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Business Model Development

A Commercialization Study of a Test Framework for Electronic Control Units

Master of Science Thesis in Product Development

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Abstract

The numbers of electronic control units (ECU) used in products have drastically increased over the past decades, putting high demands on the industry's developers and manufacturers to produce embedded systems that are thoroughly tested. These testing procedures are often time consuming and expensive, which has resulted in the development of hardware-in-the-loop (HIL) testing systems which enable testing of ECUs in a non-operational environment with possibilities of full traceability and repeatability of tests. QRTECH has developed a HIL test system for their in-house development and production projects, and want to investigate the possibility of selling their test system as a stand-alone product. Thereby the purpose of this thesis is to investigate what the business model for the tests system should contain in order to commercialize it. Included in the scope are investigations regarding customer segments, changes and modifications to the test system, and how the cost structure should look like.

To collect the information needed for meeting the thesis' goal, data collection methods such as interviews, observations and meetings were held. The information was analyzed with the result that the customer segment to target was new development, production and verification projects within the automotive industry. In order to target these customers, the test system must be further developed so that it meets the industry standards of communication, usability, software and model integration, as well as the possibility to provide bug free testing equipment which is up to date. All this, while keeping a low cost profile where customization is a priority. Since customization, i.e., flexibility is key to the value proposition of the business model, a solution where certain features were predefined but most features may be chosen at additional cost was presented as a concept to use when selling the test system to customers.

A profit and payback time estimation was made for two cases; commercialization or continuous in-house usage. The result showed a payback time of four years, and a net present value of over 2.5 million SEK at the end of the five year period for the commercialized business model, compared to a little over 1 million SEK net present value and a payback time of three years using the existing business model. This implied that the payback time was a little longer, however the potential to obtain larger profits was higher for a commercialized QTS. Thereby the conclusions were made that a commercialization of QRTECH's HIL Test System would be beneficial to the company and thus recommended.

KEYWORDS: BUSINESS MODEL, COMMERCIALIZATION, ELECTRONIC CONTROL UNIT, HARDWARE-IN-THE-LOOP, TEST FRAMEWORK

Abbreviations and Explanations

Acronym	Definition
BMC	Business Model Canvas
CAN	Controller Area Network
ECU	Electronic Control Unit
End-of-line	End of production line where product manufactured
HIL	Hardware-in-the-loop
HW	Hardware
I/O	Input/Output
MIL	Model-in-the-loop
NPV	Net Present Value
PV	Present Value
SIL	Software-in-the-loop
SW	Software
QRTECH Test Engine	Physical HIL test machine, executes all tests
QRTECH Test Board	Circuit board containing standardized interfaces
QTS	QRTECH's HIL Test System
XML	Extensible Markup Language

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1 Introduction

The following documentation is the result of a master's thesis for the Product Development Master Program at Chalmers University of Technology. The thesis is provided by and executed at QRTECH AB throughout a period of 20 weeks during the spring semester of 2015.

Following an introduction of the master's thesis is presented, providing the reader with a background of the project. Thereafter, the purpose and main goal of the thesis is presented along with research questions that will be answered in the report. Also, limitations to the project are provided along with supporting argument explaining the reasons for them. At last, this chapter provides an outline of the thesis.

1.1 Background

The increasing complexity and sophistication of electronics and embedded systems in today's products result in high development cost due to that these systems need to be tested thoroughly and with repeatability in order to meet safety and availability requirements set by industries such as medical, automotive and aerospace. Embedded systems need close monitoring and continuous improvement due to the result of failure often has a direct impact on the user (Ebert & Jones, 2009). The constant increasing number of embedded systems in today's products thereby put a lot of pressure on the manufacturers to sustain high quality.

There are many examples of the increasing amount of control units in today's products. For instance, embedded systems in vehicles have been increasing at a high rate for decades. In 1990, the amount of electronic control units (ECUs) in high-end vehicles was approximately 10 units. In 2010, the number of ECUs in high-end vehicles had reached approximately 100 units, an increase of a 10th fold in only 20 years (Ebert & Jones, 2009). These demands of increased electronics and product complexity while maintaining short lead times and low development costs put a lot of pressure on the product development process and the methods used. Especially when it comes to embedded systems development, the complexity increases with each generation of products which contributes to continuous tests in order to verify that no unintended effects are obtained with the new, updated versions (QRTECH AB, 2014).

One way of handling this issue of increased amount of embedded systems and ECUs to be monitored and tested, while maintaining low development costs, is to use hardware-in-the-loop (HIL) test systems. HIL test systems provide a way to test embedded systems in order to ensure high quality and meet the requirements set by the industry it will be operating in. The technique of HIL test systems enable a comprehensive and a repeatable testing environment for systems that are difficult and expensive to test in its operational environment, but to a very effective cost (Ledin, 1999).

QRTECH has developed a test system themselves, QRTECH's HIL Test System, which in this thesis will be abbreviated to QTS but may also be referred to as the test system. This HIL testing system is used for testing ECUs with regards to requirements set by the industry, manufacturers, suppliers and QRTECH themselves. The main reason for developing the QTS is that existing HIL test systems on the market do not fulfil the requirements QRTECH puts on its ECU testing and verification process, which include handling of functional requirements tracking and automated coverage analysis. The QTS is currently used in in-house projects where ECU testing is required, but qualifies for the highest standards required by its industry leading customers (QRTECH AB, 2014) and thereby there are possibilities of selling it to other companies where ECU testing is needed. QRTECH is now interested in evaluating the possibility of a commercialization of the QTS as a stand-alone product, both as test equipment for ECUs in the development phase but also testing and verification of products at the end of a production line (end-of-line).

1.2 Purpose and Objectives

The purpose of this master's thesis is to develop a business model for the commercialization of the QTS and specify what modifications are needed to be made to the existing business model in order to create a stand-alone product to be sold as test equipment for ECU testing. As part of developing a business model for the QTS, investigations are also made regarding other types of value adding aspects such as service, maintenance of software or hardware and educational training. These investigations will result in a solution to how the QTS should be packages and sold. Changes regarding the QTS's hardware and software that need to be made in order for the QTS to meet the needs of customers will be identified.

The outcome of the project is a developed business model, a concept working as a guideline for selling the QTS and a profitability analysis for the QTS, documented in this thesis, which will support the commercialization of the product. In order to meet the goal set for the project, the following research questions are answered in the thesis:

1. What should the business model contain in order to commercialize the QTS?
    a. What parts of the existing business model should remain?
    b. What changes need to be made to the existing business model?
2. What changes are needed to be made regarding the product design, software and hardware?
3. How should the QTS be packaged and sold in accordance to the updated business model and product changes?

1.3 Limitations

The technical modifications or extensions that need to be made in order to commercialize the QTS are identified and given as advice to the company. However, no physical changes will be made in the actual product during this project. Thus no physical prototype will be developed. Complete compatibility with the current system must be preserved, thus no changes can be made that will interfere with the compatibility of the current system.

Specific issues regarding licenses, contracts, after sales and legal parts will be considered, but not a main priority in this project. Only recommendations to the company will be given regarding how to manage these issues. The total outcome will be the thesis only, containing a business model and recommendations of how the product offer should look like and what changes need to be made to the product.

QRTECH's framework for testing hardware and software in their development process of embedded systems include model-in-the-loop (MIL), software-in-the-loop (SIL) and hardware-in-the-loop (HIL) testing. Even though QRTECH have the ability to offer testing systems for models and software for their customers that can be integrated with their HIL testing system, MIL and SIL testing will be excluded from the thesis scope. The main reason for this is that most companies developing and manufacturing ECUs create their own models and software and also the systems that will test their functionality.

1.4 Thesis Outline

Firstly, the documentation of this thesis will introduce the background, purpose, objective, and limitations to the project. Following the introduction is a thorough description of the QTS, providing the reader with knowledge to further understand the possibilities as well as the difficulties of meeting the goals set for the thesis. Among the information provided in this section are introduction to the company, a technical description of the test system as well as information regarding product requirements. A description of the current market it is targeting and a business model is provided.

The next part of the documentation of the thesis walks through the methodologies used in order to obtain qualitative and quantitative data. Moreover, this part also provides a description of the methodologies used to analyze the data collected and the methods and tools used to obtain a result that would generate a solution suitable for and meeting the goals set for the project. The methodologies used are further explained and backed up by a theoretical framework, in which the data collected from research studies are presented. The theoretical research provided not only supports the methodologies chosen and used, but also the decisions and recommendations made in later parts of the thesis.

After providing a description of the theoretical framework, the empirical findings are presented. Consisting of qualitative and quantitative data, the empirical findings are obtained from data collection methods. The information obtained is then analyzed using the methodologies previously decided upon. Decisions and analyses are made with the information at hand obtained from research, interviews, etc. The analysis section first provide the analyses leading to identified opportunities and options for the test system as well as to the generation of solutions solving the problems stated in the objective of the thesis. Lastly, conclusions regarding the project are provided, answering the initial questions asked in the objectives. Recommendation and discussions regarding further investigations of information not covered in the thesis is provided.

2 QRTECH's HIL Test System

The following chapter provides a description of QRTECH as well as a product description of the QTS as a stand-alone testing system for ECUs. Also, what types of requirements that need to be fulfilled are mentioned and the current market and business model is laid out.

2.1 About QRTECH AB

QRTECH is a Swedish firm providing development and sales of products and engineering services for industries such as automotive, medicine and defense. The main focus of product development is within the fields of electronics, software and embedded systems for the automotive industry. Projects are carried out both in-house and at the customers' facilities and cover the entire product development chain (qrtech.se, 2015).

The company was founded in 1997 in Gothenburg and currently has over 80 employees, mainly consisting of engineers from technical universities across the country. The headquarter is located in Gothenburg and other offices are located in Stockholm and Jönköping (qrtech.se, 2015).

2.2 Description of the Test System

The QTS is a HIL system developed and used by QRTECH for testing of embedded systems in a non-operational environment with regards to the demands and requirements set by suppliers and customers. The QTS allows for tests being carried out both as an iterative process during the development phase and as end-of-line products testing in order to assure quality and decrease the amount of recalls. The QTS is currently part of both development and production tests focusing on the automotive industry, however there are possibilities to expand to other industries where ECU testing also is required (QRTECH AB, 2015).

QRTECH uses the QTS in their requirements management process, so that the developed embedded systems can be tested for errors but also to verify that all requirements set by customers, suppliers and QRTECH themselves are met before delivering the developed ECU to the customer. There are several benefits with having a HIL system such as the QTS as part of the requirement management process including possibilities in adding new functionality which result in a high level of flexibility (QRTECH AB, 2015). Another advantage is that the QTS testing process demands less time, i.e., lower development cost and decreased time to market, compared to operational environment testing of ECUs. Also, the QTS creates a full test report covering how well the ECU under test fulfills the demands and requirements set by customers and suppliers (QRTECH AB, 2015). The QTS can thereby be used to test ECUs in order to higher the demands for quality assurance from suppliers.

Embedded systems can be tested in three levels; MIL, SIL and HIL. The first level is testing of a developed model (MIL) describing the embedded system. This test is purely simulated with no hardware components present. The second level, SIL, is testing of embedded software

in a simulated environment, also with no hardware components present. At last the HIL level tests the developed hardware, the finished ECU. Physical parts that in an operating environment would be present are in HIL testing simulated (Bringmann & Krämer, 2008). As seen in Figure 1, QRTECH cover the entire process of testing and verifying embedded systems previously described.

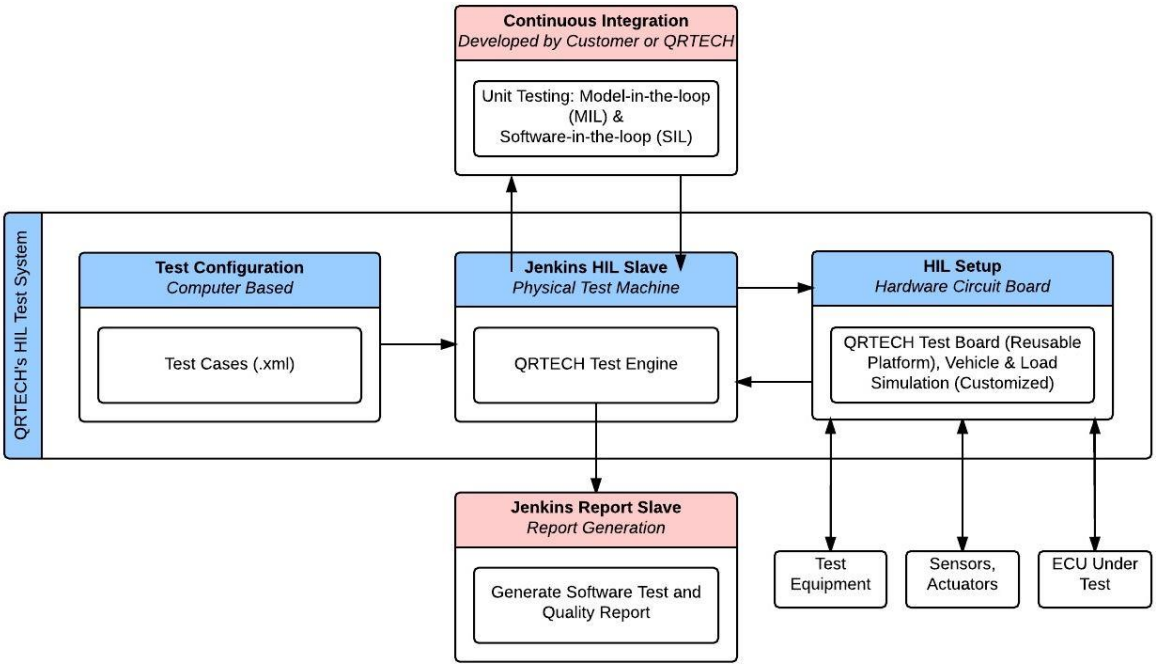

Figure 1: QRTECH's HIL Test System as part of their ECU testing process (QRTECH AB, 2015)

The HIL testing system developed by QRTECH, which this thesis is focused on, consist of three parts (illustrated in Figure 1); Test Configuration, Jenkins HIL Slave and HIL Setup.

Test Configuration

Test Configuration consists of a computer based environment where developers may design test cases that verifies and tests ECU functionality. Test cases are written in extensible markup language (XML). There are possibilities of importing requirement information from tools such as Doors and Elektra and build test cases with regards to these. By creating functions out of test cases, reuse of both test cases and general requirements is a possibility for new product development.

Jenkins HIL Slave

The core of the QTS is the Jenkins HIL slave consisting of the QRTECH Test Engine, the physical test machine that executes all tests defined by the Test Configuration on the ECU under test. The Jenkins HIL Slave communicates with all parts of the HIL test system as well as integrates with parts outside of the boundaries of the QTS; including the report generation process (Jenkins Report Slave) and unit tests (MIL and SIL) provided either by QRTECH or the customer.

HIL Setup

Connected to the Jenkins HIL Slave is the HIL Setup, the hardware that always must be customized to fit the ECU under test. The HIL Setup is currently placed on a circuit board, however consist of two parts; QRTECH Test board containing standardized communication setups such as I/Os, CAN and LIN, and Vehicle and Load Simulation which is the part of the circuit board that is entirely customized for every ECU. The HIL Setup circuit board is connected or docked with the ECU under test, but may also be connected to other hardware or test equipment so that the HIL test system is able to simulate currents, sensors, actuators, etc.

The QTS, as it is designed today, is very dependent on customization. The Jenkins HIL Slave remains the same and is independent when it comes to the ECU under test. Same goes for the QRTECH Test board, as part of the HIL Setup. The remaining parts of the QTS must be customized to fit the ECU under test by adding suitable hardware to simulate the ECU's original operating environment correctly, and the test cases must be designed so that all functionality is tested thoroughly. This contributes to high flexibility and a testing environment which is almost unlimited, but result in non-standardized production of the QTS as a stand-alone testing system. There are components that are always included when constructing a new testing system. However, there will always be a need for customization of loads, etc. in order for the QTS to function as specified for each ECU to be tested. Though the QTS hardware need customization and thus provide a more costly production, this cost can be neglected due to that it takes part of the development of new products at the company. Repeatability is a main concern when testing ECUs and thereby prioritized over this additional development cost (QRTECH AB, 2015).

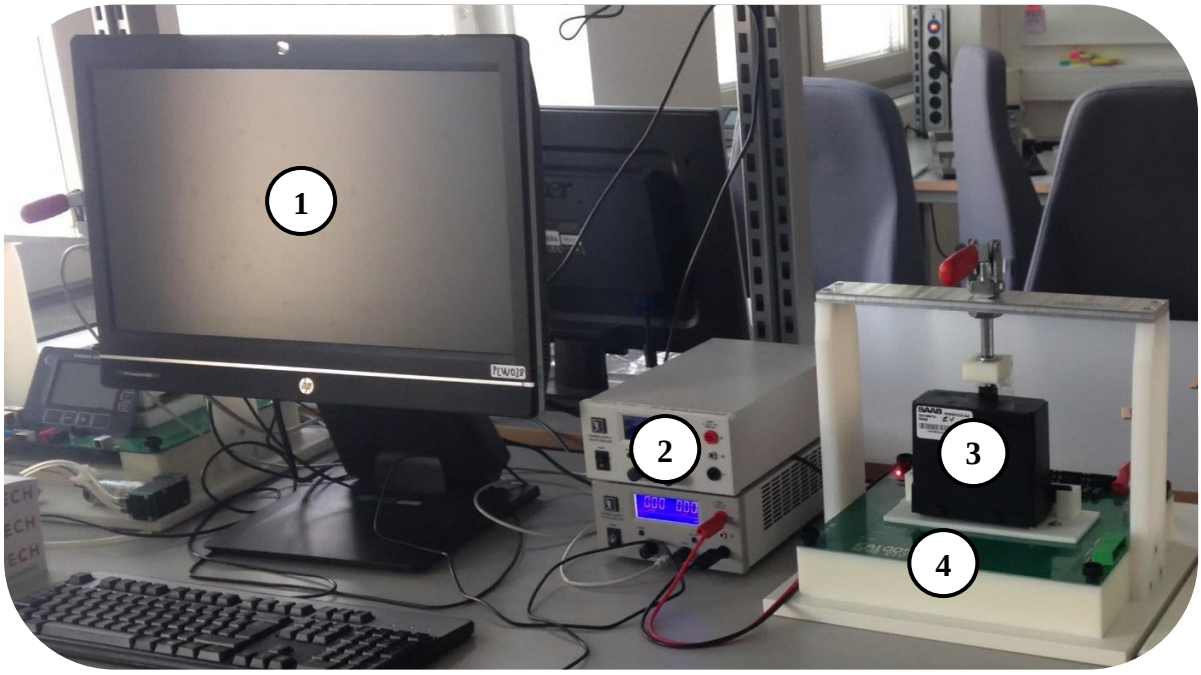

Figure 2: QTS used in end-of-line testing at QRTECH

Illustrated above in Figure 2 is a QTS used for HIL testing of finished ECUs at QRTECH, i.e., their end-of-line testing equipment. To the left (1) is a computer where the operator develops

and executes test scripts. This works as the main interface between the operator or user and the HIL test. To the right, the HIL Setup (4) is displayed, including both the Test Board and the specific Vehicle Load and Simulation setup. The ECU under test (3) is docked into place onto the HIL Setup. In between the computer and the arrangement of HIL Setup and ECU under test, are two power supplies (2) that may be connected to the HIL Setup if the simulation needs supply of electric energy for any of their loads. The only part not seen in this illustration is the Test Engine, the physical test machine. This is accessed when executing tests through connections to a server.

2.3 Requirements on Test System

Testing procedures for embedded systems are regulated by many stakeholders' requirements. The QTS, developed as a testing system for ECUs within the automotive industry, must follow the requirements of stakeholders including QRTECH, the automotive industry, suppliers, manufacturers, users of the QTS and others (for all stakeholders view Figure 3).

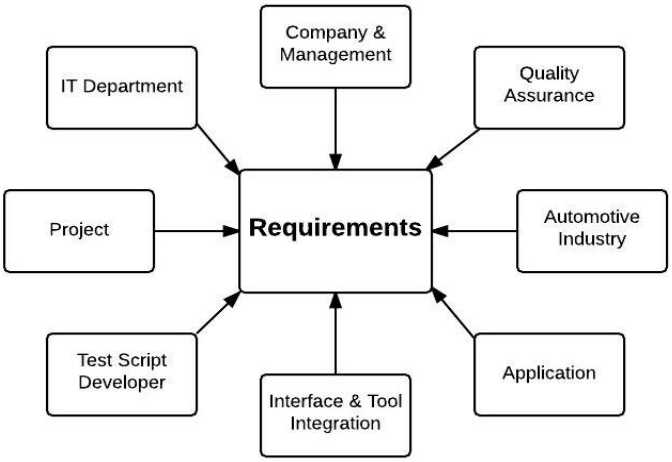

Figure 3: Stakeholders that affects the requirements of the QTS (QRTECH AB, 2015)

The company and management establish requirements such as the maximum costs, quality and time to market. These requirements then affects requirements that will be set by the IT Department and all the projects. For example, the IT department establishes how the setup and configuration should be designed and how the backup and archiving should work and the project's requirements concern software test reports, release time and low investment cost. One stakeholder is the Test Script Developer/ User of the QTS, this stakeholder sets requirements on usability, error reporting etc. In order for the QTS to function, it is important that it has a proper interface and tool integration. This means that the QTS has requirements in form of compatibility with requirements programs such as Elektra and modelling tools such as Simulink, to name a few.

