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Capturing Existing Innovation in an Incumbent Firm

A Refined Entrepreneurial Methodology

Master's Thesis
in the Management and Economics of Innovation Programme

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2018
Report No. E 2018: 087

MASTER'S THESIS E 2018: 087

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Abstract

During recent years, entrepreneurship is looked differently upon by researchers. Consensus is starting to form that entrepreneurship is not as much a personal trait as it is a methodology (Blank, 2005; Ries, 2011; Furr & Dyer, 2014). Corporations have at the same time discovered that they are facing problems when trying to adapt their organizations to an environment where technological breakthroughs appear at a higher rate than ever before. The answer may be corporate entrepreneurship, but entrepreneurial methods needs to be adapted to incumbent firms to enable them to keep innovating effectively (Furr & Dyer, 2014).

Several methodologies have been developed to cater this need (Ries, 2011; Furr & Dyer, 2014) and this study explores how entrepreneurial methods function within incumbent firms and we propose a refined methodology for organizations who want to enter new product markets with existing products. Most companies are supposed to have smart and creative people working for them and sometimes one or more of them will come up with an idea for an existing product which they believe have larger potential than what it is currently used for. This is believed to be an under-researched case in academia, as most entrepreneurial methods assume that the entrepreneur merely has an idea that will solve a specific problem (Blank, 2005; Ries, 2011; Eisenmann, Ries & Dillard, 2011).

The study results in two conclusions, partly a framework that is developed by refining existing entrepreneurial methods, and partly how business development teams, using this framework, should work with a level of autonomy from the day-to-day operations. The conclusions build upon already established theories and methods like Customer Development (Blank, 2007; Blank & Dorf, 2012), The Lean Startup (Ries, 2011), Innovator's Method (Furr & Dyer, 2014), Hypothesis-Driven Entrepreneurship (Eisenmann, Ries & Dillard, 2011), Effectuation (Sarasvathy, 2001a; Sarasvathy, 2001b) and Innovation Units (Burgelman, 1984), and adds three pre-steps to Hypothesis-Driven Entrepreneurship. These steps allow companies to find, explore and develop a business model for an already existing product, i.e. capture existing innovation.

Key Words:

Connectivity, Big Data, Lean Startup, Entrepreneurship, The innovator's Method, Icomera, Customer Development, Machine Learning, Artificial Intelligence, Predictive Maintenance

Acknowledgements

We would like to thank our tutor Professor Sören Sjölander for making this Master's Thesis possible and for providing both guidance and inspiration throughout the process. We would also like to thank Mats Karlsson and Rikard Reinhagen for all support, input and interest shown during our time at Icomera.

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1. Introduction

Technology advances rapidly and companies are forced not only to place more emphasis on frequent technological advances, but also to frequently develop business models that are aligned with the competitive landscape and current technology trends. Therefore, new methods for business development are discussed in literature (Blank, 2005; Ries, 2011; Furr & Dyer 2014) that contrast with the classic processes characterized by major investments to rapidly develop products with predefined business models.

In startup literature, theories and methods have instead been developed for the entrepreneur to search for a functioning business concept that can be transformed into a validated business model before scaling up and investing heavily. In this way, the entrepreneur develops and tests hypotheses about the business model's design and tries to find support for whether these hypotheses are correct or incorrect. This leads to creation and confirmation of business concepts from the very beginning and reduces the risk of wasted efforts based on incorrect hypotheses about the supposed problem, solution, or business model (Ries, 2011).

These startup methods have begun to interest incumbent firms as the methods are believed to be tools for creating well-founded business models in less time and with less economic effort (Ries, 2011; Furr & Dyer 2014). In the intersection of these startup methodologies and them being implemented in incumbent firms there is, however, a knowledge gap since startup literature, such as Customer Discovery (Blank, 2005), The Lean Startup methodology (Ries, 2011), Hypothesis-Driven Entrepreneurship (Eisenmann, Ries & Dillard, 2011) and The Innovator's Method (Furr & Dyer, 2014) are based on the entrepreneur having an initial idea or an insight to a problem which they can develop into a comprehensive business model. A believed common situation is, however, that there are existing products that have been developed within companies, which may have even larger area of application outside the company's current business area, i.e. product market. This situation is not extensively covered by existing startup literature and is therefore the gap that is intended to be closed by this study which proposes a refined methodology based on entrepreneurial methods, and specifically Hypothesis-Driven entrepreneurship. The refined methodology consists of the same framework used in Hypothesis-Driven Entrepreneurship (Eisenmann, Ries & Dillard, 2011) with a complementary module describing three pre-steps that entrepreneurs may consider when wanting to capture existing innovation in incumbent firms.

