here to start the research within COMPANY 1 to apply this study to the other business units. Because the COMPANY 1 situation differs less in other business units in comparison with situations at other companies.

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Appendix

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Appendix 2: High level service conversation Figure

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Appendix 3: Review service portfolio old products COMPANY 1

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Appendix 4: Side recommendation Design and Development of the Artefact

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Appendix 5: DHR and DHF

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Appendix 6: Implementation plan

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