The QTS is developed for the automotive industry which sets requirements on the hardware such support of standard interfaces and communication. However, if the QTS is used in an industry other than the automotive, other requirements will need to be met for that industry. There are also several branch standards that help provide quality assurance, these are for

example Automotive SPICE and ISO 26262 which contain requirements regarding software development processes and safety requirements for road vehicles. These standards provide requirements regarding for example traceability, worst case testing, etc. All stakeholders together provide a thorough requirements list covering different aspects of the development and usage of the QTS.

2.4 Current Market

The QTS was originally developed for testing ECUs within QRTECH's in-house projects, replacing and working as an upgraded version of a previous test system used for in-house projects. Initially it was used within the product development chain as well as final testing of end-of-line products. Since then, further development of the QTS has been part of ongoing in-house project.

QTS has been part of both development projects and end of line testing for ECUs developed by QRTECH as well as a few customers with projects carried out at QRTECH's office, mainly focusing on the automotive industry including both automotive manufacturers and suppliers. In these projects, there are possibilities of self-designed test cases as well as continuous improvement of hardware and software. Full test reports are created for each run, enabling full traceability and test documentation. In in-house projects, not only HIL testing is provided, but also MIL and SIL to cover the entire test and verification process for embedded systems.

Apart from in-house activities, the QTS has also been sold as end-of-line testing equipment for a few of QRTECH's suppliers of ECUs. On these occasions, the QTS has been fully customized to fit the requirements of the ECU under test. There is room for little changes to be made in those test systems due to that these production testing environments only need a black-box concept with start/stop functionality and no self-designed test cases.

The current market where the QTS is operating is thereby testing of ECUs within development and production for in-house activities, including both QRTECH's projects as well as customers' projects. Moreover, a few QTS's have been sold to QRTECH's customers for end-of-line testing of embedded systems targeting automotive, medical, offshore industries, etc.

2.5 Initial Business Model

The QTS works as a testing tool for QRTECH's development projects and end-of-line verification process, meaning that there were no original intentions of obtaining revenues from the system as a stand-alone product. By using the QTS to test and verify ECUs that are developed at the company, QRTECH can assure that the quality of their products are high and requirements are met. The revenues thereby do not directly come from the QTS, but from having the ability to deliver high quality products to customers and thereby obtain more

development and production projects. The value lies in what QRTECH can deliver to its customer with the help of a highly sophisticated ECU testing system.

As QRTECH provide their customers with the opportunity to have projects entirely at QRTECH's location, the QTS can be used as a selling point to obtain more projects. The projects can use the QTS for their testing of ECUs and have access to employees that are well educated with the test system. Both QRTECH's projects and customers' projects at QRTECH have the advantage of near location and eased communication between employees educated on the system. Problems can be solved fast and support is close at hand.

The main cost of the QTS is the engineering hours that are needed in order to develop and maintain the system's hardware and software. Also, costs of components and productions costs must be included in the total cost of a QTS. According to QRTECH, the QTS has cost approximately a 3 million SEK to develop up to this point (QRTECH AB, 2015).

It is difficult to estimate the revenue streams that the QTS provides QRTECH with. As the QTS can be used as a selling argument for embedded systems projects due to that it can provide quality assurance for the products developed, parts of the total revenue stream of all projects where the QTS is involved can be included.

In summary, one can say that revenues of the QTS are obtained mainly from using it in other projects and the QTS can thereby be used as selling point to obtain more projects. The customer segment is QRTECH employees using it in in-house projects. Costs include hardware components, development and maintenance of the QTS, which is partially sponsored by each project that the QTS is included in. Main resource needed is knowledgeable personnel using and developing the QTS.

3 Methodology

In this chapter the research and analysis methodologies used throughout the thesis is presented. The process is based on the concept of empathic design, feedback loops as well as the concept development funnel, both presented thoroughly in Chapter 4.2. An illustration of the process and its content can be seen in Figure 4.

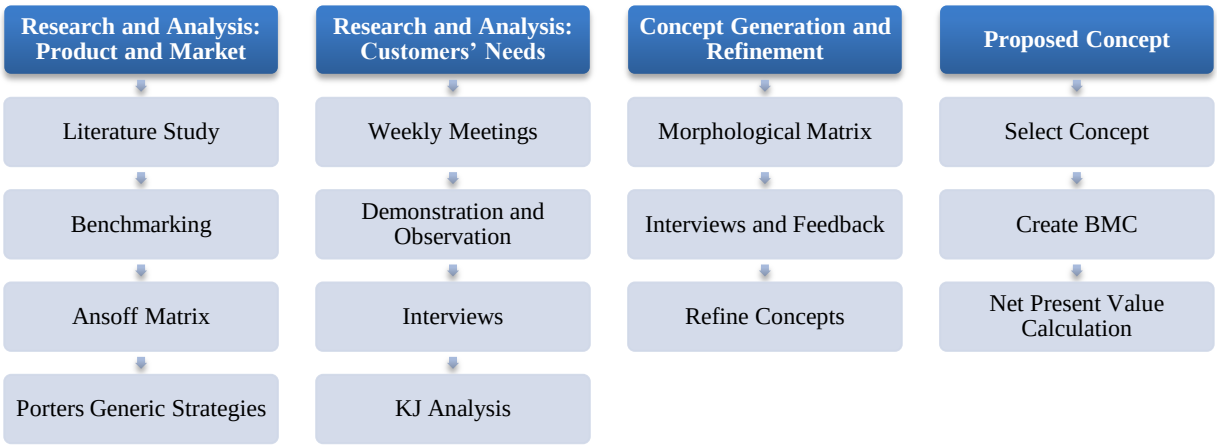

Figure 4: The methodology process of the thesis

3.1 Research methodology

The following chapter describes the research methodology used in the thesis in order to obtain information and data necessary for the execution of the project.

3.1.1 Literature study

A literature study was executed in the early phases of the project, gathering information regarding HIL test systems as well as business models for technical products and how to commercialize these types of products. Important in the literature study was to understand the product and explore the market where the product later would be commercialized for, as well as what competition the product would face once entering the market and what possible advantages and challenges there are with the QTS compared to competing, similar products or services. Search tools included Google Scholar, Chalmers Library and Chalmers Library's own search engine Summon for literature regarding business models, commercialization methodologies and HIL test systems, while Google's search engine was used in order to find information regarding competing products and current market trends

3.1.2 Weekly Meetings

Weekly meetings were held for the purpose of continuous feedback, with the following four representatives from QRTECH;

1. CEO and Sales Director
2. Products and Research Manager
3. Technical Product Manager and Founder of the QTS
4. Embedded Systems Design Engineer

These meetings were held in order to obtain direct feedback on the work done on a continuous basis. Discussions with regards to all phases of the thesis were held. Also, these meetings were used in order to gather more information regarding QRTECH, the QTS, competitive HIL test systems and potential interview candidates for further data collection, to name a few.

On each meeting, a PowerPoint presentation was prepared containing the agenda for the meeting and additional slides illustrating the work that had been done the previous week along with a plan for future work. If needed, areas of supervision were also prepared. Meeting notes were saved after each meeting.

3.1.3 Demonstration and Observation

Demonstrations of the QTS were held in the early stages of the project in order to obtain information and general knowledge regarding the QTS, its main parts and functionality. A demonstration of both the hardware and software interface as well as test runs were done in order to illustrate the multi-functionality of the product. A presentation of the requirements management process was also held in order to deepen the understanding of the company's processes as well as providing further information regarding the particular test system and how it is used at the company today. Some of the information obtained at these sessions is summarized and can be reviewed in the QTS description provided in Chapter 2.

Observations were made in order to obtain information regarding the product at hand as well as possible improvements to be made. Observations took place while current customer (internal customers working with the product on in-house projects) used the product, in order to obtain information that might be difficult for interviewees to remember at the time of an interview, for instance. Also, in order to gather data that only an observer can notice (Leonard & Rayport, 1997). A list of the Observations and Demonstrations that were made can be viewed below in Table 1.

Table 1: List of demonstration and observation participants

Position	Demonstration/Observation
Embedded System Design Engineer	End-of-line Testing
Technical Product Manager, Test System Founder	Development and End-of-line Testing, Process Description
Team Manager Engineering Electronics	Setup of HW Circuit Board

Several observations were also made during interviews held at companies, where participants showed their particular test systems in its operating environment (information regarding interviews can be read below, in Chapter 3.1.4). In this way, there were possibilities to look and examine similar systems while asking questions as they came to mind. This eased the

understanding of the test system described by the interview participants as well as challenges with the system could be noticed as it was used and displayed.

3.1.4 Interviews

Interviews were held in order to collect data that would support and guide the development of a business model for a HIL test system. Two iterations of interviews were held. The first iteration was held in order to gather information regarding customer needs and requirements, while the second iteration had the purpose of verifying and refining concepts that had been generated from the initial data that was collected from the first iteration. All interview participants and their specific interview type and iteration group can be seen in Table 2.

Iteration One
In advance, templates for each interview were prepared and can be viewed in Appendix A-D. A semi-structured interview model was used, due to that the outcome of the interviews were supposed to provide data regarding certain subject prepared in advance however still enable discussion possibilities. This was obtained by preparing open-ended questions in the interview templates, enabling qualitative answers (Bell & Bryman, 2003). All interviewees were asked if recording was a possibility so that as much information from the interviews were stored for later analysis. For a list of participants, see Table 2.

One session was made a group interview with three members of the same company. The same template was used, but more room was made for discussion among the participants. When doing group interviews, one must consider the quality of the data collected as participants may behave differently in groups. The participants may provide less honest answers or get influenced by other people in the room, which can result in misleading conclusions from the group interview (McQarrie, 2005).

Iteration Two
For iteration two, an open interview structured was used. In advance, illustrations of the concepts were printed out so that they could be presented to the interviewee during the session. The template (Appendix E) with questions prepared in advance consisted of only a few short questions that allowed for discussion regarding the concepts (Bell & Bryman, 2003). This iteration was used as a way of obtaining feedback on the work so far as well as collecting tips and thoughts from experienced personnel working at the company and working with the test system daily.

Interviewees
The interviewees for the research study were selected with support from both supervisors at QRTECH and Chalmers University of Technology. There were four types of interviewees; current users, potential users, other test rig users and sales department.

Current Users, also considered internal customers, were representatives from QRTECH that already used the QTS in their development projects or production tests. The information gathered from these interviews was focused on the knowledge and experiences one obtains

from using the product. Interviews with potential users were mainly held in order to obtain information regarding needs and requirements for the QTS as well as other aspects that could provide value to the product offering. Included in this category were the potential users of the product and the potential purchasing department that would purchase the product, both externally and internally. Other test rig users refers to interviews with companies developing similar systems or systems with similar strategies or business plans. Lastly, interviews were held with the sales department at QRTECH in order to explore the current sales and marketing strategies and business plan of the company.

Table 2: List of interviewees

Type of interviewee	Iteration	Position	Company
Current User	1	Team Manager Engineering Electronics	QRTECH
Current User	1	Embedded Systems	QRTECH
Current User	1	Engineering Software, Consultant	Company 1
Current User	1, 2	Technical Product Manager, Test System Founder	QRTECH
Potential Users	1	Manager IT	Company 2
Potential Users	1	Test Engineer	Company 2
Potential Users	1	Test Engineer	Company 2
Potential Users	2	Development Manager	Company 3
Other Test Rig Users	1	Engineering Systems, Consultant	Company 4
Other Test Rig Users	1	Department Manager: Test Engine and Test Lab	Company 5
Other Test Rig Users	1	System Developer, Consultant	Company 6
Other Test Rig Users	1	Software Developer, Consultant	Company 6
Sales Department	1, 2	Sales and Marketing	QRTECH

3.2 Analysis methodology

The analysis methodology used in the thesis will be presented in the following chapter. Analyzed by analysis methodologies is the data collected from research methodologies.

3.2.1 Benchmarking

In order to understand where the current product, the QTS, and how it is positioned compared to competing products from other companies, a benchmarking can be done. The main principles of executing a benchmarking are to map out the current product and compare the properties to competing products on the market. By considering the benchmarking result, there are possibilities to identify weaknesses of the current product and thereby also possible improvement areas (Coers, et al., 2001).

The information needed for this analysis was obtained from google searches of HIL systems and ECU test systems. Also, recommendations were given at company meetings. The information obtained from searches for different types of test systems for ECU testing were analyzed and put in a matrix in order to graphically display the differences of all the products. On the vertical axis, features and properties were displayed and on the horizontal axis the different test systems were listed. Each product obtained a color coded dot (if applicable) for each feature or property, indicating whether or not these were fulfilled. A green dot indicated fulfilled property or desired quality, while red indicated that the feature or properties were not fulfilled.

3.2.2 Analysis of Growth Opportunities

The Ansoff matrix was used as a method for identifying what type of market growth opportunities QRTECH could achieve with the QTS, by identifying what product-market alternative the QTS would be categorized as. According to Ansoff, there are four different types of market growth opportunities: Market penetration, market development, diversification or product development (Ansoff, 1957). More information regarding the Ansoff matrix can be seen in Chapter 4.1.

In order to identify what type of strategy to use for achieving competitive advantage and thereby market growth, Porter's generic strategies was used. According to (Porter, 1980), there are four types of strategies; cost leadership, differentiation, cost focus and differentiation focus. More information regarding Porters Generic Strategies can be seen in Chapter 4.1.

Identifying the product-market alternative and strategy to achieve market growth for QRTECH and the QTS was done by looking over the information obtained from observations, demonstrations and meetings. Information regarding the company as well as the product had to be considered in order to make a suitable choice regarding both the Ansoff matrix and Porter's generic strategies.

3.2.3 KJ Analysis

The data collected from interviews were analyzed using the KJ analysis, which allows for large amount of data to be organized and displayed in an effective way. This method is a bottoms-up strategy, initially focusing on details and moving towards problem levels step-by-step. It is part of the seven tools of quality management (Karlsson, 2011). The analyzed data was used for two purposes; identifying possible changes to be made in the product and identify information for the concept to be developed to fit the business model for the QTS.

The KJ analysis is done by writing down important statements collected from interviews on post-its and placing them on a board or a sheet of paper. The placement process is organized so that a first post-it is placed in the middle of the board, building a group or category. The next post-it is placed either by the first post-it if there is a recognized similarity or by itself, creating a new category. The process is repeated until all post-it notes are placed on the board.

When this is done, groups or categories can be recognized. There might be necessary to cluster groups together, creating larger groups. Finally, the groups are named (Karlsson, 2011).

When using the KJ analysis, the different interview categories were marked by using different colors of post-it notes, so that it was easier to recognize where the information was obtained. This allowed for further understanding of customer needs, if there were a need from multiple sources or only occasionally mentioned. The result was originally written on post-it notes and put up on a wall. An illustration of what this can look like can be seen in Figure 5. The result of the KJ analysis was then documented using PowerPoint post-it notes.

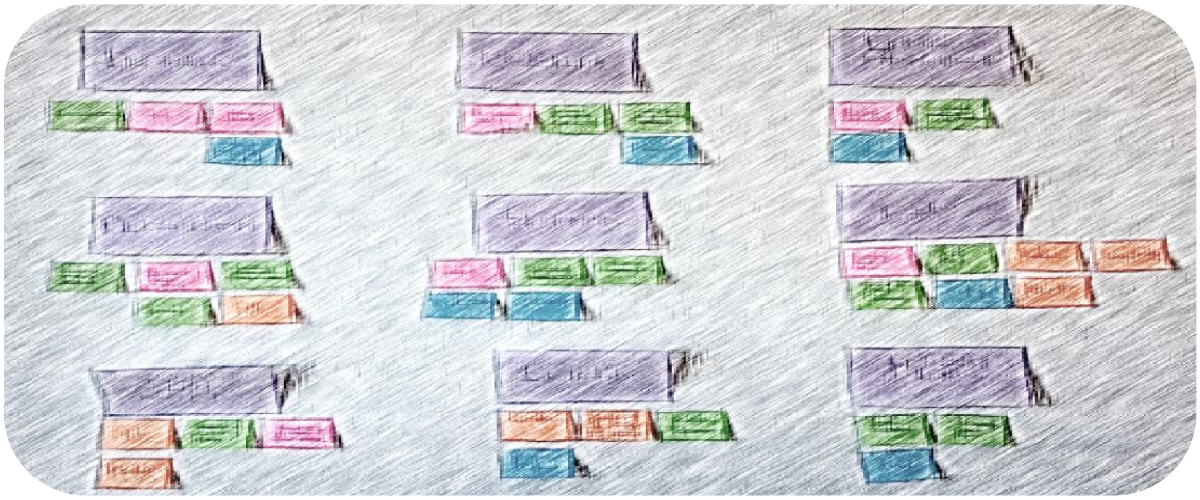

Figure 5: KJ analysis using color-coded post-it notes

3.2.4 Concept Generation

A morphological matrix was used in order to generate concepts in a systematic way. By using this tool, there were possibilities to generate a large number of concepts by exploring alternative solutions to sub-systems and combine these so that the concepts met customer needs in different ways. The concepts generated in this process were concepts that would support the commercialization of the QTS, and thereby also the business model to be developed for the QTS.

The process followed to create the morphological matrix followed guidelines of (Silverstein, 2008). First, the actual problem is to be described. This was done prior to the start of this method. The different sub-systems were identified using information obtained from interviews and observations. All sub-systems were put in a row in the matrix. Each column in the matrix has different alternatives or solutions to the parameter or sub-system. Each column was not completely filled, but as many alternatives as possible were listed after each sub-system. By combining one alternative from each row, a concept was created. Once a suitable amount of concepts were generated, all of them were analyzed. An illustration of the process of generating concepts using morphological matrix can be seen in Figure 6.

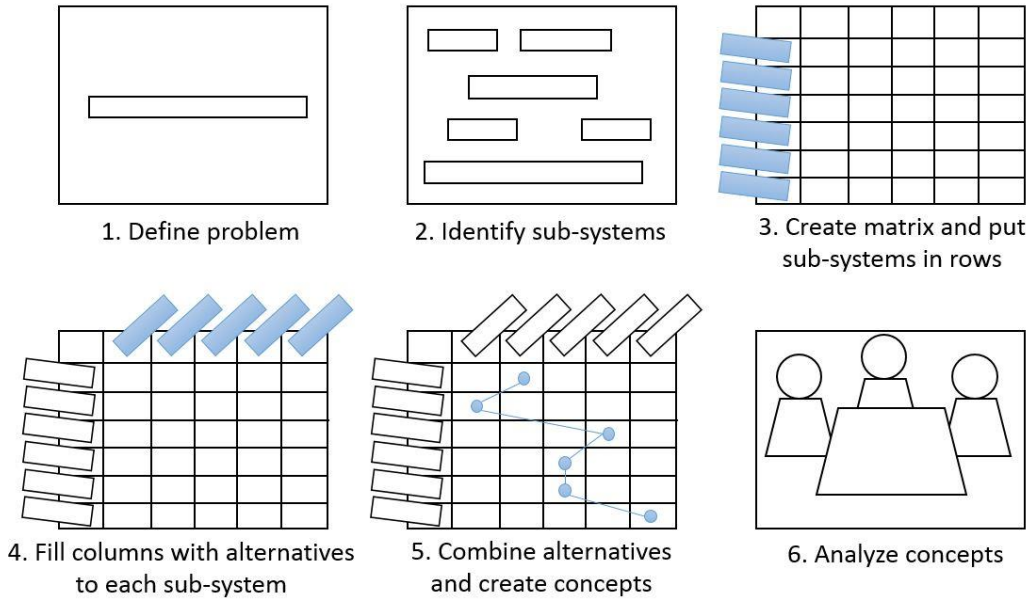

Figure 6: The process of generating solutions using a morphological matrix

3.2.5 Concept Evaluation and Selection

The evaluation and refinement of all concepts created by the morphological matrix was done by consulting QRTECH's personnel in weekly meetings and other discussions. Concepts were illustrated so that it was easy to understand what was included in each concept. The feedback was used to refine and generate new concepts. As this was done, interview iteration two was executed, where the refined and newly generated concepts were considered and given feedback. The second interview iteration gave enough input to select a suitable concept to go forward with. Time was spent on refining and develop the chosen concept. Throughout this process, input was received at meetings.

3.2.6 Business Model Canvas

A business model canvas (BMC) was used in order to create a business model for the QTS. First, an initial business model was established, using the business model canvas methodology, of the QTS mapping the model initially used when the project started. Information was obtained from weekly meetings, demonstrations and observations.

A second, final BMC was created containing the business model that under this thesis have been refined and redeveloped to fit the actual needs of the new, extended market segment. The business model was based on the concept that was selected as a final concept, the concept proposed to be used as commercialization concept.

A BMC contains nine building blocks; key partners, key activities, key resources, value proposition, customer relationships, channels, customer segments, cost structure and revenue streams (Osterwalder & Pigneur, 2010). For a thorough description of each building block, view Chapter 4.3. Each building block was created and described with the proposed concept

in mind, resulting in a complete description of the business model to use when commercializing the QTS.

3.2.7 Net Present Value

The net present value is a simple tool to estimate if an investment will be profitable and to evaluate if the investment should be made or not (Lee & Lee, 2006). In this project it was used to validate that the new business model against the original business model. The different costs for further development and production costs were estimated as well as the prices and was put into the model. For further information regarding how to estimate the net present value, see Chapter 4.4.