1.1 Background

Icomera, a spinout from Chalmers University of Technology in 1997, founded by four students, has developed a number of technological solutions for the transportation industry. Currently it has a turnover of approximately 600 MSEK and was bought in June 2017 by the French energy and communication conglomerate Engie. Icomera's core business is to provide Wi-Fi to different modes of transportation, mainly to trains, and product services based on their communication hardware. They are the leading actor in its niche internationally.

Icomera has recently developed a software tool for big data analysis called Discovery that collects large amounts of data from Icomera's current products and distinguishes data that deviates from the normal values at a particular time, place and for that particular item. Based on the detection of several deviant values, Discovery performs further data analyses which act as base for troubleshooting the hardware equipment. This will automatize and improve one of Icomera's current services and thus increase the value creation for the customer. There is however a strong belief that this tool also can be used for other product markets and purposes

than the ones Icomera focuses on at the moment[1]. Widening the focus to include new customer segments and industries means an increased amount of uncertainty (Furr & Dyer, 2014) which leads to a situation where Icomera must be able to handle this uncertainty, i.e. reduce the uncertainty, to be able to realize the full potential of Discovery. We believe this is a common situation among incumbent firms to have ideas and products that could have a high economic potential outside the company's current product market. This indicates that there might be a need for an adapted, complementary business development method that companies can use when they find themselves in a similar situation. Since startup methods are designed to handle high-risk environments (Furr & Dyer, 2014), the proposed business development method will be constructed by combining and adapting existing startup and entrepreneurial methods to fit the common case that Icomera represents.

1.2 Problem Discussion and Purpose

As Icomera believes Discovery can be used to solve problems outside their current business area[1], both technological and demand uncertainty are affected. These two factors are the components of uncertainty (Furr and Dyer, 2014), and are dramatically increased for Icomera if they wish to proceed with this vision.

As uncertainty increases, incentives to lower risk increase with it. One way to reduce risk is to use startup methods for taking a new product to market. Two core characteristics of these methods are rapid iterations with potential customers and partners through "experiments" in order to validate or reject hypotheses without investing too much time and resources, and to initially focus on valuable customer problems before developing solutions (Ries, 2011).

The purpose of this study is to refine existing entrepreneurial methods and develop an approach for firms to capture and exploit existing innovation outside of their current product markets. The study will, more specifically, develop a method for companies in the same situation as Icomera who wish to find additional product markets for their existing products. Therefore, the following research question is formulated: *How may entrepreneurial methods be adapted to help companies enter new product markets with existing products?*

1.3 Limitations

The study only investigates the case class of having an existing product in an incumbent firm that is expected to have applications outside the current product market. In the investigation of this assumed general problem, only one case will be examined, and general knowledge will be tried to be drawn from it. The case concerns the one company, Icomera, and one of their software tools, Discovery, which is under development.

The study is also limited in time due to the requirements that the end product will be a business case delivered to Icomera, and a master's thesis delivered to Chalmers University of Technology. Because of this limitation, the project of finding a new validated business model for Discovery was not fully completed and we only reached a proposed new business model with only a partly validated product-market fit. The methods being used to create the refined framework are chosen due to their prominent position in the body of literature about entrepreneurship, which means that relevant literature that has not been popularized to the same extent will be overlooked.

[1] Project initiation workshop with supervisors Mats Karlsson, Rikard Reinhagen & Sören Sjölander 2018-01-15

2. Literature Review

The literature review firstly focuses on Entrepreneurial Methods which starts with the model of *Customer Development,* leading to *The Lean Startup*, which is also an important building block of *The Innovator's Method*. Further, *Business Model Canvas*, a business model template, *Interviewing*, a background to how interviews should be designed when searching for new business models, and *Effectuation,* an entrepreneurial philosophy in opposition to the more traditional philosophy of causation, are presented. Finally, a method for idea generation, *C-K Theory*, is displayed.

Steve Blank published his book *The Four Steps to Epiphany* in 2005 and described the difference between executing business models and searching for business models as he introduced the Customer Development model. This, in many ways seminal book, builds upon his empirical experience from numerous startups during the 80s and 90s (Blank, 2018) and his work was a starting point for his student Eric Ries who later wrote the best-seller *The Lean Startup* in 2011 (Blank, 2013) and *Hypothesis-driven Entrepreneurship: The Lean Startup* with Thomas Eisenmann and Sarah Dillard the same year (Eisenmann, Ries & Dillard, 2011). Steve Blank summarized his experiences since *The Four Steps to Epiphany* and wrote *The Startup Owner's Manual* together with Bob Dorf in 2012 where they further developed the Customer Development model (Blank, 2018). In 2014, Nathan Furr and Jeff Dyer used the methodologies developed by Blank and Ries, among other scholars, to explain how successful companies innovate. This resulted in their book *The Innovator's Method: Bringing the Lean Startup Into Your Organization* in 2014 which presented a method for implementing lean business development methods in organizations (Furr & Dyer, 2014).

2.1 Customer Development

Steve Blank argues the traditional way of launching a new product, The Product Development Model, often ends with failure. Instead, he suggests a greater focus on the customer instead of the product and presents *The Customer Development Model*. This model suggests that businesses should be built in four steps; Customer Discovery; Customer Validation; Customer Creation; and Company Building (Blank, 2005).

The Customer Development model, see Figure 1, is further developed by Blank and Dorf who describe the model as an iterative process where the first two steps make up the Search phase. During Search, the entrepreneur turns visions into hypotheses and runs experiments to find out whether the hypotheses should be validated or invalidated. The aim is, firstly, to get an understanding of the customer problem and, secondly, to put proposed solutions in the hands of customers and validate, or invalidate, hypotheses. By applying iterations and pivots, when hypotheses aren't validated, the entrepreneur aims to reach a thorough understanding of the customer problem and develops a validated solution for these customer problems. When this is achieved, the entrepreneur should enter the Execute phase of *The Customer Development model* to perform the remaining steps Customer Creation, where sales are accelerated, and Company Building, where the business model is successfully validated and the startup can start to scale the business into a growth company (Blank & Dorf, 2012).

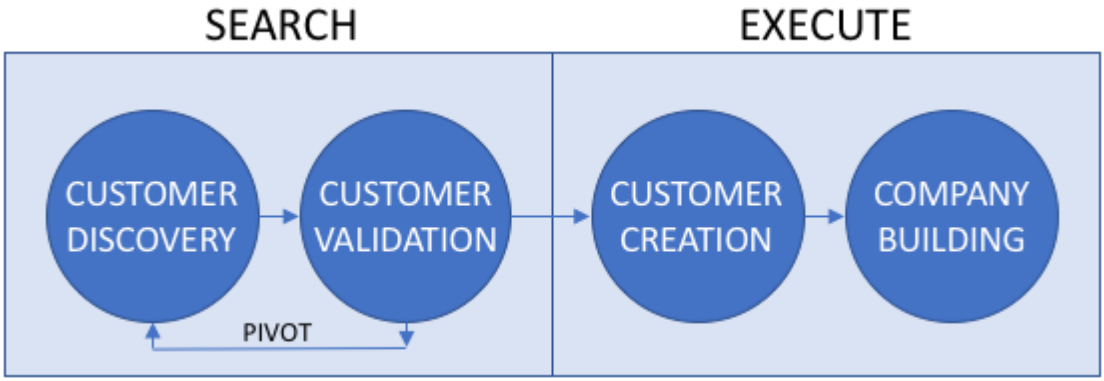

Figure 1: The Customer Development model (2012).