The calculations were made with data estimated for two fictive cases. The first case represented a scenario where the test system is sold to in-house customers, i.e., an example of how it looks today. The second case represented a ramp-up in sales, both internal and external sales of the QTS. Both cases are fictive and may only be viewed as examples of how it may look when selling the QTS, regarding both quantities, costs and prices. This due to confidential material.

3.3 Reflections on the Process

This chapter provides reflection on the process used in this thesis regarding the methodologies used and the results obtained from these methodologies. Special focus is put on validity and the reliability.

3.3.1 Reliability

Due to that only one methodology did not fit the purpose of this thesis, a combination of a few methodologies were used; the development funnel, empathic design and feedback loops. All of the methodologies used had their founding's in customers' opinions and knowledge in combination with theory to identify customer needs. Since the test system is to be used by customers, their opinions are of great value to the development process and thus this combined process is well suited.

The research methodologies used can be extended by interviewing and observing more customers and users of the QTS or other similar test systems. The amount used in this thesis was considered enough due that it targeted multiple types of users and customers, as well as a lot of input was obtained from meetings so a continuous feedback process provided new information. The information obtained from these interviews and observations have contributed to high reliability due to that four different groups of interviewees were questioned and their answers pointed towards the same issues. Of course, there is a possibility of missing out on valuable information due to the limited amount of interviews and observations made, in result of the limited time of the thesis. For instance, contact with purchasing department of potential customers may have resulted in further understanding of

how to package and sell the QTS, such as price range, which would have contributed to higher reliability.

Developing a business model may be done in many ways, however the theoretical finding regarding systematic ways of creating a business model implied that the most important thing is to create a business model systematically and the model used is of less importance. The outcome may slightly vary depending on the model used, but the overall business model would with high probability be more or less indifferent.

3.3.2 Validity

When it comes to validity, the main factor is the input which as been obtain early in the thesis so that the right methodologies and tools have been used. At the project start, there was a lack of information regarding the test system as a product. No product documentation existed, which led to a slow start up process. Lack of valid information regarding the test system has of course affected the project both time wise as well as how the project scope was interpreted. Moreover, no previous knowledge regarding HIL test system was possessed. This factor may also affect the validity of the project, the project scope and the assumptions that were made early on in the process regarding methodologies. If more knowledge regarding the test system was possessed earlier in the process, more valid questions might have been asked to the interviewees during interview sessions. This information might have affected other methodologies as well, such as the benchmarking and the literature study. Overall, the information obtained from the research and analysis methodologies have been useful and pointed towards the same issues, coming from multiple directions, so the validity of the results are satisfying. The validity would have been assured to a larger extent if more time was put on executing the actual methodologies and analyses, rather than spending a lot of time researching the product functionality.

Calculating profits for the test system according to the accumulated profit and NPV gives an understanding of how much the cost are when selling it to customers as well as it gives an estimate of the payback time and whether or not the investment pays off. The comparison of the two cases provides a reasonable argument for the financial changes that can be achieved with a commercialization of the QTS compared to remained in-house sales. The two cases are as mentioned examples, thereby the actual profits are not granted. A more valid prediction of the profits can be obtained if estimating costs more accurately and deciding upon a reasonable price. Due to confidentiality reasons, higher accuracy regarding the predictions of costs and revenues were not presented in this thesis. Thereby the company must make these calculations themselves in order to obtain higher validity.

4 Theoretical Framework

Following the theoretical framework for the thesis is presented. It walks through the initial phase of identifying the opportunities for growth within a company and for a product or service. This is followed by theory regarding how to generate concepts and evaluate them systematically, so that they meet customer needs. Lastly, how a company can create their business model in a structured way so that the growth opportunities can be achieved. All this in order to increase the understanding of how a product and its business model must meet customer needs in order to be successful and thus provide a company with market growth.

4.1 Growth Opportunities

There are many ways for a company to gain market share. It is crucial for companies to consider what strategies to use in order to stay competitive on the market and provide customers with highly sophisticated products meeting customer and market needs. The Ansoff matrix, named after and created by H. Igor Ansoff, describes and clarifies different ways for companies to expand their business by developing products or targeting new markets. The four product-market alternatives described by (Ansoff, 1957) are illustrated in Figure 7.

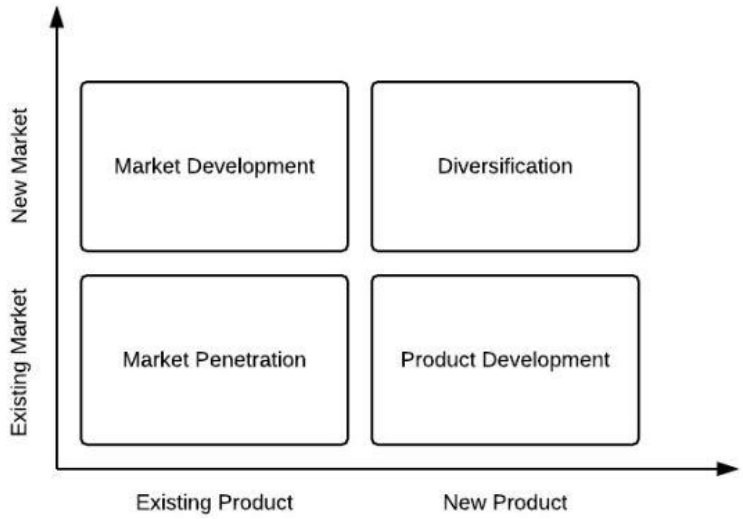

Figure 7: The Ansoff matrix

Identifying which of the product-market alternatives to aim for may help companies focusing on tasks as well as realizing what risks comes with each of them. According to (Ansoff, 1957) the four alternatives can be described accordingly:

Market Development
A company introduce an existing product to a new market. Business is improved by adapting present products to new missions set by the company, normally by modifying existing products so that they fulfil the new missions.

Diversification
A company introduces an entirely new product to a new market. This kind of market growth is the most risky one, since it includes departing from the present product line as well as the present market.

Product Development
A company introduces a new product to an already existing market. The products are developed to aim for new characteristics in order to boost performance, while still retain the current mission set by the company.

Market Penetration
A company introduces an existing product to an already existing market. Growth is achieved by either increasing volume of sales or search for new, potential customers.

The fundamentals of the matrix provided by Ansoff is rather simple, however focuses on an issue that all organizations have to manage. Products launched to the market will always be either new or be part of an existing offer, as well as the market to launch the product on to will either be new or an existing market (McDonald & Meldrum, 2013).

The Ansoff matrix is one way to describe market growth and compete with their competitors; another is Porter's Generic Strategies. The idea is that a company can choose between two kinds of competitive advantage; low price or differentiation. Another choice the company needs to make is what competitive scope they want; to focus on a narrow market or a broad market (Porter, 1980). As seen in Figure 8, there is a scale for both these choices. It is not recommended to try being in several of these boxes and thereby be stuck in the middle. Although it is not impossible, it is often easier to succeed if one area is focused on.

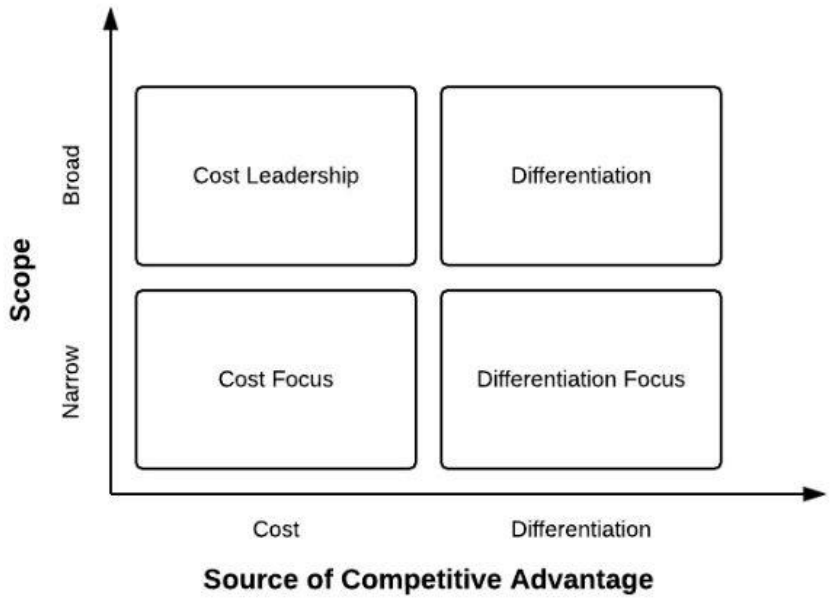

Figure 8: Porters generic strategies

Porter's generic strategies as described by (Porter, 1980) contain four options: cost leadership, differentiation, cost focus and differentiation focus.

Cost Leadership
The competitive advantage of cost leadership lies in having competitive prices, or the right price for the value ratio. Larger companies may achieve this by economy of scale.

Differentiation
Differentiation is all about creating products that meet a need that is not currently fulfilled, by having access to patents, expertise or special materials or manufacturing methods no other company possesses.

Cost Focus and Differentiation Focus
Cost leadership and differentiation are most beneficial for larger companies, while cost focus and differentiation focus suite small companies that have no intention of competing on a large scale. Both categories suite a narrow market, a niche market, where the product can be tailored to meet the needs of certain customers by either offer a low price or differentiate.

4.2 Customer Needs Mapping and Concept Generation Processes

When developing new products and services in order to obtain commercial success, one of the main challenges is exploring the actual need of customers so that those could be used when searching for solutions. An approach to finding the needs of customers are interviewing potential customers in order to find out what their product requirements are. In many cases, however, customers are limited to their previous experiences and their imagination. Thereby, interviews alone could limit the outcome of the research and thus limit the innovativeness of the developed product or service (Leonard & Rayport, 1997). It is therefore crucial to find processes which support the search of customer needs so that solutions are created and further developed to meet the exact requirements and wishes of the customers.

4.2.1 Empathic design

One way of handling the complex task of finding accurate needs of customers is to use empathic design. This process has its foundation in observation: to gather, analyze and apply information from observation taken place in the customers' own environment. Not only gather information from texts and numbers, but take into account visual information as well. This way a company obtains knowledge regarding critical customer needs, but to a very low cost and low risk. It allows for companies to redirect capabilities in order to create new business. This method can be seen as a complementary technique to traditional market research; it does not replace market research but contribute to a flow of innovative ideas in need of further testing (Leonard & Rayport, 1997).

The process of empathic design may vary between users. According to (Leonard & Rayport, 1997) the process commonly consists of 5 steps, as can be viewed in Figure 9.

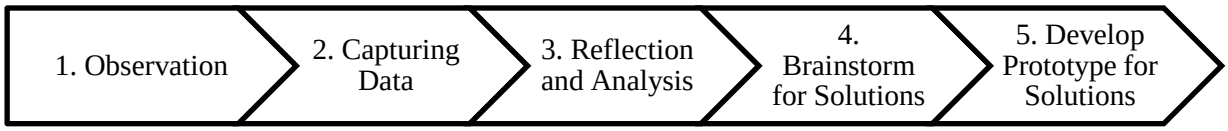

Figure 9: The process of empathic design

1. **Observation**

This step consists of deciding upon who to observe and what to observe, usually a daily routine where issues or problematics can be noticed that originally is not noticed by an operator or user. Also, who should be the observer is important to decide upon, since diversity effect the data extracted from different scenarios.

2. **Capturing Data**

In this step of the process it is important to stress the usefulness of observing over inquiry. Information is gathered from visual, auditory and sensory cues, with additional open-ended questions to go with each scenario. Tools to ease this process can for instance be video recordings.

3. **Reflection and Analysis**

By reflection upon the information gathered and discuss in groups to obtain and share observations made by yourself and others, possible customer needs are identified. It is important to never leave out anything, and to include all possible problems identified through the observations and inquiries. The needs identified in this step can for instance be translated into a requirement specification.

4. **Brainstorm for Solutions**

In this part of the process, ideas founded by observations executed earlier in the process are transformed and turned into solutions which then are graphically and visually presented. The brainstorming session enable ideas and solutions to pop up both during the session and afterwards.

5. **Develop Prototypes for Solutions**

Prototypes are a very important part of the empathic design, due to that it clarifies the concept for the development team as well as it can be shown to customers and others involved with the project. Prototypes can be created in various forms and must not illustrate the entire product, but could consist of a single functionality, a shape or a simulation.

As mentioned, empathic design is only a complementary tool in order to map the needs of customers and find solutions to meet those needs. If combined with other research methods and processes of generating concepts, the result will have great potential of being very accurate to what customer demands of new products and services.

4.2.2 Needs Mapping and Concept Development

One of the processes that can be used in order to generate concepts is the concept development funnel (Figure 10). Prerequisites for this process are to already have established the needs of the customers and have created a requirement specification. This can be done, as mentioned earlier, by interviewing and observing customers and analyze the obtained data using clustering methods. Once customer needs have been explored and transformed into customer requirements and wishes, the concept development process can start. According to (Ulrich & Eppinger, 2008) the concept development funnel is described by the following groups; concept generation, concept screening, concept scoring and concept testing. The process is supposed to be iterative, where concepts are constantly reviewed, further developed and refined or eliminated if proven unsuitable for meeting customer requirements (Ulrich & Eppinger, 2008).

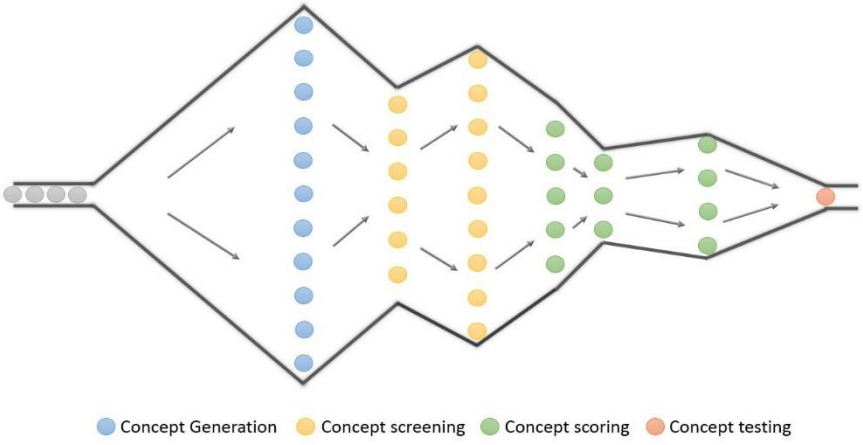

Figure 10: Concept Development Funnel

In the concept generation phase, solutions are created using information obtained from brainstorming sessions or other discussion sessions. Solutions are created to meet customers' requirements and demands, which are based on findings from interviews, observations and literature. When finding solutions it is important to consider all kinds of solutions that solve the problem at hand. There are tools that help generating solutions, in a systematic way, including the morphological matrix (Ulrich & Eppinger, 2008).

Once concept have been generated, it is necessary to screen and score them. This also needs to be done in a systematic way with customer needs in mind. Helping tools for this part of the process include the elimination matrix, the Pugh matrix and the Kesselring matrix. What these screening and scoring matrices have in common is that all of them are constructed with the requirements specification in consideration, and evaluate each solution according to how well a solution fulfill all wishes and requirements. Throughout this part of the process there are possibilities to change, mix, refine and create new solutions as information come along (Ulrich & Eppinger, 2008). The most suitable solution is thereby not limited to the ideas

obtained in the early stages of the concept development process, but could be discovered later when more information has been gathered and processed.

4.2.3 Feedback loops

Once one or more concepts are generated, it is important to consider feedback from customers. Not only can interaction with customers provide useful help regarding the needs of a product before a concept generation, but can also provide useful feedback on what is developed or intended to be developed. According to (Ries, 2011) ideas are hypotheses, what entrepreneurs think or assume a customer want. In order to know if the generated idea is wanted or create value for customers, it must be tested as quickly as possible. This can be done by either interviews, observations, experimentation or tests. It is important to understand and know the customers in order to provide services and products to them. (Ries, 2011) states that one must "*get out of the building*", meaning that information regarding customers, markets, suppliers and channels are gathered outside of the office. Hypotheses must be turned into facts. According to (Blank & Dorf, 2012), companies with existing customers tend to stick to classic product development methods leading to fully developed products without having to ask customers what features they really want. Advice is given to startups, however, to go out of the office and get to know the customer and thereby understand what types of products or services they want. (Blank & Dorf, 2012) argues that no business plan survives the first contact with a customer, thereby the necessity of getting to know customers to constantly improve an idea. A company developing for a new market can as well consider this type of approach in their processes for obtaining market growth.

4.3 Business Models

A business model's main goal is to describe what an organization creates and delivers in order to create value for customers. It should be easily understood and enable discussions, thereby be both simple and understandable while still describing complex functions of an enterprise in a relevant manner. According to (Osterwalder & Pigneur, 2010), the four main areas of a business model include customers, customer offers, infrastructure and financial viability. There are many types of business models, all describing these four areas. According to (Muehlhausen, 2013) business models all have a common ground no matter if the model is based on a 100 year old principle or is recently published. All business models should include a description of the problem to solve, whose problem to solve and how the particular solution stands out from other offers solving the very same problem. Moreover, (Muehlhausen, 2013) argues that a business model should contain information regarding the particular value proposition, where the offer is placed on the value chain and what the revenue model looks like. The competitive strategy must also be considered; how the offer differentiates from other offers on the same market and how the offer will remain different. Finally, (Muehlhausen, 2013) mentions to consider partners and complementary products to go with the offer as well as what networking effects that can be harnessed.

Traditionally, business models have been created by imitating existing, successfully working business models and copying into another industry or simply just go with an idea and let the business model fall into place as the idea develops. Not all planned activities turns out successful, however planning the business model may help evaluating not only the obvious factors that immediately comes to mind but also the finer points. Recently, more structured ways of creating business models have emerged. Three examples are business model canvas (BMC) created by Alexander Osterwalder and Yves Pigneur, four-box business model by Mark W. Johnson and business model wheel created by The Business Model Institute (Muehlhausen, 2013). These methods for creating business models have a common ground of answering the above mentioned focus areas. They do however differ from one another. For instance, the BMC work very well in group sessions or brainstorming sessions while the Four-box business model highlights the interplay between factors to a larger extent. The business model wheel is more practical, while the other two have a more theoretical approach (Muehlhausen, 2013). In this thesis, the BMC was used and thereby a thorough description of this method is provided.

A BMC is a tool that in a structured way creates and develops a business plan. The BMC allows for an easy way to get a holistic overall understanding of the business model by describing, visualizing, assessing and constantly changing the current model. The canvas consists of nine basic building blocks (Figure 11) that together build a business model covering the four main areas (Osterwalder & Pigneur, 2010).

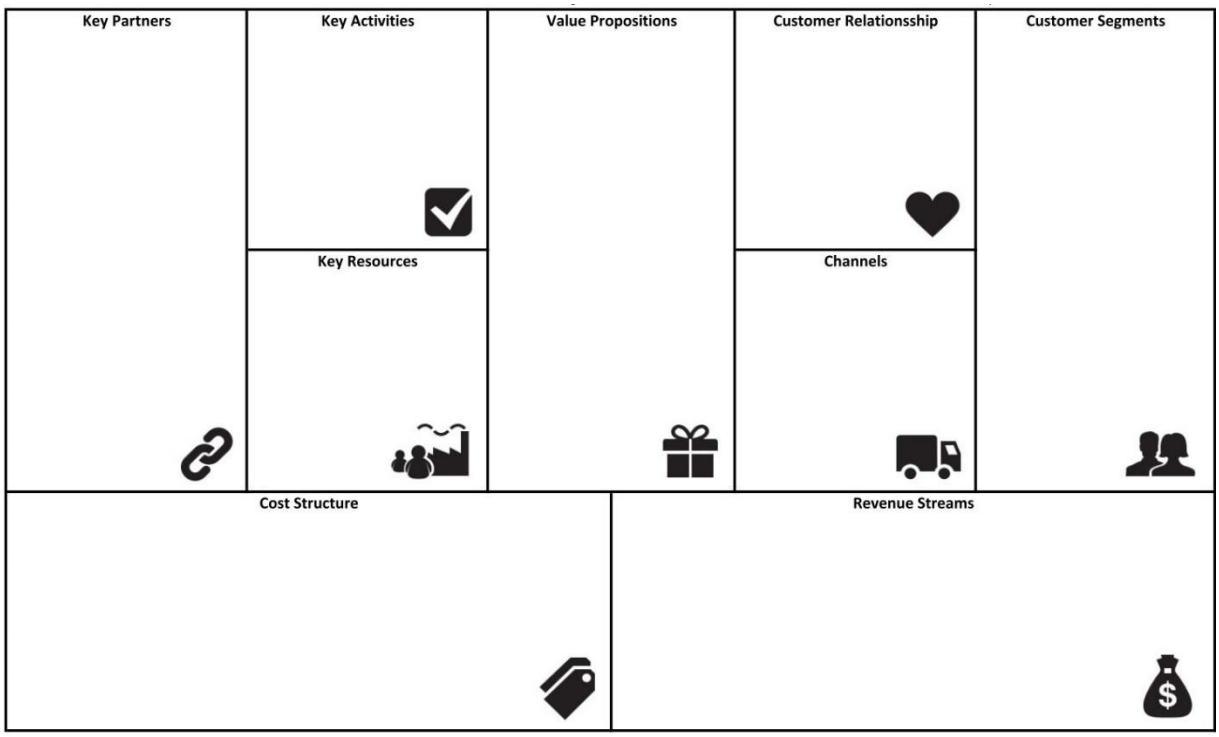

Figure 11: Business Model Canvas

(Osterwalder & Pigneur, 2010) describe the nine basic building blocks of the Business Model Canvas accordingly:

Customer Segment

Included in the customer segment building block are all organizations and groups of people a company aims to target with the decided product, service, etc. All customers should be placed in a segment depending on what needs, behaviors and other attributes they have in common with other groups or organizations. Same attributes are part of the same segment. Important is to decide upon which segments to target and which segments to ignore, since it is not viable to target all at once. Depending on what type of business model a company aims for, the customer segments may vary quite distinctively. For instance, if a company targets a mass market a quite large group is focused on and thereby all customers are part of the same segment. On the other hand, if a company targets niche markets the customer segments are very specific and specialized in order to be tailored and meet requirements of that particular niche market. In order to ease the process of deciding customer segments, one can try to answer for whom the product or service is creating value and what customers are the most important ones.