2.2 The Lean Startup

Eric Ries introduces a methodology he coins *The Lean Startup* as a quick way for an entrepreneur to develop a suitable business model for an initial and visionary business idea. This is done by implementing rapid loops of Build-Measure-Learn, see Figure 2, where the entrepreneur uses experiments to adjust the business idea by either performing pivots or perishing the initial guesses after having measured and learnt from previously built products or prototypes. *The Lean Startup methodology* rests on five principles: Entrepreneurs are everywhere; Entrepreneurship is management; Validated learning; Build-Measure-Learn; and Innovation accounting. In other words, Ries' message is that entrepreneurs exist in all industries, in both start-ups and large companies, and that anyone can act as an entrepreneur. Entrepreneurship is also a variant of management and it is focused on a process characterized by learning where the entrepreneur develops hypotheses and prototypes which are tested and evaluated. This means that it is difficult to assess the value of innovations with traditional methods, which calls for different approaches for evaluation (Ries, 2011).

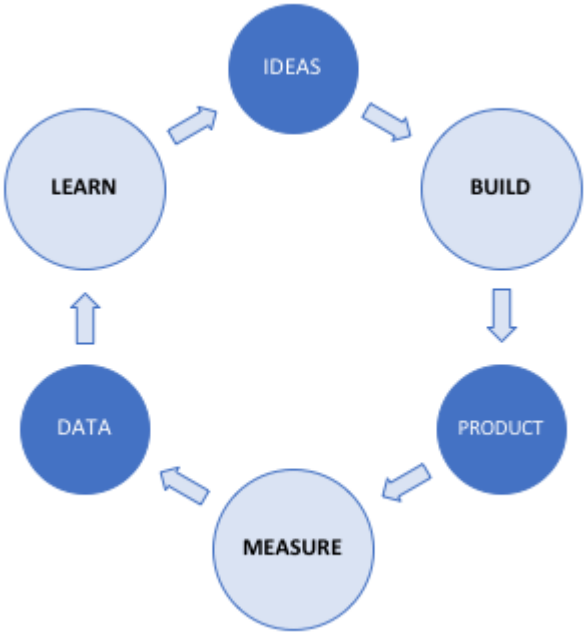

Figure 2: The Build-Measure-Learn Loop used in Lean Startup (Ries, 2011).

Robert Eisenmann, Eric Ries and Sarah Dillard refine the work process of *Lean Startup* in their article *Hypothesis-Driven Entrepreneurship (2011)*, see Figure 3. The entrepreneur should start by setting a vision which is translated into falsifiable hypotheses. For each hypothesis, Minimum Viable Product tests, MVP tests, should be designed and prioritized in order to be able to run experiments and learn from them, i.e. build-measure-learn. Finally, the entrepreneur has the choice to either preserve, pivot or perish the vision depending on whether the hypothesis was validated or rejected. If the vision is preserved, the entrepreneur continues to run tests on other important hypotheses until a product-market fit is found. This is when the hypothesis testing is done and it is time to scale the business. Otherwise the vision should either be refined or perished (Eisenmann, Ries & Dillard, 2011).

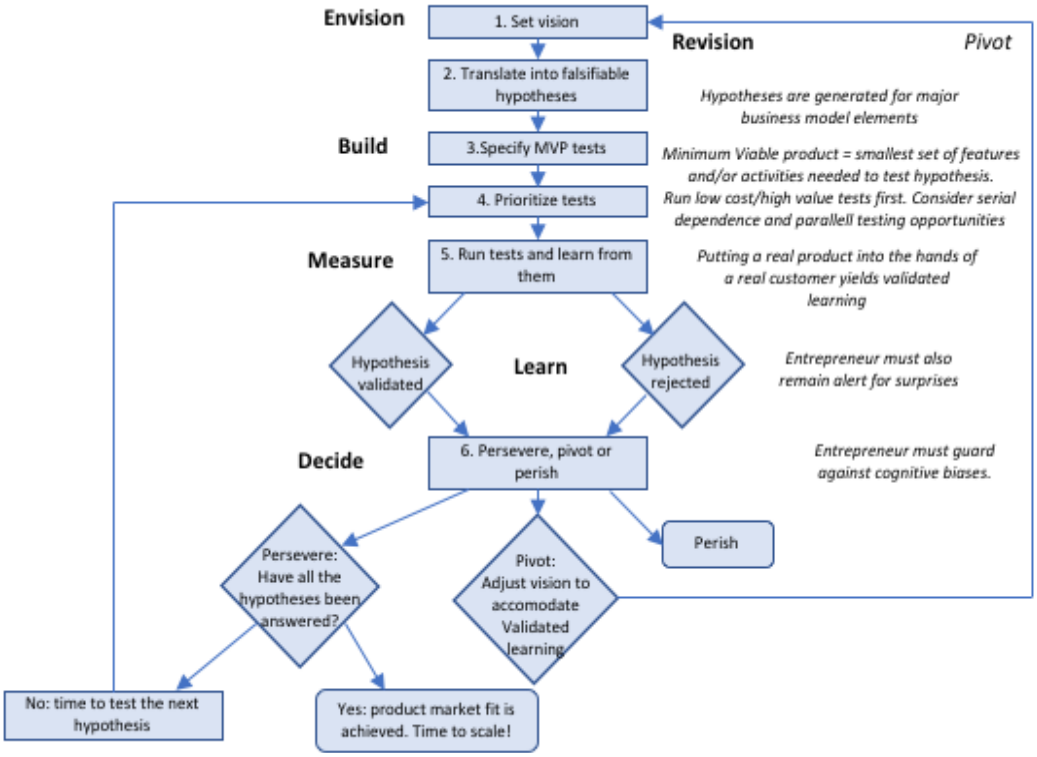

Figure 3: Hypothesis-Driven Entrepreneurship Process (Eisenmann, Ries & Dillard, 2011).

2.3 The Innovator's Method

Clayton Christensen illustrated, in his book *The Innovator's Dilemma*, established firms' issues of not being able to compete with agile startups. The incumbent firms, in his studies, lacked the capabilities to readjust the focus toward disruptive innovations fast enough and therefore missed opportunities that more agile startups could leverage in their favour (Christensen, 1997). Ries (2011) meant that Lean Startup could be used anywhere and that entrepreneurs exists everywhere and these ideas were further developed by Furr and Dyer who put together several existing methods also involving creativity and ideation, open innovation, design thinking, agile software, Lean Startup, and Business Model Canvas, to aggregate it all to *The Innovator's Method* (Furr & Dyer, 2014).

The Innovator's Method is designed to help entrepreneurs in incumbent organizations to take insights and ideas through an iterative process of Insight, Problem, Solution, and Business Model before the business idea should be fully scaled, see Figure 4. The purpose of the method is to eliminate as much uncertainty as possible and use inexpensive and rapid loops of testing hypotheses and learning. Although the method itself can be alternated in its execution, the

authors propose that entrepreneurs should begin with gaining insight about potential customer problems and thereafter discover the job to be done which, thoroughly, illustrates customer's core problems. When the customer problems are understood, the entrepreneurs should formulate as many solutions as possible and start forming hypotheses about them which can be tested with experiments of MAPs, Minimum Awesome Products, in the hands of customers. When, finally, a product-market fit is validated the rest of the business model components and aspects should be hypothesised and tested in order to build a repeatable and scalable business (Furr & Dyer, 2014).

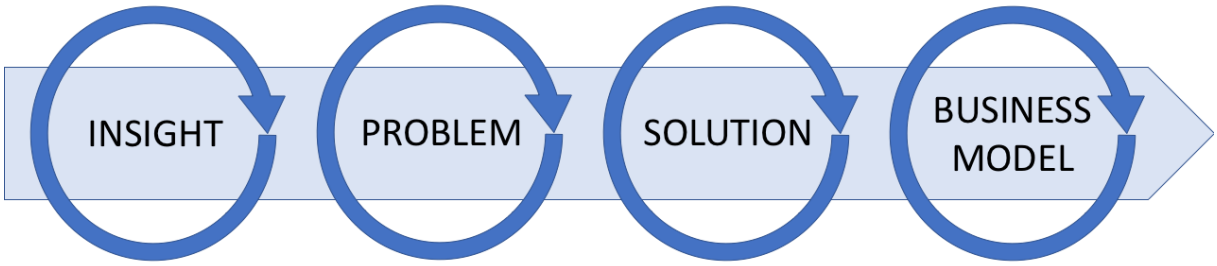

Figure 4: Illustration of The Innovator's Method consisting of the iterative steps Insight, Problem, Solution and Business Model (Furr & Dyer, 2014).