Value Propositions

This building block describes what services and products that create value for the customer part of the customer segments. The value proposition should meet a certain need or requirement of a customer, solve a problem or issue, and thus create value. Examples of this could be innovative, new products or incremental changes to existing products. Creating value for customers include performance, customization, cost reduction, usability and many attributes. Important to focus on is the value delivered to the customers, the customer needs that are satisfied and the problems that are actually solved.

Channels

Channels is one of the building blocks that serves as a link between the value propositions and the customer segments. It describes how to communicate and reach customers, so that a value can be delivered. Among many things, the channels function as help regarding awareness about a company's products and services, allowing customer to purchase products and services as well as post-purchase support and maintenance and of course delivering the actual value. Channels can be direct or indirect as well as privately owned and partner owned. There are many important aspects to consider when it comes to channels to distribute products and services. For instance, it is of importance to figure out which channels customer actually want to be reached and how they are integrated with a daily routine. There are also important to consider efficiency and costs of different channels in order to maximize revenues.

Customer Relationship

The customer relationship building block establishes what type of relationship the company should maintain with its customers. This could vary depending on product or service, and range from very personal assistance to fully automated services. Since the customer experience is very much influenced by the relationship established by the company, this building block is very crucial. A company must consider both what type of relationship they actually want to withhold with different customer segments but also they need to consider meeting customer expectations. Of course, different types of assistance and service are costly and thereby a trade-off must be made so that it fits with the rest of the business model.

Revenue Streams

The revenue streams building block consists of all revenues generated from customers. This can include payments from one-time customers or ongoing payments from continuous delivery of value proposition or post-purchase support. Generating revenues can be managed in multiple ways, but the right price for the Value Proposition is crucial for success. One must find the price customers are willing to pay, but also consider what they might pay today for a similar Value Proposition from another company. Payment methods include subscription fees, selling ownership, usage fees, advertising and leasing agreements, to name a few.

Key Resources

The key resources are the resources an enterprise needs in order to deliver the value proposition to its customers. Key resources make a business model work, without them no customers could be reached nor could any products or services be provided. Examples include financial, physical, intellectual or human resources, but must not be owned by the company itself. For instance, key resources can be acquired by partners. Resources are needed in order for the other blocks to be fulfilled. Not only for creating value for customers, but enabling customer relationship, revenues and different types of channels. Important to consider is what resources are required in order to fulfill the business model with all its building blocks.

Key Activities

A company must execute activities in order to make the business model work and these activities together make the key activities building block. Similar to key resources, the necessary actions taken by the company in order to operate successfully provide the company with products and services to offer customers and it enables the company to reach the market and maintain customer relationship. Key activities include production and problem solving activities. Companies must consider what type of activities that are needed in order to offer value propositions to its customers, but also what is required in order to maintain channels and relationship between company and customer.

Key Partnerships

Key partnerships include alliances, suppliers, joint ventures and others, which contribute to optimization, risk reduction and resources. In many cases, there is a need for partnership in order to successfully launch a product or service on the market due to that in most cases one single company does not have all resources required. Partners therefore include all partners as part of the network making the business model work. When deciding upon what key partnerships should include, one must consider who the most important suppliers and partners are, what key resources that must be required from the partners and which key activities that the partners perform.

Cost Structure

The cost structure building block describes all costs that are included in operating a business under the specific business model. All parts of the business model will generate costs, however some models are more cost-driven than others. Many times, one describes the two extremes: cost-driven and value-driven cost structures. Business models are often not in any

end of these two extremes, but somewhere in between the two. Apart from these two extremes, the cost structures are divided into four different characteristics; fixed cost, variable cost, economies of scale and economies of scope. Successful business models have of course a balance between revenue streams and cost structure so that the earnings are maximized. Achieving this include figuring out which costs that are the most important and what resources and activities are most expensive within the business model.

4.4 Return of Investment

There are many methods that can be used to calculate the profitability of a project or an investment. All these estimate a potential profit in different ways, all of them provide calculations that may ease the understanding of whether or not the project will be profitable. Examples of these include break even analysis, payback method and net present value (NPV) (Lee & Lee, 2006).

Often desired is the amount of years until an investment pays off, i.e., the payback time on an investment. This can be calculated using accumulated profit. Starting with the year at which an investment is made, each following year's profit is added. The accumulated profit for a certain year describes the net profits which it not paid to shareholders, as of the beginning of the year. Once the accumulated profit exceeds zero, the investment has paid off (Law, 2014).

The present value (PV) is an estimation of the value a future investment, cost or revenue would have today, calculated with regards to the discount rate, i.e., the expected rate of return of an investment or cash flow. It can be used to compare and add cash flows that occur at different times and is the basis of the NPV calculation (Lee & Lee, 2006). The formula for calculating the PV is as follows:

$$PV = \frac{CF_n}{(1+r)^n}\text{, where}$$

$$PV = Present\ value, CF = Cash\ flow, r = Discount\ rate, n = Period$$

NPV is an estimation of the investment's and all cash flows' value today, calculated by estimated the current value of the investment and all profits with regards to the discount rate for the total project life span. The result indicates whether or not to make the initial investment. The rule of thumb is to make an investment if the NPV is positive (Lee & Lee, 2006). Following is the formula for calculating the NPV:

$$NPV = -CF_0 + \sum_{i=1}^{N} \frac{CF_i}{(1+r)^i}\text{, where}$$

$$NPV = Net\ present\ value, I = Initial\ investment, CF = Cash\ flow,$$
$$r = Discount\ rate, N = Project\ life\ span$$

5 Empirical Findings

The following chapter provides the empirical findings obtained from interviews and observations held at QRTECH and at QRTECH's customers.

5.1 Initial Business Model Canvas

In order to compare the initial business model and the new business model generated from this project, a BMC was mapped out for the existing business model for the QTS at an early stage of the project. The findings of each BMC building block are based on discussions and documentation gathered at QRTECH in an initial state of the thesis. Findings are explained below and an illustration of the canvas can be seen in Figure 12.

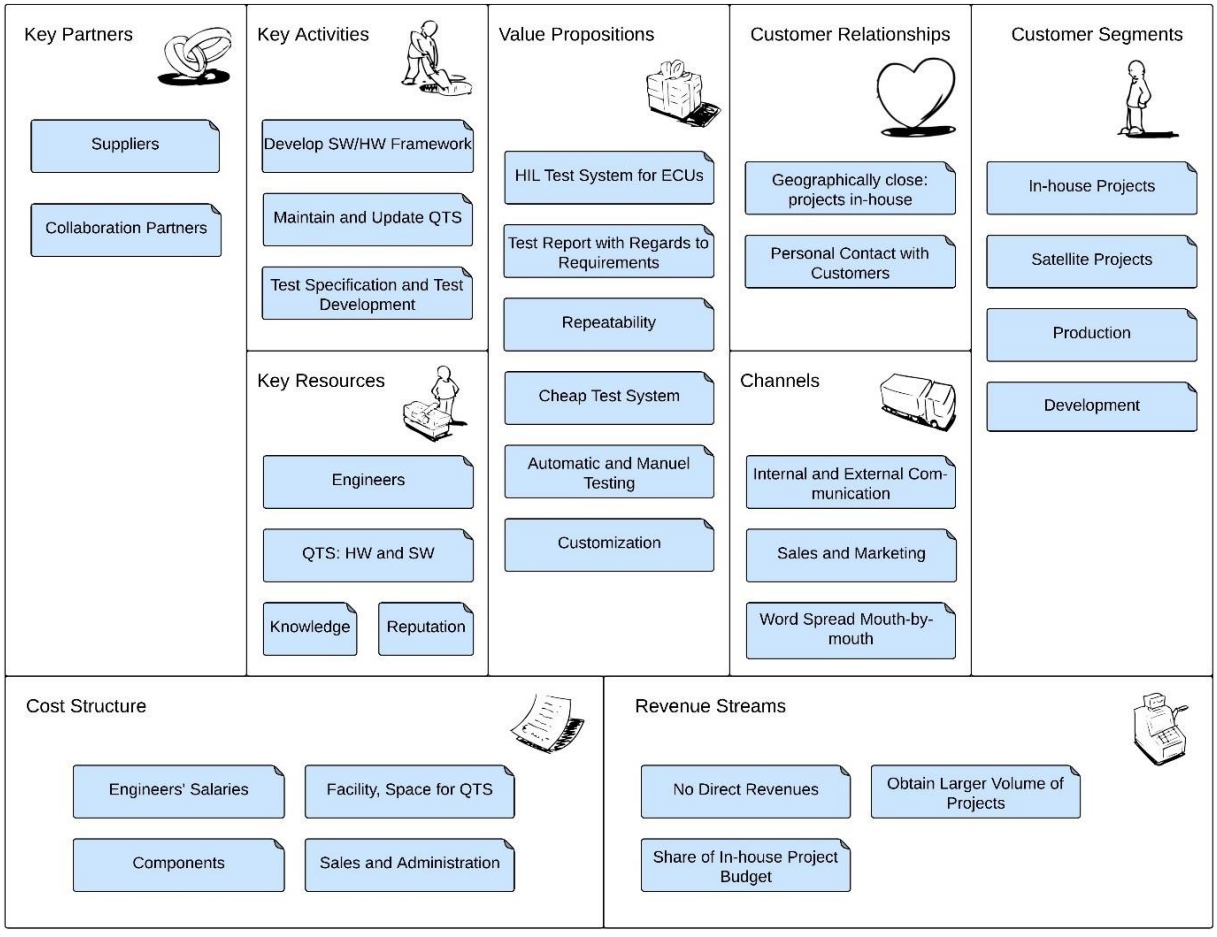

Figure 12: Business Model Canvas describing the initial business model

Value Propositions

The main value proposition in the QTS is that it allows for HIL testing of ECUs with regards to the requirements. The automatically generated test report is of high value to the customer as it saves much time and presents both details as well as a summary of the results from the test. The possibility to repeat tests with the same prerequisites and parameters as previous tests is also a value proposition for the customer. The QTS can perform both automatic and

manuals tests, during both the development and the end-of-line phase to a low cost, which adds value for the customer. Another important value is the possibility to customize the QTS so that it fits the actual need of the customer.

Customer Relationships
The customer relationships in the original BMC consist mostly of in-house relationships as the rig is used only in-house. This allows for a close relationship as the customers easily can just walk across the hallway and talk to the developer in order to get help and answers. The developer can also fix bugs and other problems in the system when they are found.

Channels
The channels that customers are reached through are for the most part the sales department. The customers already have business with QRTECH and the sales department sells the QTS as an extra feature. Information regarding the QTS is also spread to customers mouth-to-mouth.

Customer Segments
The segments in the original business model are mainly in-house customers that use the QTS both for development and for production testing. There is also one smaller customer segment which include the projects that are collaborations with other companies.

Key Partners
The suppliers of electronics components as well as the collaboration partners are the key partners in the original BMC. Since most is developed in-house, there are only a few key partners.

Key Activities
The most important activities in order to fulfill the value propositions are developing both hardware and software in order to keep the QTS up to date and maintained. Key activities are to write test cases and set up specifications for customers. It is also important to teach users how to use the QTS and how to write test scripts to match the ECU under test.

Key Resources
The key resources needed are the engineers developing the QTS and of course the QTS itself, its hardware and software. Another important resource is the established customers and the good reputation the company possesses.

Cost Structure
The main cost for the QTS is the development costs, the facilities and to some extent the components and the administration.

Revenue Streams
Currently the QTS does not have any revenues of its own. It does however contribute to an increased amount of projects for the company as well as it decreases the cost for recalls of all produced ECUs that have been tested due to quality assurance with regards to requirements.

5.2 Observations

Observations were made of the QTS as part of both the development projects and end-of-line testing procedure. Three main areas to consider were found when observing; usability and hardware. Following are the findings with regards to those two categories.

Usability:
Observed when using the QTS, both within development and end-of-line, was that the user interface might take time to understand. The language used for writing scripts was XML, which means that knowledge regarding the language at hand is needed as well as knowledge regarding how a tests script should be designed. For software engineers with experience in programming of multiple languages, the XML programming might not be difficult. The difficulties might lie in designing the tests scripts, knowing what signals to test. The overall impression, however, was that this procedure might take time to learn and an easy way to learn fast is desired, in order to spare time and money.

Hardware:
The hardware where the test is designed consisted of a circuit board. A couple of components were the same in each test system, but components such a loads were customized each time. Observing the circuit board made it clear that customization is always needed, but some components could be reused in many test setups.

5.3 Interview Iteration One

Interviews were held with the four different groups of interviewees: current users, potential users, other test rig users, and sales department as part of interview iteration one. The KJ method was used to organize the data collected from the interviews, which resulted in the recognition of nine categories; error messages, usability, education, customization, support, revenue and cost, segments, desired system features and test functionality. These categories marked importance of certain features as well as problematic areas. The result of the KJ method can be viewed in Figure 13 and below is a summary of the results obtained from the interviews with respect to those nine categories.

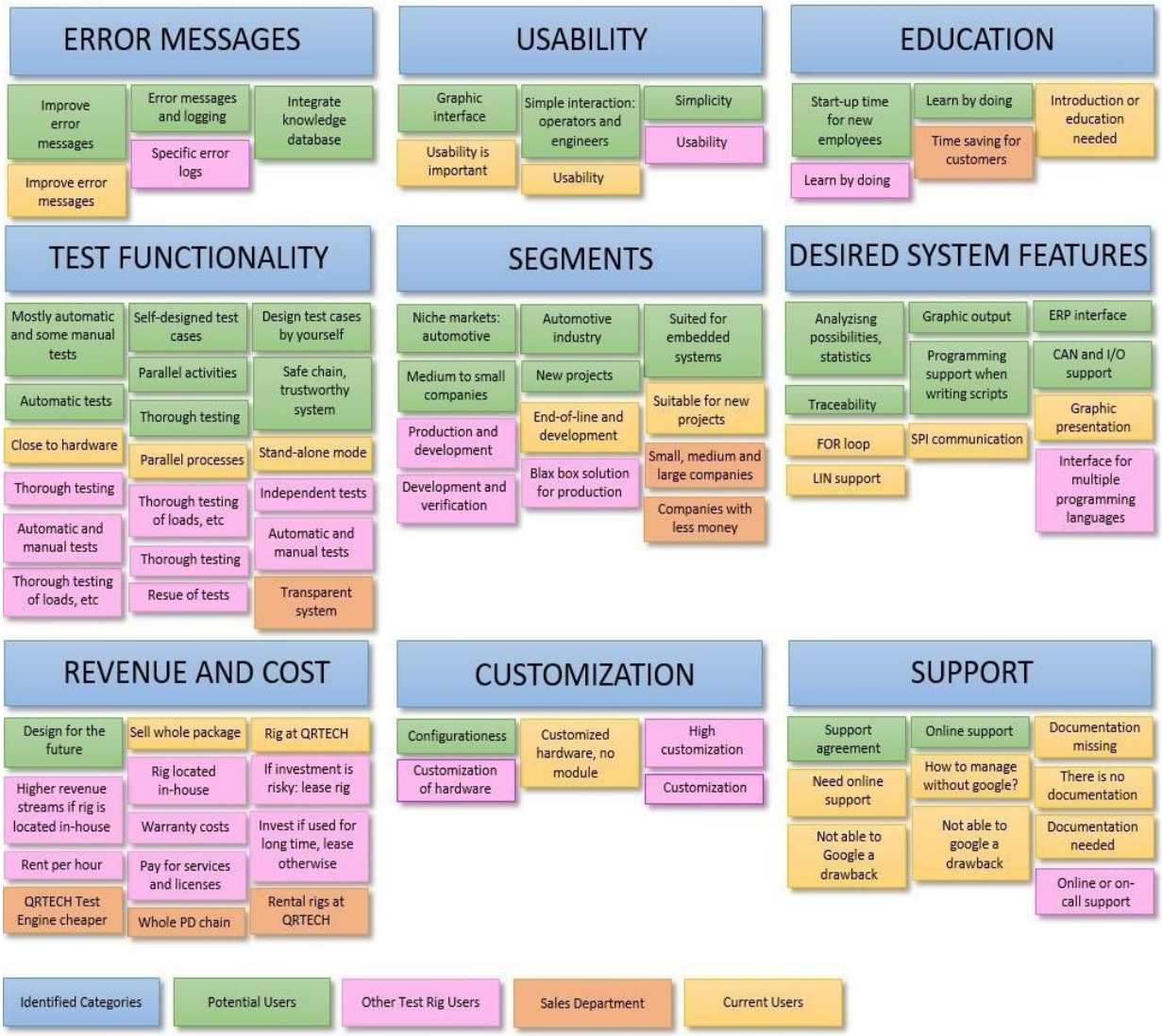

Figure 13: Documented results from the KJ analysis

Error Messages

It was debated and argued that error messaging for HIL systems need to be developed further in order to support the user when tests fail or there is a need for fault analysis. There seem to be some kind of error processing in most systems that are present on the market today, however most of them are not nearly as informative as most users would want. An integrated knowledge database is needed in order to store common mistakes and errors so that these are corrected both easily and fast.

Usability

The interviewees agreed upon the fact that usability and simplicity is very important for HIL test systems. The interface should suite both engineers developing and verifying products as well as operators that uses the system for end-of-line tests. One way of obtaining user friendly system is increasing the graphic interface and output, that way creating a more intuitive environment.

Education
Mentioned in the interviews were the rate at which a new employee or user can learn the HIL system and how long it takes before new users are productive. The start-up time is crucial and money can be saved if proper educational material is prepared for the users. Interviewees agreed upon that introduction and education is needed, but the examples of how this could be organized varied among the interview participants. One possibility mentioned was to prepare tasks starting at beginner's level and advancing step-by-step until user is fully operational with the system. Also mentioned was the fact that the easiest way of learning a new system is to work with the system, a learn-by-doing approach.

Customization
The desired level of customization of a HIL system varied among the interviewees, however all wanted the hardware to be customized. Difference in opinion could be noticed when considering a HIL system for production versus development purposes. Designing test cases, for instance, was desired for development while not in production. More information regarding the design of test cases can be seen under the category Test in this chapter.

Support
The main concern among the interview participants was the fact that major manufacturers of HIL systems have a well-developed supporting system consisting of websites, forum support and search engine such as Google, while the QTS does not so far. Support must be provided, preferably online but could also be by phone or email. Suggestions from the interviewees were to use supporting agreements, online support and provide the user with a product documentation.

Revenue and Cost
Revenues for the QTS can be obtained in many ways, according to the interviewees. Some examples included licensing agreement, service, sell a large package with the QTS included and leasing fees. An idea was to have the QTS at QRTECH and thereby obtain revenues not only for the product itself but also from administration, location and maintenance of HIL system. An interviewee suggested that by locating the QTS in-house, the product can be up to date at all times and customers may lease the rig and pay per hour of usage. Interviewees also mentioned that leasing the QTS would be beneficial if investment is risky or very high.

Segments
Interviewees agreed upon that the QTS could be used for production, development and verification purposes. Suggested was to start on a niche market such as the automotive industry where ECUs are currently being tested quite frequently by many companies. Also suggested was to start with projects that have not yet established a testing and verification process of their products in development or end-of-line products. An idea was to target the market where cost is an issue, either small companies or larger companies with economy of scale to consider, as the QTS can be sold to a lower cost compared to larger systems such as LabVIEW and dSPACE.

Desired System Features

The interviewees suggested many system features that would be desirable in a HIL system, including support for CAN, LIN, I/O, FlexRay and SPI. Moreover, the system should be able to analyze data and provide the user with necessary statistical data, with the requirement of full traceability. A desired feature was to be able to use many types of programming languages and not only XML to write test cases, which allows for companies to use other programming languages, resulting in no additional time for learning. Interviewees already using the QTS suggested that for-loops should be implemented for eased creation of test cases and a graphic interface could be a possibility for future improvement.

Test Functionality

According to the interviewees, the QTS should be customized so it meets customer needs when it comes to hardware and software, with the possibility of writing their own test cases. Most interviewees working with development projects wanted the possibility to write their own test cases while production tests were to be designed entirely to fit the product to be tested with limited or no option for self-designed testing. The possibility of doing in depth, thorough testing of specific I/Os, currents or loads was desired by the interviewees, which considered this an advantage compared to larger systems such as dSPACE. Both automatic and manual testing of ECUs should be possible to execute with a HIL system and parallel processes would be beneficial.