Furr and Dyer's method is ultimately designed for entrepreneurs dealing with high uncertainty, of either customer demand or technology's abilities and performance or both, but it can also be adapted to situations characterized by lower degrees of uncertainties or even situations where organizations don't wish to implement the method at all (Furr & Dyer, 2014).

2.4 Business Model Canvas

The business model canvas is a template for illustrating an organisation's business model. A business model "…describes the rationale of how an organization creates, captures, and delivers value" (Osterwalder et al., 2010, p. 14). The template is divided into nine sections describing different key elements of a business model, see Figure 5. The offering element is Value proposition, the customer elements are Customer Segments, Customer relations and Channels. The infrastructure elements are Key activities, Key resources and Key Partners. The Finance elements are, finally, Cost structure and Revenue Streams (Osterwalder et al., 2010). The canvas can be painted on a large surface so that groups of people can jointly discuss the elements of the canvas and sketch the content of the elements with markers or post-it-notes. Questions they can ask themselves to help fill the elements with content are shown in Figure 5. By visualising the business model in this way, a groundwork for business model innovation is laid which can allow companies to innovate in other ways than inventing innovative products or services (Osterwalder et al., 2010).

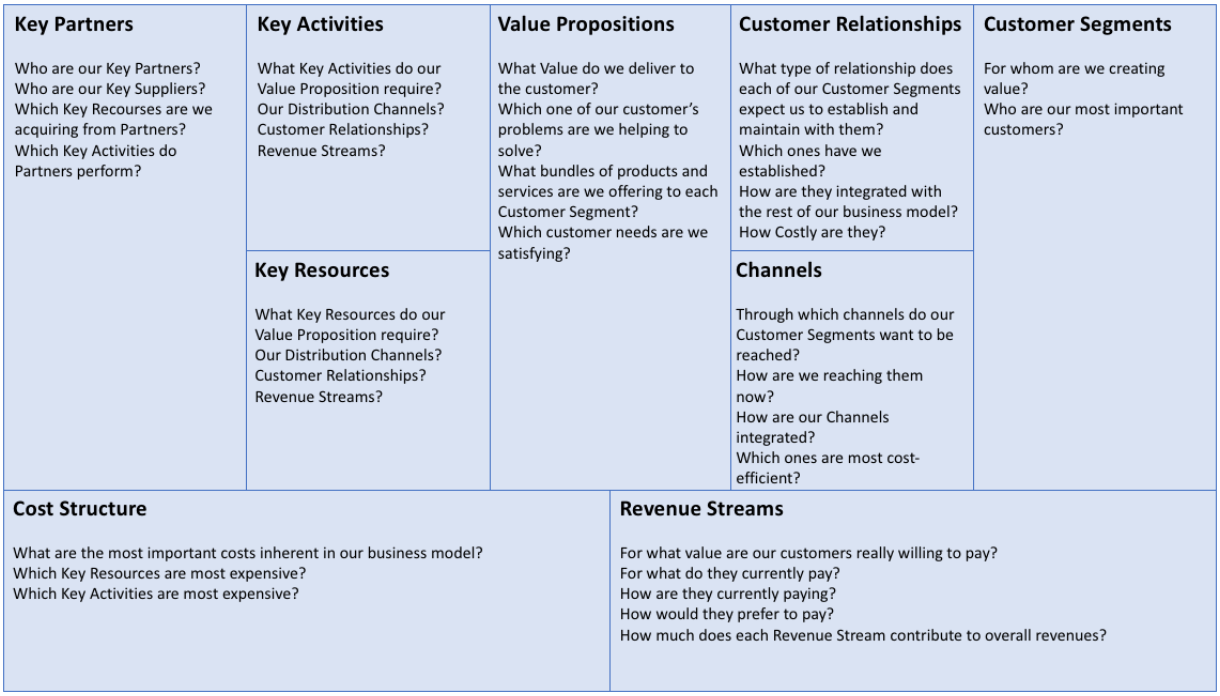

Figure 5: The Business Model Canvas (Osterwalder et al., 2010).

2.5 Innovation Units

Burgelman (1984) claims that there exist corporate entrepreneurs in organizations who can come up with products that are more or less disconnected from the company's strategy. How the proposals from corporate entrepreneurs should be treated depends on two factors; strategic importance, and operational relatedness.