Summary of Findings

Interview iteration one resulted in much knowledge both regarding the QTS as it is today, and also demands and wishes from users and customers. The users of the QTS and other test rigs users stated that it is of high importance to have specific and detailed error messages, it is also of importance to have a test system that is easy to learn to use and easy to use once you are well familiar with it. There also seemed to be a desire from the engineers to write test cases by themselves and to have to opportunity to use several different interfaces, such as CAN, LIN, FlexRay, etc. These interviews resulted in much knowledge regarding how to develop the QTS further, but also provided much inspiration regarding how to design the business model.

5.4 Interview Iteration Two

The second iteration of interviews resulted in feedback on the different concepts from the morphological matrix as well as on the platform concept. Following is a summary of the data collected.

The interviewees all agreed that having a modular approach to the test system would probably be the most beneficial alternative for both customers and QRTECH. It that way, customers may choose between many modules in order to create and buy a test system that is suitable for their particular needs. The reason QRTECH would prefer to have a modular approach is mainly because it is preferred by customers, and thus easier to sell. QRTECH however suggested that it might be beneficial to also provide finished packages where everything is

specified, to decrease the amount of choices for customers that prefer to not have a highly customized testing system. The interviewees also reflected upon that the platform concept in a way is all the other concepts put into one. By using this concept, high degree of flexibility is achieved. As an example, one company mentioned they may want to write their own test scripts if using the QTS for development, but if they are also using it for end-of-line testing they would prefer to buy finished test scripts from QRTECH. Depending on the price of the test system, this company would prefer one-time-cost over a monthly payment. If, for instance, the product price would end up lower than 10 thousand SEK, they would prefer a one-time purchase and own the test system themselves.

How much support and maintenance each customer will need may vary, and QRTECH pointed out that this needs to be handled at an early stage, and be clearly specified in the contracts. The sales department at QRTECH suggested that the company and customer should agree upon a certain amount of hours QRTECH is supposed to use each month to provide support. If the allocated hours are not used during this time, it may be used for upgrading or developing the system further. Sales department mentioned that in that way, the customers' payments would always contribute to something and never go to waste. This may benefit both parties, due to that the customer gets value for the money spent and for QRTECH, the test system will be further developed at the customer's expense.

The sales department also advocated providing support through a standardized email template due to that technical support often need thorough description of the problem, which in most cases is most proficiently communicated in writing. It would also be beneficial if QRTECH remotely could access the test system located at the customer. How the IT system works and is structured is often of low interest to the customer, it is only important that is functions as promised.

Regarding training and education, it was mentioned that courses would be a good way to speed up the learning process. It would provide a revenue for QRTECH and it is a fast way for the customers' employees to learn the system fast. Courses might be of higher priority than for instance tasks, since time would be allocated towards courses, compared to tasks which time would be taken from regular working hours. It is also an opportunity for QRTECH to promote and keep selling extra courses that thoroughly walks the user through a specific subject.

The "Outsourced" concept differentiates itself from the other concepts as it is concerns selling only a service with no product. The sales department however advocated that it is a good business idea that could provide QRTECH with more business opportunities and revenues, and it should not be eliminated, but be developed and sold in parallel.

In summary, the interviewees agree that the platform concept is the most suitable concepts to go forth with, as it provides high flexibility for the customers. The support however needs to be clearly specified and it is beneficial if QRTECH provides courses for test system users. The "outsourced" concept however is to be kept, but separated from the platform concept.

5.5 Costs and Prices

For this thesis, a cost and price example was needed in order to calculate profits. The following prices, rates and costs were used for calculations made in this thesis (Table 3). These are examples of how this could look like for the QTS, but is only an example and thereby these figures may increase or decrease in the case of an actual commercialization of the QTS.

Table 3: Cost, Prices and Rates for the QTS

Cost, Prices and Rates	
Type	**Amount**
Cost	
Hourly Cost: Developers, Sales, etc. [SEK]	550
Invested Development Cost [SEK]	3 000 000
Production Cost Test Engine [SEK]	0
Production Cost Test Board [SEK]	1 000
Price	
Customer Price Test Engine [SEK]	70 000
Customer Price Test Board [SEK]	4 500
Rates	
Support Fee [%]	17
Support Usage [%]	60
Discount Rate [%]	5
Other	
Working Hours [h/y/person]	1 740

The estimated cost for developing the QTS as far along as it is now, is estimated to be 3 million SEK, these will not be taken into account, as the investment has already been made. QRTECH rates that the hourly cost for an employee such as a developer or sales person is 550 SEK. The amount of hours spent on development and production of a component is then estimated.

The cost of the QTS is divided into two separate parts; QRTECH Test Engine and QRTECH Test Board. QRTECH Test Engine, the physical test machine, will be sold at a cost of 70,000 SEK. For each QRTECH Test Board, an additional cost of 4,500 SEK will be added. In this price, the customized Load and Simulation Board is not included due to that this cost vary for all projects. The yearly rate for the customers, i.e., the support fee, will be 17% of the QRTECH Test Engine price in accordance to industry standard. This cost covers one software license and basic support for that license. If a customer would like more licenses it will be an extra 17% per license. QRTECH only believes that 60% of the hours that are dedicated to cover support will be used. The Test Engine has no direct production cost, as it will be

reached from a server and the cost is negligible. Costs will however be generated from sales and marketing efforts at a cost of 550 SEK/h. Depending on the customer, the amount of hours will vary. For instance, internal customers need less marketing efforts than an external customer. QRTECH Test Board however has a production cost of 1,000 SEK.

The rate at which an investment will increase over time for this type of industry, i.e., the discount rate, was estimates to be 5%. This information was needed for further analysis of pay-back time of investment and estimations of profitability.

In order to commercialize the QTS, further development was needed. In accordance to the findings obtained from interviews and with consolation from QRTECH, an estimation of the hours and the material cost of further development was done. This estimation can be seen in Table 4. The cost of further development is dependent on engineering hours and on material cost.

Table 4: Estimations of further development cost for the QTS

Estimated Cost of Further Development of QTS				
Type of Cost	**Units [h]**	**Unit Price [SEK/h]**	**Material Cost [SEK]**	**Total Price [SEK]**
General	120	550	0	66 000
Documentation	208	550	0	114 400
Test Engine Base	770	550	0	423 500
Test Engine Advance	850	550	0	467 500
Test Board Software	370	550	0	203 500
Test Board Electronics	340	550	0	187 000
Industrialization	358	550	60 000	256 900
Total Development Cost				**1 718 800**

The further development cost is mainly developing the software so that it is bug free and support industry standards and electronic components, but also producing documentation and preparing the product for industrialization. With the estimated hours and needed material, the further development cost sums up to 1,718,800 SEK.

6 Analysis

Following is a presentation of all analyses done in this thesis, based on the analysis methodologies decided upon and the collected data.

6.1 Benchmarking

The literature study executed in order to find information regarding competitive products were gathered and analyzed in a benchmarking matrix. In Figure 14, a matrix containing HIL systems and their properties is illustrated. These systems are provided by different companies and all target the automotive industry. The companies and their test systems presented in the analysis are just a few of what is currently on the market, but are among the most used in the automotive industry. Five test systems were compared to the QTS. There are many HIL test systems on the market today, however these were among the most established for the automotive industry.

The characteristics used in the benchmarking for comparison purposes were the characteristics that most companies illustrated or described on their web pages. Also, these characteristics were discussed during weekly meetings and it was agreed upon to use the ones that can be seen in Figure 14. QTS is illustrated furthest to the left and contain the properties as of the project start (January, 2015). In the matrix, the color green shows that the properties are at desired level, while red stands for low desirability. Yellow shows that properties are of medium desirability or that there is a possibility to meet the desired target.

Characteristic	System					
	QTS	LabVIEW	dSPACE	Etronix	Vector	LABCAR
General						
Price	*			*		
Tests hardware						
Tests software						
Suitable markets		etc.	etc	etc		
Used in production						
Used in development						
Product Documentation						
Designing the tests						
Traceability						
Automatic tests						
Manual tests						
Customization from company						
Connected to requirments						
Output from tests						
Produces test report						
Graphic output						
Services						
Training						
Maintainance						
Online support						

*No Data Available

Figure 14: Illustration of the benchmarking matrix

As illustrated in Figure 14, the different HIL systems from all companies have desirable properties. Below follows a description of the findings regarding the test systems included in the benchmarking and a comparison with the QTS.

NI LabVIEW

LabVIEW, developed by National Instruments, is a commonly used for testing and developing systems for the automotive industry, but is also used in other industries such as aerospace. It is an open platform that can be used in many fields and is compatible with many systems such as MATLAB and SIMULINK. LabVIEW allows for many opportunities since the customer itself can design the test system to fit the task at hand. Support of such a system is well developed, there are both support from the National Instruments web page and on forums across the web. This support is very much needed since all development is made by the customer. To buy equipment and licenses from National Instruments is very expensive due to the wide range of applications, programs and tools can the company offers, even though not all of them are used in the customer's particular HIL system (National Instruments, 2015).

dSPACE

dSPACE provide HIL systems for automotive, aerospace and other industries. Their product offering is wide and has possibilities of targeting both small and large systems with multiple ECU testing in parallel. The simulator is designed by dSPACE to fit the customer's needs, while test cases can be designed by the customer itself. The HIL system is compatible with modelling systems such as SIMULINK, which makes it a highly attractive system for larger

companies already using MathWorks products. There are also possibilities to use only dSPACE products for the HIL system. dSPACE provide training and online support, especially if chosen to integrate with MathWorks products. Both licenses and simulator are very expensive, since the system provided by dSPACE is fairly unlimited and maintain high standards (dSPACE, 2015).

Etronix

Etronix offers a product called Digital Tests that allows tests for circuit boards, software, automation and quality management systems. The product is used in several different markets, such as the automotive and the aerospace industries. Services and maintenance can be included if the customer wishes. Test systems purchased from Etronix is highly customized and few options for manual tests are available (Etronix AB, 2015).

Vector

Vector is a provider of test systems focused on the automotive industry, working on a global scale. Their test system allows for both hardware and software testing and their tools and programs are developed to help and provide useful data to the user, both data logs and graphic interfaces. Vector's strengths lie in their usability, highly developed test systems that ease both development of tests and execution of automatic/manual tests. Furthermore, they provide customers with support and training globally. Tests can both be customized by Vector or self-developed by customers. The main drawback is the price of Vector products, which is fairly high (Vector Informatik GmbH, 2015).

ETAS LABCAR

LABCAR is a testing system developed by ETAS Group that functions as a modular HIL system targeting ECU's mainly from the automotive industry, thus the name. It is a very open test system which is compatible with modeling tools such as SIMULINK and most of the C-code model suppliers. It is easy to adapt to future requirements due to the open architecture of the system, thus suits well in development environments (ETAS, 2015). Models are developed by the customer, with varied online support depending on the tools that the customer decides to use. LABCAR is also considered fairly expensive due to licensing from third parties such as SIMULINK. This cost can somewhat be decreased if using cheaper modelling tools.

QTS

QRTECH's HIL test system have many qualities that the other systems have as well; targeting development and production within the automotive industry, well developed test environment suitable for both manual and automatic tests, advanced reporting system, etc. What the QTS currently lack are a thorough product documentation and specification, graphic output, educational training and support such as websites and handbooks. The main advantage of the QTS is the price.

Summary

Comparing all the testing systems (illustrated in Figure 14) show that QTS have indeed many qualities that customers seek in a HIL test system and may compete with larger systems by proving same service and product but to an affordable price. Currently the development of new QTS's are customized in a way so that only the necessary components are included, compared to LabVIEW and dSPACE users which often have large simulators targeting a wide range even though there are few who use all of it. Thus the price advantage. Vector is probably the most similar system, containing many of the desired features and high level of support. In order for QRTECH to compete with a system like Vector's, documentation, graphics and support must be established so that it meets the need of the customers.

The business model for all of the above HIL test systems are based on the value of providing a fast and cheap way of testing ECUs in a non-operational environment. Today, the HIL systems looked into are bought for a one-time cost, with licenses for the programming and test script environment. According to (QRTECH AB, 2015) it is industry standard to take 17% of the total test system cost as license cost on a yearly basis. Most of the HIL system providers target the automotive industry, but there are others who include other industries such as aerospace and medical. The larger, industry leading companies such as National Instrument and dSPACE target more industries with their test systems due to the open environment where customer design tests themselves.

6.2 Growth Opportunities

According to (Ansoff, 1957) the four different types of market growth opportunities are market development, market penetration, diversification and product development. Identified from the project scope and from discussions with the employees at QRTECH, market development is most suitable in order to obtain market growth. This, due to that the QTS only need modifications to its hardware and software but has opportunities of expanding to other markets if packaged in a way that suite customers' demands. As illustrated in Figure 15, market development can be assured by introducing existing product to new markets.

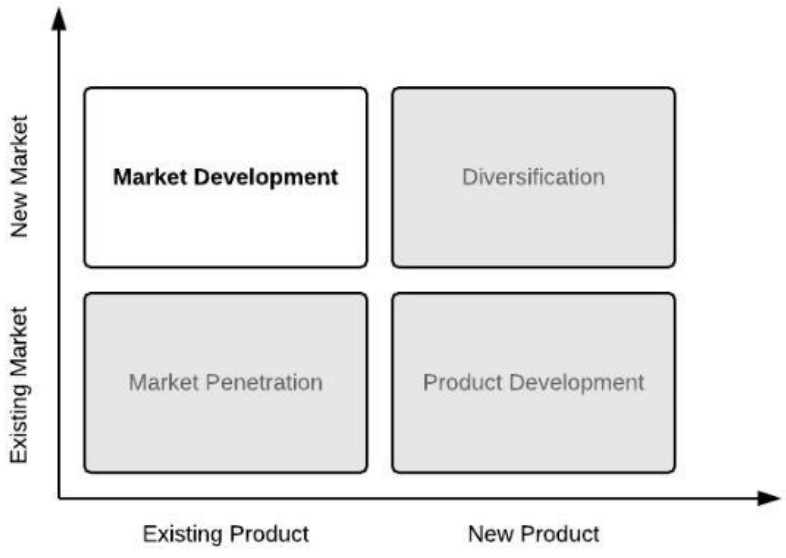

Figure 15: Illustration of Ansoff matrix showing the most suitable way of market growth for the QTS

According to (Porter, 1980), the different generic strategies that can be used are cost leadership, differentiation, cost focus and differentiation focus. Today, the QTS have the competitive advantage of being cheaper than other products on the market due to that it is customized to meet the demands of the customer and only contain the features that the particular customer wants. When it comes to the scope, it is considerably more narrow than that of its well-known competitors. The idea is to start off by introducing the QTS to QRTECH's already existing customers, local businesses within the automotive industry, both manufacturers and suppliers.

The low-cost and narrow target suggests that a cost focus would be appropriate strategy for QRTECH when commercializing the QTS, as seen in Figure 16. Due to the fact that it is preferable to only be positioned in one box, it is wise for QRTECH to not expand their customer segment too much and stay on a niche market.

If considering the theories provided by (Ansoff, 1957) and (Porter, 1980) regarding market growth opportunities and strategies, is seem to be most suitable for QRTECH to expand by entering the QTS to new markets, but to keep a low-cost profile and narrow the segment to local businesses or current customers within one field, preferably the automotive industry since this market already is targeted.

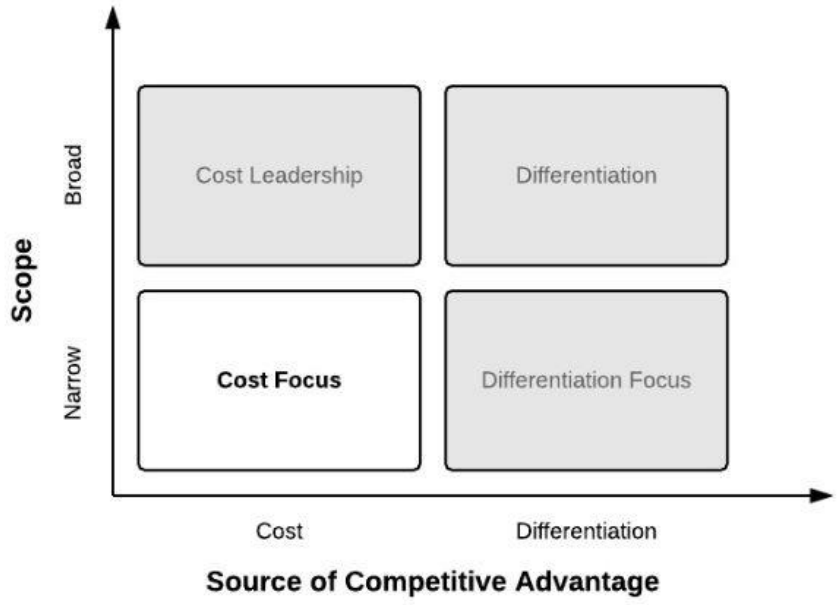

Figure 16: Porters generic strategies showing the most suitable strategy for the QTS

6.3 Market Segments

As it was identified that a market development was an opportunity of growth for the QTS, further investigation was done regarding what types of markets the system could potentially enter. There were potential markets already identified previous to the project start, due to that the QTS on occasion already had been developed for a few customers. These customers, described in Chapter 2.4, were taken into consideration when looking for potential markets.

Consultation with the employees at weekly meetings at QRTECH in combination with the existing markets that the QTS already had entered resulted in the proposal of three markets: HIL tests for development, production and supplier verification. Since cost focus was recognized as the most suitable strategy of Porter's Generic Strategies, the market to initially target is the automotive industry including manufacturers and suppliers. This in order to stick to a niche market. Seen in Figure 17 is an illustration of the product package of each segment, implying that there are possibilities for each segment to share commonality while some attributes are distinctive for each segment. Following is a description of the three segments.

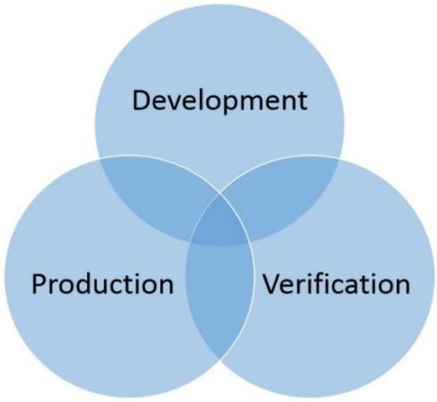

Figure 17: Potential market segments for the QTS

Development

The market segment of development was considered and chosen due to that the QTS was originally developed for this exact purpose for QRTECH's in-house projects. Intended now is to expand the scope to customers and offer a cheap solution to test ECU's in the development phase, competing with larger and more expensive systems such as dSPACE and LabView (mentioned in Chapter 6.1).

Production

Also this segment has been tested by the QTS previously, as the system also was developed for end-of-line testing of the in-house projects QRTECH continuously have. Occasionally, the QTS has been sold to other companies (as mentioned in Chapter 2.4) and thereby this segment was assured to be included. The idea is to now promote QTS and expand so that more customers want the test system for their end-of-line testing procedures.

Verification

A third, not yet tested segment is supplier verification. Included in this segment is all ECU testing for products provided by a supplier, thus not products that either QRTECH or the customer has developed or manufactured. The idea of this segment came forth in one of the many discussions held at meetings at QRTECH and the reason for it being that supplier products must withhold certain standards and fulfill requirements set by the industry. In order to assure this, verification tests are a possibility.

Summary

As mentioned, there are possibilities of common and distinctive properties in each package to be developed for each market segment. The automotive industry was chosen as the main field

due to the location of QRTECH's headquarter is in Gothenburg, surrounded by manufacturer and suppliers to the automotive industry in which QRTECH already is in business with. Another reason is the high standards and requirements set by the automotive industry, resulting in the development of a product which meet these requirements. Later changing industry would not acquire as much effort once all requirements are met of a highly demanding automotive industry.

6.4 Product Modifications and Development

In order to attract the customer segment mentioned above, the QTS need to be up to date and fulfill the requirements set by the industry, suppliers and the customers themselves. Since the customer segments to focus on was decided to include new development, production and verification projects within the automotive industry, the customers voices within these segments must be heard and taken into consideration. Thereby the findings obtained from interviews were considered and valued. Moreover, the benchmarking was also of great value due to that information regarding competitive HIL systems were discovered.

First of all, the requirements and demands set by the automotive industry must be fulfilled. During the interviews, a lot of requests concerning what the test system should supports came up, including SPI communication, CAN, FlexRay, LIN, for-loops as well as support for both automatic and manual tests. It is of great importance that the test system supports the industry standards such as the above mentioned. Also, as interviews have covered, there is a need for increased performance. The QTS should be up to date and modern, which means supporting parallel processes and execution of multiple test cases at once and bugs should be eliminated so that the tests sun smoothly.

Usability is of importance to the users, as mentioned in interviews. It is therefore crucial to consider the suggestions that test users have and analyze what parts of the system that are hard to understand or simply not intuitive enough. For instance, there were many comments regarding how failure or errors are presented to the user. To further investigate and develop this feature might thereby be essential to increase usability. Another feature mentioned was graphic outputs instead of code or text. To present the data in an easy and supporting way, that both operators, test case developers and other users appreciate in their daily work. A third development possibility of the QTS to increase usability is to add the possibility of writing test cases and models in various environments such as Simulink or Python.

Lastly, there is a need for increased documentation activities. If the QTS is to be sold to external customers, there is a need for product documentation, a web page, product specification and sales material. As it was mentioned in interviews that there probably was a need for courses, tasks or other support to get to know the test system, material must be prepared for those activities as well. Found in Table 4 in Chapter 5.5 is an estimation of the

cost these changes will generate. The amount ended up at around 1.7 million SEK. These are just estimations of the work that needs to be done prior to commercialization.

6.5 Concept Generation

Following is the results and analysis of the concept generation process, including the creation and reasoning behind the concepts developed from the identified needs and requirements of customers. The concepts generated do not concern the above mentioned changes in the product, but how to package the QTS when sold to customers. The concept generation thereby does not include any data or features representing the hardware or software of the QTS, only options and alternatives the customer will face when buying the test system.

6.5.1 Morphological Matrix

A morphological matrix was created (illustrated in Table 5), consisting of eight categories with up to five different alternatives to choose from the different categories. One alternative from each category was chosen to create a concept. The alternatives are listed a-e and have no specific order whatsoever. Categories represent the different options a customer may face when buying a test system, so that concepts created by the morphological matrix represent a package deal customers would want to buy.

Table 5: Morphological matrix

Category\Alternative	a	b	c	d	e
Support	Phone	Website, Email	Phone, Website, Email	Personal Assistance	Not Applicable
HW Revenues	Leasing	One-Time Cost	Included	Outsourcing	Pay-Per-Hour
SW Revenues	Licenses	One-Time Cost	Included	Outsourcing	
Rig Location	At QRTECH	At Customer	Satellite		
Customization	HW, SW	HW, SW, Test Cases			
Training	Tasks	Learn-By-Doing	Course	Not Applicable	
System Owner	QRTECH	Customer			
Result Presentation	Extensive Report	Extensive Report, Graphics	Graphics, Data Log		

All categories emerged from the data obtained from interviews and observations. Following is a description of each category and what the different alternatives for each category mean.

Support

The first category, support, consists of alternative ways of communicating with QRTECH when support or advice is needed. Options are to contact QRTECH via mail or phone. Further support may be personal assistance from a QRTECH employee in the case of the QTS being located in-house. Another alternative is to log on to a webpage to search for assistance using Q&A or product documentation.

HW Revenues and SW Revenues
The categories of hardware and software revenues describe different options for QRTECH to earn money on their product. There are possibilities of selling the QTS for a one-time cost as well as lease the QTS and thereby earn money from leasing and licensing agreements or pay-per-hour deals. There are also possibilities of not having direct revenues from the QTS, for instance if the QTS were to be part of a larger business deal.

Rig Location
The rig location category describes the different options of where to place the physical QTS. The main possibilities are at the customers' facilities, at QRTECH or some form of collaboration project, where the QTS is placed in a satellite facility. The location of the rig is important due to the different possibilities of keeping the QTS updated, if the rig is located at QRTECH, it is easier to access and update it.

Customization
There are two different alternatives for the category customization, the first being customized hardware and software and the second being customization of everything: hardware, software and test cases. Designing test cases demand that the customer has knowledge of programming and thereby also staff that have the responsibility of developing test cases for each project.

Training
It is important that the customer knows how to use the QTS, in order to work with it efficiently. It is also of value if an engineer can learn the system fast, as it saves the company money. This category describes different ways of teaching employees how to use the system, for example simple tasks or a course. Learn-by-doing is also an alternative which might suite developers that have previous experience of HIL test systems.

System Owner
There are two types of system owners, QRTECH or the customer. The ownership of the HIL system describes whose responsibility it is to withhold an accurate, updated and maintained system as well as who the owner is once, for instance, a leasing agreement is over. System owner does not describe who is responsible for faults in the test system that could lead to product recalls later. This is specified in a contract between QRTECH and its customers.

Result Presentation
This category provides different options of how the results of the test should be presented. The different possibilities are; an extensive report, graphic representation and/or a data log of the results. Currently QRTECH has developed an extensive report generation which is highly appreciated. Depending on the usage, however, this report might not be used. Thereby there should be options to what kind of output to obtain once tests have been made.

6.5.2 Concepts for the Development Segment

In Table 6, the concepts suitable for development projects are illustrated. Below, a description of the four concepts suitable for development projects is provided. Key to a development

profile is that test cases might be done by the developers and not by QRTECH as well as the output being very thorough so that fault analysis is possible.

Table 6: Concepts suitable for HIL testing in development projects

Category \ Concept	Development			
	1. Leasing	**2. Pay-Per-Hour**	**3. Satellite**	**4. HW Owner**
Support	Phone, Website, Email	Personal Assistance	Not Applicable	Website, Email
HW Revenues	Leasing	Pay-Per-Hour	Included	One-Time Cost
SW Revenues	Licenses	Included	Included	Licenses
Rig Location	QRTECH	QRTECH	Satellite	At Customer
Customization	HW, SW	HW, SW	HW, SW	HW, SW
Training	Tasks	Course	Tasks	Tasks
System Owner	QRTECH	QRTECH	QRTECH	Customer
Result Presentation	Extensive Report	Extensive Report	Extensive Report, Graphics	Extensive Report

1. Leasing

The concept Leasing allows for QRTECH to provide a full service test system for the customer, without the customer needing to make a large investment from the start. QRTECH owns all the equipment and provides phone, website and email support along with updated and customized software and hardware, at a monthly rent, which provides QRTECH with a continuous revenue flow. The customer does however need to write test scripts and perform the test themselves. To educate employees on the system, there are several tasks that need to be completed before starting to use the QTS, these task should provide the employee with sufficient knowledge of how to function the QTS. If possible the QTS hardware should be placed at QRTECH and the customer should access it through a server.

2. Pay-per-hour

The Pay-per-hour concept is inspired by the way one of the interviewed companies sells test rigs for HVAC systems, as discovered in interview iteration one. QRTECH will have a facility with fully equipped and updated test rigs that several customers rent by hour or day. There will be support in form of personal assistance from QRTECH and the customers will start with a course in the QTS before they start using the test rigs. This concept allows for QRTECH to retrieve higher revenues due to that the rig's location, administration and availability of engineers to assist increase the costs and thereby also the price.

3. Satellite

A satellite development project enables QRTECH to have the QTS in-house while still managing to provide the customer with an isolated working environment where no other employees are allowed. The benefits of having a satellite is that the QTS can be easily

maintained and up to date since it is located at QRTECH and there are possibilities of hiring system experts to consult the project, thus little or no support needed. A satellite also enables close communication and development possibilities at a lower cost due to that the development is sponsored by the customer.

Development can be done continuously and feedback can be obtained on the system throughout the project. Revenues are not obtained from the QTS itself, but rather from the whole satellite package provided to the customer. The QTS is therefor provided for free, including a certain amount of licenses agreed upon. QRTECH customize the system for the satellite project, thereafter there are possibilities to update, add features and maintain the system free of charge. This does however mean that QRTECH obtains lower revenues on the QTS itself, but may retrieve more revenues in a longer perspective, as they might be able to land more satellite projects.

4. HW Owner

The concept HW Owner provides the customer with full ownership of the hardware of the QTS. The software is still owned by QRTECH and the customer pays for it through licenses. If support is requested, it needs to be bought separately at the time of need. With this concept QRTECH gets larger revenues when the QTS is sold and a smaller continuous flow through software licenses and possibly through support. The user does in this concept write the test cases themselves and obtain knowledge of how to operate the system through example tasks provided on the webpage.

6.5.3 Concepts for the Production Segment

In Table 7 the concepts suitable for production or end-of-line testing are illustrated. Below, a description of the three concepts suitable for production or end-of-line is provided. Key features in a concept used for production is minimizing down-time by increased support and training activities so that engineers and operators can handle the system.

Table 7: Concepts suitable for HIL testing of end-of-line or production

Category \ Concept	Production		
	5. Small Scale	6. Short Life Cycle	7. Mass Production
Support	Website, Email	Phone, Website, Email	Phone, Website, Email
HW Revenues	One-Time Cost	Leasing	One-Time Cost
SW Revenues	One-Time Cost	Licenses	One-Time Cost
Rig Location	At Customer	At Customer	At Customer
Customization	HW, SW, Test Cases	HW, SW	HW, SW, Test Cases
Training	Course	Tasks	Course
System Owner	Customer	QRTECH	Customer
Result Presentation	Extensive Report, Graphics	Graphics, Data Log	Graphics, Data Log

5. Small Scale

The concept Small Scale allows for testing of systems that are only produced in a small scale, where the products need to be thoroughly tested. An example of this could be medical devices or equipment with high quality demands, however low scale production. In this case QRTECH provides the hardware, software and test script, and the customer pays a one-time cost for the product, but needs to pay extra in order to receive updates, support and maintenance. If needed QRTECH provides a course for employees to get basic knowledge of the QTS.

6. Short Life Cycle

The Short Life Cycle concept allows for end of line testing for products that are not produced during a long time, for instance cellular phones. The concept is alike the Mass Production concept (see below), but the main difference is for how long time the product is being produced. The customer receives customized hardware and software, but writes the test scripts themselves. The hardware is leased from QRTECH and the license for the software is included in that cost. In order for the customer to obtain knowledge of how the QTS works, the customer can complete tasks provided by QRTECH.

7. Mass Production

The concept Mass Production is designed to allow usage of the QTS in end-of-line testing. The products being tested should be produced in large amounts for a long period of time. For instance, this could be ECUs operating in vehicles, however not ECUs that are easily replaced by new technology. QRTECH customizes the hardware and software and writes the test cases, which provides the customer with a finished product ready to be used, support is also included. This serves as one-time revenue for QRTECH, but also provides an opportunity to sell updates and maintenance.

6.5.4 Concepts for the Verification Segment

In Table 8 the concepts suitable for verification of supplier's products are illustrated. Below, a description of the two concepts suitable for verification is provided. Verification, as well as development, need extensive reports due to fault analysis.

Table 8: Concepts suitable for HIL testing with the purpose of verifying supplier products

Category \ Concept	Verification	
	8. At QRTECH	9. At Customer
Support	Not Applicable	Website, Email
HW Revenues	Outsourcing	Leasing
SW Revenues	Outsourcing	Licenses
Rig Location	QRTECH	At Customer
Customization	HW, SW, Test Cases	HW, SW
Training	Not Applicable	Learn-By-Doing
System Owner	QRTECH	Customer

Result Presentation	Extensive Report	Extensive Report

8. At QRTECH

The concept Verification at QRTECH is a way of outsourcing verification of developed products. For example, a customer could send the product and the requirement list to QRTECH and QRTECH could return an extensive test report with the test results. The testing can from a customers' point of view be seen as a black box. This means that the customer does not need to reflect about hardware, software or writing test cases. QRTECH needs to put in many engineering hours in order to fulfill what is promised, but can on the other hand charge more for the service.

9. At Customer

The concept At Customer is directed to customers that want to verify their own or suppliers' products. The customer leases the QTS, which will be placed at the customer's facility. The customer writes the test scripts and performs the tests. The main difference from the "Leasing" concept is how the QTS is used. In this case it is used to verify products, in the "Leasing" concept it is used during the development of the product. These two concepts can however be combined, and the customer can use the QTS for both purposes.

6.6 Concept Evaluation and Selection

In the following chapter, the concepts are evaluated and refined before a final selection can be made. This was done through continuous input and feedback from meetings and interviews. Once a final concept was decided, that concept was further developed and refined with continuous feedback from weekly meetings and other discussions.

6.6.1 Early Evaluation

An early evaluation of the concepts that were generated from the morphological matrix was made with regards to the information obtained from interviews, observations and research studies. When comparing the concepts, two main things came to mind; there are many similar concepts generated from the morphological matrix and QRTECH may need more than one concept to target a desired amount of customers. This, in order to fulfil customer needs and make a commercialization possible.

Many of the concepts had similar features, only one or a few categories differed from one another. Also, there were similar concepts targeting one or more segments. It was realized that it was perhaps not the segment that should be the main differentiating factor, but how the QTS would be used at a company. For instance, testing for verification or development might not differ at all when it comes to the setup of the QTS and thus may have the same concept. It was decided that the segments were good to have in mind when looking for customers, however would not be a differentiating factor when it comes to what concepts to choose for a certain company.

It was realized that the segments of development, production and verification may not have one concept that would fit them all, so more than one concept is reasonable to provide the customers. In this early evaluation, it was not stated which concepts to go forth with. It was decided that more than one concept would be kept in order to target the right amount of customers.

6.6.2 Refine Concepts

During weekly meetings at QRTECH, a discussion was held regarding the concepts generated. During these discussions, a new idea was developed. Due to the customer range; verification, production, development, there are low chances of choosing only one concept. Therefore a new concept was developed with regards to all of the previously generated concepts. The new concept was a platform concept that could target all customers. By having certain features already decided, while others may be chosen, the concept could reach more customers. This concept would work as a substitute for all other concept, since there would be possibilities to choose a customized solution that fits the need of the customer within the boundaries of the platform. An illustration of the platform can be seen in Figure 18.

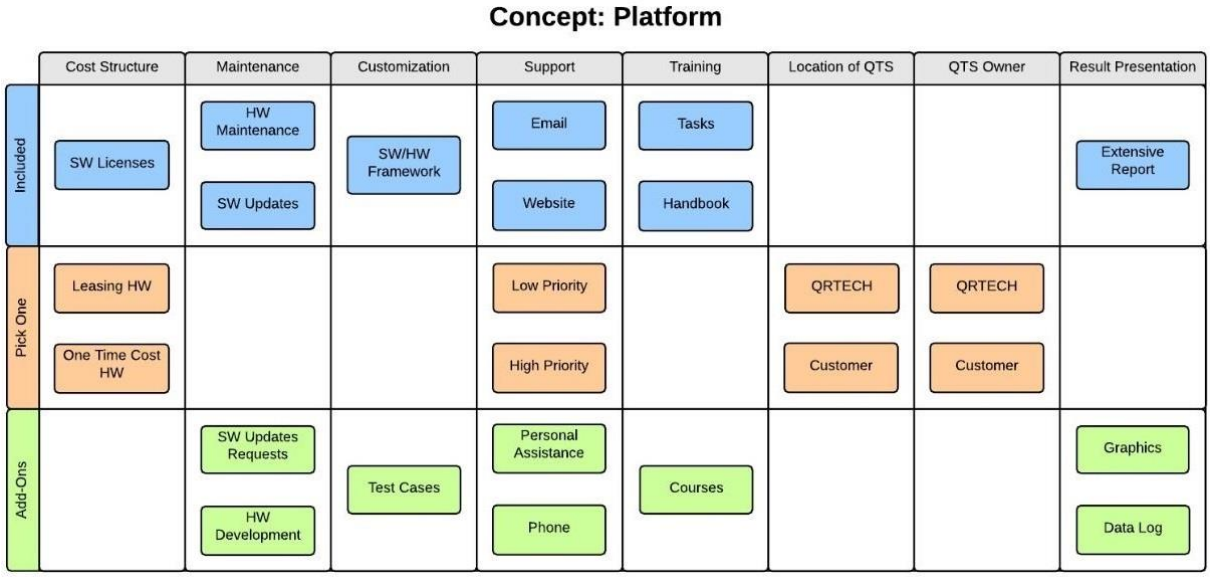

Figure 18: Concept: Platform

As seen in Figure 18 the concept: platform was based on the categories of the Morphological Matrix, however some adjustments were made due to that the original structure of the other concept was not suitable for a concept which would include options. Moreover, after giving the concepts more thought there were other issues with the current categorization such as names that could be misinterpreted or part of concepts that should be more thoroughly specified. The following changes were made:

Cost Structure
Revenues from hardware and software was made one category: cost structure, and it was decided to only offer software licenses as payment for software.

Maintenance
Maintenance, which before was included, was made a category where the customer could now choose to obtain customized updates and further development of the test system beside the regular maintenance and updates that were included.

Support
Originally, support stated only what type of support QRTECH could offer. Added to the Concept: Platform was the priority desired which states how fast the response time would be as well as the granted uptime, the maximum time for QRTECH to solve a problem.

Training
Added to training was a handbook of the system, explaining the functionality of the test system, its main components and how it should be used.

Location of QTS and QTS Owner
The categories of rig location and system owner were renamed location of QTS and QTS owner respectively.

To this platform based concept, it was also realized that an extension was needed. According to the interviews the concept of having everything entirely outsourced and thereby tested by QRTECH was still a good idea. This option was however difficult to fit into the updated platform structure. It was therefore decided to keep the concept of verification at QRTECH as a stand-alone concept, making the alternate version to consist of two concepts. It was decided to change the name of the concept to Outsourced. The reason for changing the name from verification at QRTECH to Outsourced was mainly because an outsourced testing project may not be limited to supplier verification and thereby the name might be misleading. The concept was adapted to the same structure as of the concept: platform. No alternatives are possible, it is one package where the cost is dependent on only the volume of ECUs to be tested. QRTECH provides testing of ECUs. Customers only specifies the product to be tested and obtain a report with the end result. There are possibilities to contact QRTECH by email. The concept: outsourced is illustrated in Figure 19.

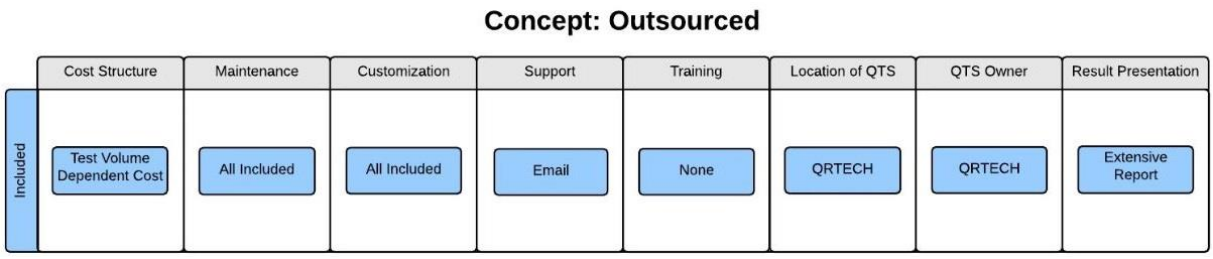

Figure 19: Concept: Outsourced

6.6.3 Concept Selection and Final Refinements

Interview iteration two was used in order to obtain feedback regarding what concepts to choose. All concepts were presented and the opportunity to give feedback was provided each interviewee.

The interviewees from the second interview iteration agreed that there was a need for many concepts, and that one single concept would not target enough customers. Flexibility is a major benefit for small companies that cannot target as many customer segments as larger international companies can. By using the platform concept rather than choosing one or a few of the other concepts will result in the possibility of meeting customers' needs of customized products. The platform will provide a common ground with the possibility to customize the features needed in order to fit into the testing procedures of a certain company.

Since the interviewees all agreed upon the fact that a type of platform was needed in order to reach all customers within the specified segments: development, production and verification, this concept was chosen to move forward with. Investigations regarding the final concept was started, looking into possibilities to refine and develop the concept further in order to end up with a final concept that meet the actual needs of customers. At this point, no major changes were made, only small refinements. Following is a list of these refinements:

Customization
One small refinement was the decision to divide the category of customization into three boxes instead of two: SW/HW framework, test specification and test development. Discussions regarding the platform concept concluded in the realization of the option test cases (see Figure 18) having two meanings; develop specification of test cases and develop/write the actual test cases in which the customer could choose whether to have both or just one of them. Thereby the option of test cases as add-on was replaced by test specification and test development.

Payment Structure
The category of cost structure was renamed to payment structure due to that it described the way customers pay for the QTS. This was a more accurate name for the category and would not mislead anyone into thinking it has something to do with another cost structure: one of the nine building blocks of the business model canvas.

Training
Training is not necessary due to that no customers will use the test system, however needed to point out is the fact that experienced test developers will handle the testing procedures. The option; none was thereby changed to experienced personnel.

7 Proposed Concept

In this chapter, the concept proposed for the commercialization of the QTS is thoroughly described. A BMC is also included, providing an overview of the new, updated version of the business model for the QTS. Lastly, an estimation of the profits will be made for two cases with varied volume of sales.

7.1 Concept Description

The final concept or solution, initially emerging from 9 separate concepts created by the morphological matrix and later refined by input from interviews and meetings, resulted in a solution consisting of two parts; Concept: Platform and Concept: Outsourced. Following is a description of these two parts which will be proposed to the company.

7.1.1 Concept: Platform

As mentioned earlier, the platform concept is a combination of all the concepts previously generated and provides the customer flexibility and customization. An illustration of the concept can be viewed in Figure 20. Each category and option is explained below.

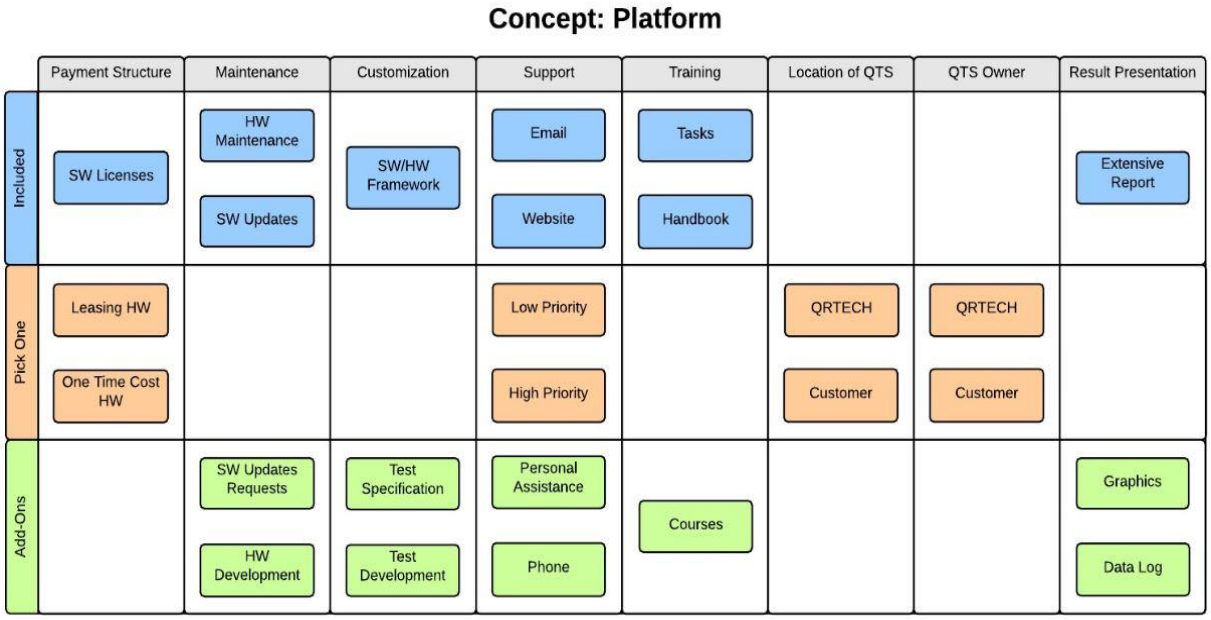

Figure 20: Illustration of final proposal, Concept: Platform

Payment Structure

The payment structure offers several different possibilities. Paying for a software license is compulsory and is thus always included in the package. The standardized price for the licenses will be 17% of the initial cost or value of the QTS, as the industry standard (QRTECH AB, 2015).

The choices for the customers in this category are weather to lease the hardware or to purchase it at a one-time cost. The most likely scenario is that when using the QTS in development, it will be leased, but when using it in production it might often be sold at a one-time cost. No matter what a customer choses, licenses will still be paid each month. In the leasing arrangement support and maintenance is included, but the monthly cost will differ depending on other choices the customer makes, for example how much support, priority and maintenance they choose.

If leasing is chosen, QRTECH will probably sell the QTE to a lease back company, which allows for QRTECH to not tie up their capital and instead use it for other investments. This after recommendation from the CEO on one of the weekly meetings.

The monthly rate depends on what choices and add-ons the customer chooses to their QTS package.

Maintenance

There are several different options regarding maintenance. General software updates and HW maintenance is always included, but if the customer would like something extra there are two different solutions, one is reporting it to QRTECH, and if they see that this can be useful for several different users, they develop it and it is added as a software update for free. However, this is not always possible or it may take time. The other option is that QRTECH develops the desired feature to the specific customer, but it is not covered as a general software update, the customer will need to pay extra to get the feature developed. The update will only be made for the specific customer. If a customer wants to develop the hardware further, it will always be at an additional cost, only maintenance to keep the QTS functioning is initially included.

Customization

The hardware and software framework, i.e., the physical HIL test machine and the customized test board, is always included in the package. The customer chooses whether or not to let QRTECH develop a test specification and test cases for them, or if they instead prefer to do it themselves. The test specification includes writing the specific requirement list for the test at hand, while the test development option includes writing test scripts as well. Both these options are ideal when using the QTS in production. When using the QTS in development projects it is of advantage for the customer to write the requirements and the test scripts themselves, as customers might want to obtain knowledge regarding HIL tests for future work.

Support

If problems regarding how to use the QTS or problem with the QTS arises, it is important to have an already specified support arrangement. In the package email support and a website with common questions will always be included. The email is on a standardized template, and the customer will receive help within a maximum of three days. The standardized template helps the support engineers at QRTECH to receive all the needed information from the start, this was recommended during interview iteration two, with the sales department.

Another choice the customer needs to make is how much priority they need, this covers response time, amount of support and at what hours support is available. High priority is recommended for customers using the QTS in end-of-line testing, as it is of high importance that the down-time is kept to a minimum. Most customers using the QTS for development will be sufficient with the low priority package, due to that it includes one hour a month set aside for support. The customer needs to make a choice between the high and low priority package. The high priority package costs more per year than if the low priority is chosen, and includes extra three hours of support per month as well as phone support. If a customer needs extra assistance or extended amount of support hours, this can be arranged at an additional cost.

Training
In order for engineers to use the QTS, tasks and a handbook will be provided in the package. It is highly recommended that the engineers perform the tasks before starting to use the QTS. At an additional cost, courses concerning how to use the QTS can also be bought. Both introduction and advanced courses will be available.

Location of QTS
The customer needs to choose between having the QTS at QRTECH or at their own facilities. Since the QTS is supposed to allow use for it through internet, it should not be of very high importance for the customer. However, it is easier for QRTECH to perform hardware maintenance, but the downside is that they may need to store several QTS.

QTS Owner
This option only concerns customers that have chosen to lease the hardware. It needs to be decided who owns the QTS after the leasing contract ends. If the customer is the owner afterwards, there will be a higher monthly fee during the leasing period.

Result Presentation
The customer needs to pick between an extensive test report and a data log as the result presentation. The extensive test report is likely preferred by the customer using it for development of products, the data log is often to prefer for end-of-line testing. The customer can also choose to add graphical presentation. This is often a good option for end-of-line testing, as it makes it clear how well the production is going. The graphical representation may for instance show number of produced products, how many that has been approved or denied and other statistics the customer would prefer.

7.1.2 Concept: Outsourced

The Concept: Outsourced is used for customers who does not want to take part of the testing procedure, but only want the final results of the tests as a measure of how well their products meet the requirements of their customers or their own requirements. In this concept, no decisions need to be made. All categories are predetermined and what is included can be seen in Figure 21.

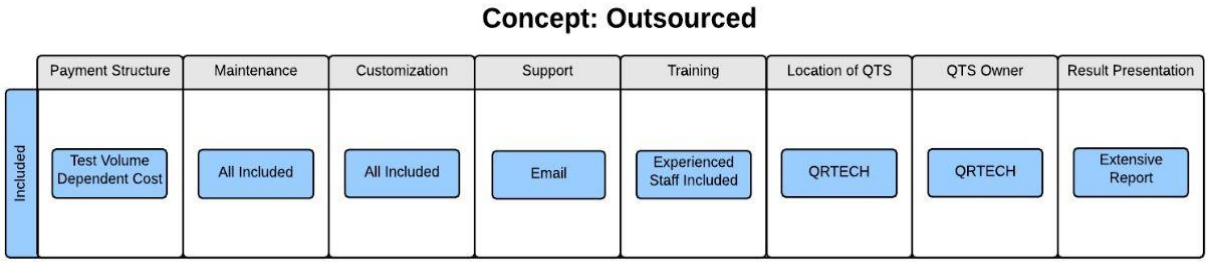

Figure 21: Illustration of final proposal, Concept: Outsourced

The Payment Structure of the concept is based on the volume size. No software licenses or hardware costs will be paid. Instead the payment will contain a one-time cost for the development of the test specification and test scripts as well as for the SW/HW Framework. Moreover, the customer will pay for each product to be tested as stated in an agreement or contract. This cost will be based on the amount of engineering hours needed to perform the tests as well as the estimated cost of maintaining and updating the system. The volume is specified in an initial state and thereby also the customer prices. After the volume decided upon is tested, there are possibilities to extend to another batch of products to be tested with the same system.

The concept provide the customer with full Maintenance and Customization, meaning updates of software, maintenance of hardware and to some extent receive requests of updates and further development of both hardware and software. Requests will in the end result in increased prices for the customer due to that QRTECH receives payment of the estimated engineering hours and supplies needed to execute updates and development, as previously stated.

Support will only consist of email to one specified contact in charge of the testing procedure of the specific product. No priority will be necessary due to that the email support will only consist of questions and support regarding the agreement, delivery aspects, etc. No actual support regarding the tests system will be needed since QRTECH executes the tests only. This goes for Training as well.

Location and ownership of the QTS will in every case be QRTECH. The tests will be carried out at QRTECH's facilities. The only thing the customer will be part of is the establishment of the test itself, providing the product and a description of that to be tested. They receive a full report in return once the test has been carried out.

In summary, the Concept: Outsourced has the input of a description of the product to be tested provided by the customer. QRTECH create a test specification, develop test scripts and a SW/HW framework and later perform the tests on the product. The customer receives a report with the test results. An illustration of this can be seen in Figure 21.

7.2 Business Model Canvas

Following is an updated version of the business model for the QTS. Under each of the nine building blocks, an updated description is provided as well as a guidelines to what needs to be

done to the current business model in order to be proficiently updated and changed into the new, developed business model. An illustration of the new business model adapted to the structure of (Osterwalder & Pigneur, 2010) Business Model Canvas can be seen in Figure 22.

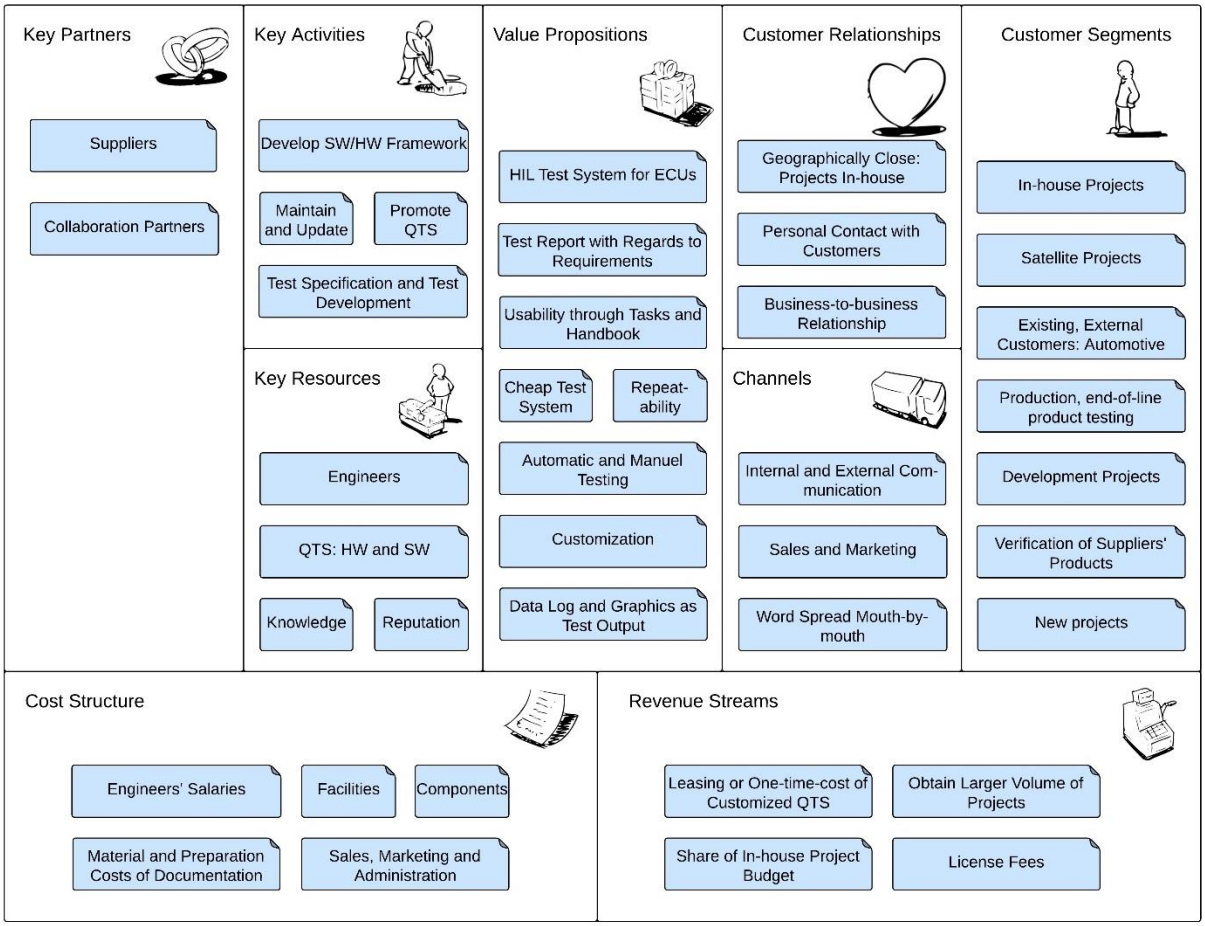

Figure 22: Business Model Canvas adapted to the Concepts: Platform and Outsourced

Value Propositions

The main value proposition in the QTS is that it allows for HIL testing of ECUs with regards to the requirements set by suppliers and other stakeholders. The automatically generated test report is of high value to the customer as it saves much time and presents both details as well as a summary of the results from the test. Customers may choose to also obtain test results in form of data logs and graphics, if desired. The possibility to repeat tests with the same prerequisites and parameters as previous tests is also a value proposition for the customer. The QTS can perform both automatic and manuals tests, during both the development and the end-of-line phase to a low cost, which adds value for the customer. Another important value is the possibility to customize the QTS's SW/HW framework as well as test scripts. Furthermore, QRTECH always provide a handbook and tasks of the test system for eased usability as well as provide educational courses if desired. The QTS's new concept provide the value of customization, giving the customer alternatives so that the entire offer will meet their needs.

In order to achieve this, QRTECH need to implement the platform based concept. The QTS need to be updated with the possibility to produce graphics and data logs with the test results. Also, QRTECH need to update test system continuously in order to constantly meet the needs of the customer. By starting to provide the value proposition to an increased number of customers, thorough documentation is needed both for the handbook and for in-house purposes such as creating courses material.

Customer Relationships
The customer relationships consist mostly of in-house relationships initially, but will expand to business to business relationship as the test system is sold to customers and not only to in-house projects. Starting with current customers will allow for a close relationship as the customers are already known to QRTECH. Customer relations that are already established will continue.

As in-house projects will remain, this type of customer relationships will remain the same. QRTECH need however to expand the customer relationships to new customers of the QTS that may be customers that they already have had business with. The challenge there lies in establishing new customer relationships with existing customers so that the customers remain happy with the relationship. This might result in having closer relationship with customer due to the new type of projects.

Channels
The channels that customers are reached through are for the most part sales department. The customers already have business with QRTECH and sales department sells the QTS as an extra feature. Information regarding the QTS is also spread to customers mouth-to-mouth. Channels will remain the same initially due to the targeted segment is existing customers.

Customer Segments
The segment of the QTS is development, verification and production testing of ECU's with focus on the automotive industry and customers QRTECH already have had business with. Also, it is suitable to start off by introducing the QTS for new projects that have not yet established a testing process.

The main difference from the initial business model is the focus of trying to enter new markets, such as verification of suppliers' products. QRTECH will still use the QTS for in-house development and production projects. The focus is now to find customers that want to buy the QTS as a stand-alone product for their testing procedures or customers willing to outsource testing of ECUs to QRTECH.

Key Partners
The suppliers of components and the collaboration partners are the key partners in the business model for the QTS. This remains the same for the new business model as well.

Key Activities
The most important activities in order to fulfill the value propositions are developing both hardware and software in order to keep the QTS up to date. It is also important to teach users

how to use the QTS and how to write test scripts to match the ECU under test. As the QTS now will enter new markets, it is important to promote the test system as a stand-alone product.

By selling the QTS as a product to customers, it is very much needed to continue fixing bugs as well as maintain and update the QTS. Developing the QTS further so that it is not only up to date but also industry leading will be necessary. Integration and compatibility with industry standards must be considered. Further development is thereby a priority and thus a key activity. Also, an important activity is marketing. Currently the QTS is only promoted as part of other projects. In order to expand into other markets, the marketing strategy must be changed so that it supports the new market growth opportunity that is focused on.

Key Resources

The key resources needed are the engineers developing the QTS and of course the QTS itself, its hardware and software. Another important resource is the established customers and the good reputation the company possesses. This is same both the current business model as well as the updated one.

Cost Structure

The main cost for the QTS is the development costs, the facilities, engineering hours and to some extent the components and the administration. Moreover, costs will also include hours for preparing marketing material, course material and other documentation that need to be prepared.

The main changes in cost structure lies in the increased amount of hours spent on developing the QTS, since more updates, bug fixes, graphics etc. will be needed before commercial ramp-up of such a test system. Also, hours for email, phone or other support will increase. Since little or no marketing material, course material or documentation is available, this will increase the cost as well. This cost is however temporary, and will decrease significantly after some time once this material is finished.

Revenue Streams

The revenues will mainly include the one-time cost or the leasing cost obtained from the test system framework and development cost. Depending on what pick one choices and add-ons the customer wants, this price will vary and thus the revenues will depend on each situation. Apart from that, a continuous revenues stream from software licenses at the amount of 17% of the total cost of the QTS will be collected. Furthermore, the QTS will still be part of in-house and thus obtain revenues from each projects in which is used.

The main difference in revenue streams is that the QTS will obtain a direct revenue stream instead of just taking part of other projects' revenues. In order to achieve this, a licensing and leasing agreement must be established as well as deciding upon a way of putting a suitable price for the offering, depending on what the customer chooses within the platform or outsourced based concept.

7.3 Profit Calculations

Calculations were made regarding profits and how long the payback time would be if the investment of around 1.7 million were to be made (as presented in Chapter 5.5). In order to estimate sales volumes and other parameters, two cases were created. Case 1 illustrates the scenario where an investment is made, however sales are somewhat continued as they are today with internal customers only. These numbers are based on today's sales, i.e., today's usage of the QTS in other projects. Case 2 illustrates a ramp-up of sales in the next five years, starting with the investment in the year of 2015 and increasing the yearly sales to 55 pieces a year in 2020. In the profitability calculation of both cases, one QTS and one license is included. If more licenses were to be purchased, the figures would differ slightly. These estimations of quantity were provided by QRTECH and can be viewed in Figure 23.

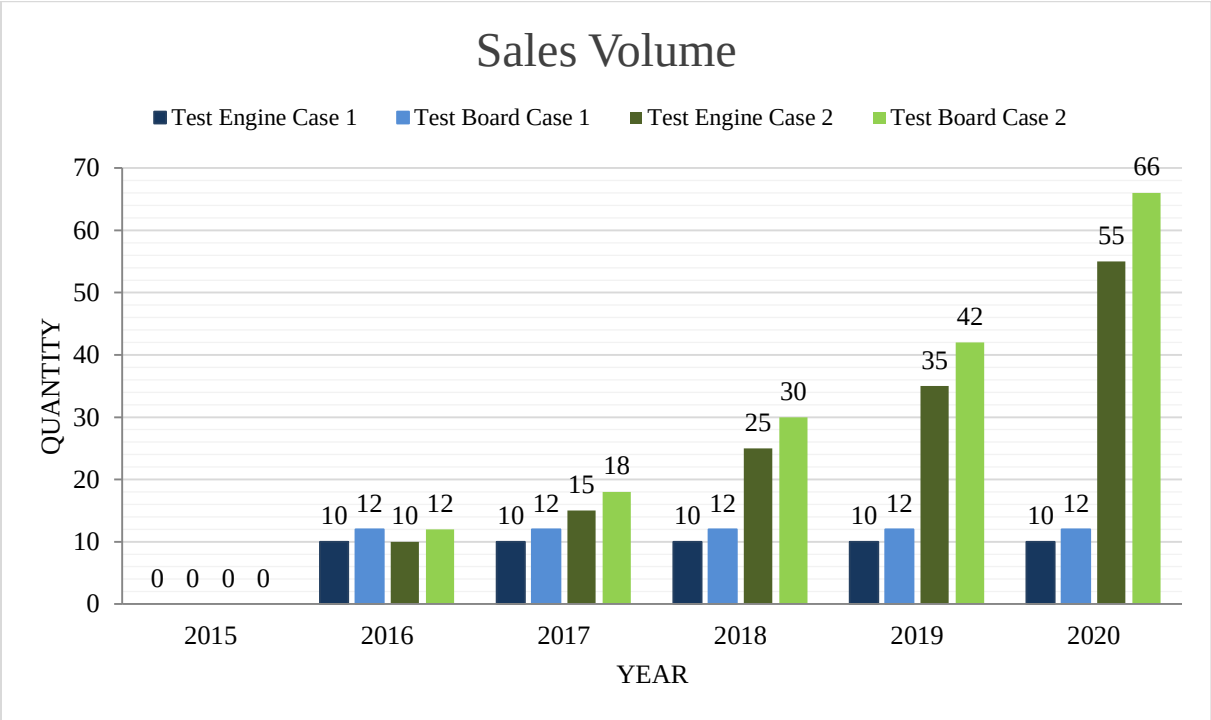

Figure 23: Chart illustrating the sales volume of the QTS for Case 1 & 2

In Table 9 and Table 10, the estimated volumes of sales for the next five years for the two cases are noted. Seen in both of the tables are the calculations made from these estimations. The QTS prices and costs are divided into two parts: Test Engine and Test Board. The reason for this being that a customer only purchase one Test Engine (the physical HIL test machine) but may purchase multiple Test Boards (possibility to test ECUs in many projects, or have spare ones). The cost of Test Board only includes standardized components such as I/Os. Cost will increase when adding development and production of customized components such as loads. These options will of course change the profits.

Table 9: Cost, revenues and profit for Case 1

Type\Year	2015	2016	2017	2018	2019	2020
Quantity: Test Engine [Units]	0	10	10	10	10	10
Quantity: Test Board [Units]	0	12	12	12	12	12
Accumulated: Test Engine [Units]	0	10	20	30	40	50
Sales & Marketing [h/Test Engine]	0	20	20	20	20	20
Revenue Test Engine & Test Board [SEK]	0	754 000	754 000	754 000	754 000	754 000
Revenue Support [SEK]	0	71 400	142 800	214 200	285 600	357 000
Resources Needed [%]	0	20	20	20	20	20
Dev. & Support Cost [SEK]	1 724 300	203 400	203 400	203 400	203 400	203 400
Sales & Marketing Cost [SEK]	0	110 000	110 000	110 000	110 000	110 000
Profit [SEK]	-1 724 300	512 000	583 400	654 800	726 200	797 600
Accumulated Profit [SEK]	0	-1 724 300	-1 212 300	-628 900	25 900	752 100

In Case 1, which can be viewed in Table 9, the accumulated profit is positive in 2019. Since the sales are estimated to be linear the only factor increasing the profits each year are the once obtain from support for the test systems that are used. Looking at the profits indicates that the the initial investment would be paid pack in the end of 2018. Worth noticing are the estimated resources needed and the sales and marketing hours per test engine, which is at a constant rate of 20% and 20 hours respectively.

Table 10: Cost, revenues and profits for Case 2

Type\Year	2015	2016	2017	2018	2019	2020
Quantity: Test Engine [Units]	0	10	15	25	35	55
Quantity: Test Board [Units]	0	12	18	30	42	66
Accumulated: Test Engine [Units]	0	10	25	50	85	140
Sales & Marketing [h/Test Engine]	0	50	50	50	50	50
Revenue Test Engine & Test Board [SEK]	0	754 000	1 131 000	1 885 000	2 639 000	4 147 000
Revenue Support [SEK]	0	71 400	178 500	357 000	606 900	999 600
Resources Needed [%]	0	50	55	65	75	95
Dev. & Support Cost [SEK]	1 724 300	490 500	544 350	652 050	759 750	975 150
Sales & Marketing Cost [SEK]	0	275 000	412 500	687 500	962 500	1 512 500
Profit [SEK]	-1 724 300	59 900	352 650	902 450	1 523 650	2 658 950
Accumulated Profit [SEK]	0	-1 724 300	-1 664 400	-1 311 750	-409 300	1 114 350

The example provided in Table 10, Case 2, states that in 2015, QRTECH will develop the QTS further so that it is ready for commercialization, with a total investment cost of 1,724,300 SEK. During 2015, there is no intention of selling the QTS. Once development is finished, QRTECH estimates to sell 10 QTS's the first year, increasing the amount each year to finish at 55 units per year in 2020 and with a total of 140 QTS's sold until 2020. In this case, the hours spent on sales and marketing is higher due to that the customers are not only in-house but external customers also. The initial investment of developing the QTS further will be paid back in the end of 2019.

The investment of developing the QTS to its current state as of project start is not included in the calculation due to that it was already developed and part of another business model. Worth noticing is also the fact that these calculations are only based on costs and profits of the QTS and the support fee. Not part of the calculations that generate profits are fees for developing test specifications, test scripts and customized load and simulation circuit boards, high priority support, educational courses, graphics and log result presentation, and requests for software updates and hardware development. These are however not as simple to estimate due to that all of these are specific to each customer, product and situation. All of the above mentioned extra features have the possibility of generating revenues. Customer prices will be dependent on the time spent on development and support as well as extra charges for material and component cost.

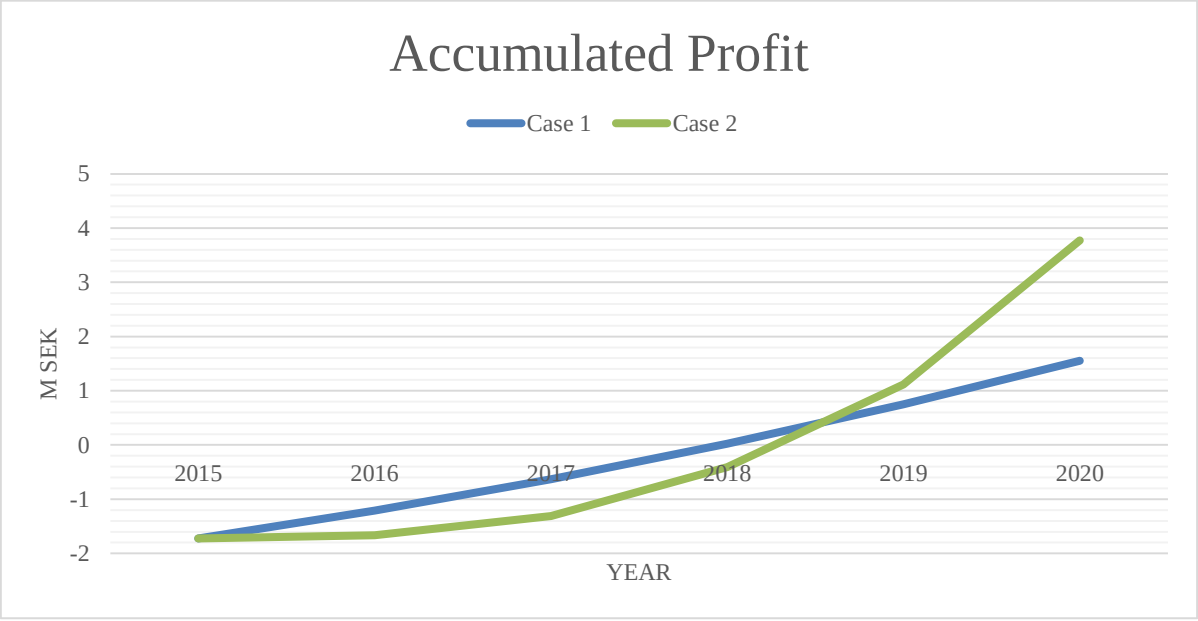

Figure 24: Accumulated profit for Case 1 & 2 in a span of five years

In Figure 24, the accumulated profit for both of the cases is shown. As seen, by choosing to increase the sales of the QTS by reaching external customers, the profits will increase drastically in a long perspective. At first, Case 1 will increase more in accumulated profits due to that the resources needed are at a constant of 20% while in Case 2 it is over 50% and increasing with the amount sold. Once sales increases, the resources needed influence on profits decreases. The payback time of both cases are within the five year span, with Case 1 reaching a little faster. After five years, the amount of sales possible for QRTECH is uncertain

due to unknown saturation of the market. In order to increase sales further there might be necessary to expand the customer segment outside the automotive industry or considering international sales. Since this is outside of the recommended starting customer segment, which was earlier decided upon, this will not be estimated nor calculated.

Table 11: Comparison of net present value for Case 1 & 2

Period		Case 1		Case 2	
Year	n	Cash Flow/Profit [SEK]	Present Value [SEK]	Cash Flow/Profit [SEK]	Present Value [SEK]
2015	0	-1 724 300	-1 724 300	-1 724 300	-1 724 300
2016	1	512 000	487 619	59 900	57 048
2017	2	583 400	529 161	352 650	319 864
2018	3	654 800	565 641	902 450	779 570
2019	4	726 200	597 447	1 523 650	1 253 511
2020	5	797 600	624 940	2 658 950	2 083 357
Net Present Value			**1 080 508**		**2 769 049**

According to the calculations made with the values presented, the project will generate profits either by continuing with the present sales as of Case 1 or if QRTECH chooses to increase sales like Case 2. The payback time will differ around a year. Another way of looking at whether or not the project is beneficial is considering the NPV. Using the two cases as before, with a time span of 5 years in total, gives a net present value of 1,080,508 SEK and 2,769,049 SEK for Case 1 and Case 2 respectively (calculations can be seen in Table 11). The general rule of NPV say that if the value is positive, the investment has paid off and the investment can thus be recommended. Both of the results are positive, implying that the investment is beneficial either way only more beneficial if going for increased sales as in Case 2. A disclaimer would be that the initial investment might differ in the two cases due to that continuous in-house sales would need less urgent development and marketing efforts compared to a commercialization. If the initial investment is lower for Case 1, the difference in total profits will also be less.

In summary, the Test Engine and the Test Board including support fee generate profits for both cases. Profits will be higher, however payback time will be marginally longer if the QTS is commercialized. Many of the changes suggested earlier must be done, disregarding the outcome of the thesis. Not included in the calculations are development of customized loads and simulation boards, development of test specification and test cases, and add-ons or choices that can be made in the platform concept. The concept: Outsourced is not part of the calculation. It is fair to say that commercializing the QTS may generate large profits for the company in a long perspective.

8 Conclusions

The purpose of this thesis was to develop a business model for the QTS, identify features that should remain from the current business model and what changes that need to be made. Moreover, changes in the product design, software and hardware should be identified as well as how the QTS should be packaged and sold to customers.

An analysis of the QTS potential resulted in the conclusion that market development is the most suitable possibility to achieve market growth. The strategy to use is cost focus, which indicated that keeping a low price on a narrow, niche market would be most suitable. Conclusions made regarding the customer segment was thereby to focus on achieving market growth by introducing the QTS to QRTECH's already existing customers as well as local customers within the automotive industry, including both manufacturers and suppliers.

Investigations regarding the commercialization of the QTS and how it should be packaged and sold to customers resulted in the proposal of implementing a platform based concept where some features were predefined, working as the common ground of the platform. Possibilities to choose between certain features were given as well as adding some extra features, all so that the test system is customized to fit the specific requirements and needs of a customer. Not fitting into the platform model was the option of having test procedures outsourced and thus a concept was created for that purpose. Conclusions can be made that this thesis, with support from the empirical findings and theory presented, points out that the Concept: Platform and the Concept: Outsourced in combination is the most suitable solution to use in order to commercialize the QTS for the above mentioned customer segment.

The existing business model for the QTS include the value proposition of enabling the possibility for QRTECH and their customers to test ECUs in development projects as well as end-of-line products. This, for a lower cost compared to operational environment testing. In the current business model, the QTS does not obtain any revenues alone, just as part of the projects where it is used. Main costs consist of engineering hours put into developing, updating and maintaining the tests system, as well as facility and components costs. QRTECH rely on experienced and skilled engineers developing the test system further and the key activities are mainly making sure the test system is up to date, modern and meeting the needs of the customers, thus a close relationship with those customers is needed. The existing business model, as described, provide QRTECH with many projects due to that the QTS is included. It is reasonable to conclude that the current business model is proficient in generating new projects for the company, thereby providing revenue streams. Conclusions were made that the current business model should be kept to a large extent. Changes are going to be necessary in order to adapt the concepts to the current business model, however few features will be removed. Features will instead be added or moderately refined.

Implementing the concepts of Platform and Outsourced result in a few changes to the current business model, as follows. The value proposition is ultimately the same, however the customer segment expands from in-house projects to also include customers from the automotive industry in which QRTECH has already established business with previously.

Apart from development and production, the new segment of verification is added to the business model. This expansion results in a need for larger marketing efforts, keeping close relationships with customer. Also, large efforts must be put on developing the test system further so that it meets industry standards, customers' needs and is bug free. The revenue streams are direct in the new business model, obtained from licensing and leasing agreements, one-time costs of SW/HW framework and additional choices that may be purchased along with the concepts. This updated model provide extra costs for the company too, of course, such as extra marketing efforts, increased amount of engineering hours and material for educational purposes. In conclusion, the current business model remains and some extra features are added so that the model target more customers from the segment previously described.

In order to produce and sell the QTS for commercial purpose, further development is needed. Following is a summary of the changes that needs to be made to the product. Software bugs, standardized interfaces and communication, improved error messaging support and support for multiple programming environments are all improvement areas in need of consideration. Documentation and specification of product as well as course material, tasks and sales material must be focused on. Conclusions can be made that in order for the QTS to meet the needs of customers, the above mentioned development and modifications must be considered and solved prior to commercialization. Also fair to conclude is that many of these changes are a necessity, disregarding neither sales numbers nor which customers to target.

The new business model, including an updated and further developed QTS has many possibilities in generating revenues for QRTECH. A case where 140 test systems are sold in a period of five years resulted in a net present value of over 2.5 million SEK, and an estimated time of four years until the cost of developing the QTS further is paid back. This figures can be compared to the scenario where sales remain the same and a net present value of around 1 million SEK is obtained after five years and with a payback time of three years. With the additional features that may be added and thereby would increase the revenues further for a commercialized QTS, conclusions can be made that there are great possibilities in earning money on a commercialization, even though the payback time is marginally longer, and can thus be recommended.

9 Recommendations and Discussion

In order for QRTECH to successfully commercialize the QTS, it is recommended to adapt the new business model and make the necessary investments that are estimated to cost around 1.7 million SEK. It is recommended to start by producing the needed documentation for the QTS. Even if QRTECH chooses to not commercialize the QTS, the documentation is needed for the continuous internal usage of the test system.

It is of high importance to develop the QTS further before selling it as a finished product to customers. One way to develop the QTS is to start a project at QRTECH that focuses on the QTS, another option would be to start a collaboration with another company that has interest in the QTS or a R&D project collaborating with a university and/or another company. This could be cheaper but will likely take more time and QRTECH will have to make compromises with the collaborating partner.

The features that need to be developed before selling the QTS is mainly updating it to industry standards, such as supporting bus signals CAN, LIN and FlexRay. It would also be beneficial it the QTS is compatible with other coding languages, as this allows the customer to reuse previous written test scripts and implement them on the QTS as well as that the users do not have to learn a new programming language at project start. A graphical interface and statistical output would also be a wanted feature. Another change that could be beneficial for QRTECH is separating the test bard from the load card, and turning them into modules, this would simplify the customization for each customer.

One of QRTECH's benefits is that the company already have good customer relationships, it is suggested that QRTECH starts promoting the QTS to their existing customers on a niche market, and keep the close business-to-business relationship. The niche market should preferably be the automotive industry due to the established relationships and local connection, Gothenburg having a strong industry related to automotive manufacturers and suppliers. One of the most important benefits with the QTS compared to larger firms' solutions with test equipment, such as dSPACE and Vector, is the possibility to have a close relationship and to customize the QTS. The contract should also be customized according to the chosen parts from the platform concept, so it suits the customer and QRTECH well. The flexibility and customization together with the lower price would provide QRTECH with a strong competitive advantage. It is however important to continue a dialogue with customers, so that demands are met in the future as well.

The two selling cases described in previous chapters are as mentioned examples; it might be possible to increase the number of sold QTS in Case 2 as well as the costs might differ in the end, which could increase or decrease the profit. It should be remembered that the two cases are not covering the cost and revenues from the add-ons in the platform concept or outsourced concept, as they are hard to estimate, but it is likely that the real scenario has a shorter break-even point due to this. However, it should be kept in mind that these scenarios are estimated, and when an investment is made there is no guarantee that the investment will pay off, regardless of how the estimated profit is. A recommendation is to further investigate in the

costs and revenues of the QTS, especially costs and revenues of the add-ons that may be chosen by the customer.

One way to reduce costs is if the users quickly learn to use the QTS correctly. This can be achieved by completing some training tasks. However, for the user to do so, the manager needs to point out the importance of doing this, it is otherwise likely that the user feels he or she have other more important work to do, and starts using the QTS directly, without having the basic knowledge, this will in a longer perspective cost more.

When designing the contract, it is important to exclude QRTECH from any form of responsibility if the test fails. QRTECH only tests the product with regards to the requirements decided upon and the service only provides a way of testing ECUs for errors anticipated. The responsibility of failures and recalls should lie on the customer.

Overall, there is reason to believe QRTECH will benefit more from adapting the new business model and using the two developed concept rather than keeping the original, however it is hard to estimate how many QTS that are sold, and there is a risk the investment might not pay off. The in-house usage is large enough to consider making the recommended changes to the product regardless of the volume sold to external customers.

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11 Appendices

Appendix A: Template for Interview Iteration One: Current Users

1. How would you describe the product (QTS)?
2. Have you used similar systems before?
    a. If yes, what are the main differences compared to the QTS?
    b. If no, do you have any ideas of how the QTS differ from similar systems?
3. What are the main advantages and disadvantages with the QTS?
    a. If you were to sell the product, how would you promote it? What are the major benefits?
    b. Are there characteristics found in other systems which cannot be found in the QTS?
4. What should the business model for the QTS look like, according to you?
    a. Maintenance and service
    b. Customization
    c. Education/courses
5. If you were to buy a product similar to the QTS, what would be the most important features?
6. What types of customers do you think are interested in buying the QTS?
    a. Production and/or development purposes
7. Are there any other aspects in need of consideration when commercializing the QTS?

Appendix B: Template for Interview Iteration One: Potential Users

1. Could you tell us about your company and what you develop/produce?
2. Are tests being made on your products?
    a. If yes,
        i. Are you using a HIL system or other type of test system?
        ii. What types of components are tested with the system?
        iii. What parts of the system are developed by the company and what parts have been bought pre-developed?
        iv. Is both hardware and software tested?
        v. Is the system used for tests in production and/or development?
        vi. How does the system handle traceability?
        vii. Are there any standards or requirements that need to be followed, such as ISO, etc.?
        viii. How is components tested with regards to requirements set by customers and suppliers?
        ix. Are tests carried out automatically, manually, or both?
        x. In what ways are employees taught about the system?
    b. If no,
        i. Do you need to perform tests? Do you need/want to test your product with a HIL system?
        ii. What qualities are you looking for in test equipment?
3. What are the most important properties when using a HIL system?
    a. What should the system be able to accomplish?
    b. Should the system be customized or designed by developers at the company?
    c. If you were to buy a product like this, what would be most important for you?
    d. Where would the test system be located?
4. What kind of business plan does your company have for its HIL/test system?
    a. Who takes care of maintenance and keep the system up to date?
    b. Who is responsible for faults or system failure? Ownership.
    c. How does you company handle training of its HIL system?
        i. Workshops, educational courses, learn-by-doing
    d. What costs are there?
5. In your opinion, what should a business model for a HIL system look like?
    a. Maintenance and service
    b. Level of customization
    c. Educational courses, workshops, etc.
    d. Support
    e. Location of rig
6. Are there any other aspects that we need to consider when commercializing a HIL-system?

Appendix C: Template for Interview Iteration One: Other Test Rig Users

1. Could you give us a short introduction to the company you work for and to the HIL-system you use?
    a. What types of components are tested with the system?
    b. What parts of the system are developed by the company and what parts have been bought pre-developed? Does the provider of the HIL-system deliver those pre-developed parts?
    c. Is both hardware and software tested?
    d. Is the system used for tests in production and/or development?
    e. How does the system handle traceability?
    f. Are there any standards or requirements that need to be followed, etc.?
    g. How is components tested with regards to requirements set by customers and suppliers?
    h. Are tests carried out automatically, manually, or both?
    i. How are test results reported?
        i. Graphically, report?
2. What major benefits and drawbacks are there with your HIL-system?
    a. Are requirements and wished fulfilled?
    b. If you were to promote the system to customers, what would be the major selling points?
    c. Are there functions that fulfill requirements poorly?
    d. Are there any attributes found in other systems that is not present in your test system?
3. What are the most important properties when using a HIL system?
    a. What should the system be able to accomplish?
    b. Should the system be customized or designed by developers at the company?
    c. If you were to buy a product like this, what would be most important for you?
4. What kind of business plan does your company have for its HIL system?
    a. Who takes care of maintenance and keep the system up to date?
    b. Who is responsible for faults or system failure?
    c. How does your company handle training of its HIL system?
        i. Workshops, educational courses, learn-by-doing?
    d. What costs are there?
5. In your opinion, what should a business model for a HIL system look like?
    a. Maintenance and service
    b. Level of customization
    c. Educational courses
    d. Support
    e. Location of rig
6. Are there any other aspects that we need to consider when commercializing a HIL-system?

Appendix D: Template for Interview Iteration One: Sales Department

Regarding QRTECH:

1. What kind of business plan does QRTECH have at the moment?
2. What main characteristics have contributed to QRTECH's success?
3. What are the major strengths, weaknesses, opportunities and threats?

Regarding QRTECH's HIL Test System:

1. Could you describe the QTS with your own words?
2. What do you know about the QTS?
3. How are you currently making money of the QTS?
4. What properties create the most value for customers?
5. Does any product changes need to be made in order to sell the QTS to external customers?
6. What type of business plan would fit this product?
    a. Service
    b. Maintenance
    c. Educational courses
7. Do you currently have any similar business plans for other products?
8. How should the product be packaged in order for it to sell as much as possible?
9. Do you have any other recommendations or comments regarding the commercialization of the QTS?

Appendix E: Template for Interview Iteration Two

Provide illustrations of concepts to interviewee and explain what the different concepts mean.

1. What do you think of the concepts?
    a. Customer coverage, customer needs, etc.
2. Regarding the Platform Concept
    a. Are there any choices that need to be changed, updated, added or removed?
3. Which concept do you think the customers would prefer?
4. Which customers should be targeted first?
5. Do you have any other thoughts, recommendations, etc.?