To find out the *strategic importance* of the entrepreneur's proposal, management can ask themselves questions like if it helps them to move to new markets, or find out where not to move to, if it can create a defensible niche or if it can put the company at risk. Corresponding questions for *operational relatedness* can be which capabilities that are needed for the proposal, how these are acquired, and how they affect existing capabilities in the company.

Depending on how strong these two factors are, there are numerous ways to design an organization for corporate entrepreneurship. The degree of strategic importance the proposal has will impact the level of control posed on the business development project, and the degree of organizational relatedness will impact the level of efficiency that the business development project will managed at. Based on this, Burgelman (1984) has constructed a matrix to illustrate nine different organizational designs and when they may be used, see Figure 6.

Figure 2: Strategic Importance (Burgelman, 1984).

2.6 Interviewing

A motto of startup methods is to "get out of the building" in order to collect information needed to either verify or dismiss a hypothesis about the market. This approach to product development has gained ground over the traditional approach of writing a business plan, pitching it to investors, assembling a team, and launching and selling a product. However, getting out of the building is easy, doing it right and gaining the maximum amount of insight is not. Constable (2014) has in the book *Talking to Humans* described how early customer discovery can be performed correctly.

Qualitative research puts high demand on the researcher to be systematic and thoughtful in collecting and analysing data. A set of core question can be helpful to think about when doing qualitative research in order to help in this endeavour:

Who do you want to learn from? There are some groups that often are educational to talk to. The typical customer that is envisioned to be among the first ones to use the product, the early adopter that will take a chance and use the product before others and critical partners for the business can all be used to gain valuable insight.

For business to business, B2B, products, it is a good idea to map out the different buyers in the enterprise and figure out which ones are champions or saboteurs for the product. There is often a strategic, economic and technical buyer, as well as the actual user of the product.

What do you want to learn? It is more effective to hear a story from the interview subject that highlights related problems or other incidents than an opinion or a speculation. It is also a good idea to ask the subject open-ended questions in order to get the subject to speak freely. Often it is effective to make the situation more real as well. Making the interview subject to believe that they are buying an actual product is a good way to test the willingness to pay and a good way to gain a lot of insight is to expose the subject to a prototype. The researcher should also be prepared to stray off the interview guide when an interesting lead comes up in order to not lose valuable insights. Finally, the researcher should be able to observe the behaviour of the interview subject since observations can gain just as much insight as the answers to the questions.

How do you find your interview subjects? Constable (2014) emphasises three general rules when finding the interview subjects:

- Try to get one degree of separation away. Don't interview someone who has a personal connection to you, i.e. close relatives or friends.
- Be creative. Try to find several ways to find interview subjects.
- Fish where the fish are. If a method doesn't work, try something new (Constable, 2014, p. 45).

Other tips that can be useful when trying to find interview subjects is to observe the supposed moment of pain that can be addressed. Go to conferences, use LinkedIn, make the subject refer to more interesting people, and make gatekeepers such as assistants to senior employees refer to the right person. Asking for advice due to the subject's expertise and mentioning that you are a student or researcher are methods for people to be more open to speak freely.

How to ensure an effective session? Several methods for making the session effective are suggested. They include practical tips such as doing the interview in person, talking to one person at a time and have one person quietly taking notes alternatively use a recorder, warm up the subject with a few easy questions, get the subject to tell a story rather than speculating, and find out if the pain is acute enough and if they even have tried to solve it themselves. The interviewer should not be afraid to be silent, to ask why, or to parrot back what the subject just said to drill down into a subject and to avoid misinterpretations.

How do you make sense of what you have learned? Once the interview is done, what remains is to extract insights from the notes. Qualitative data collection through interviews will not give statistically significant data but will instead let the researcher gain insights through recognition of patterns in the interview notes. This can be made by an exercise where the team gathers to write down all interesting observations they picked up during the interview on post-it notes and then have them put up and sorted into groups of patterns. These patterns can guide the interviewer to make decisions and design the product through intelligent interpretation of the patterns. To ensure qualitative data from the interview, one should expect false positives since most people are inclined to be polite, and make sure to get enough interviews to make the results reliable. Constable (2014) finishes with claiming that Customer Development and Lean Startup are powerful ways to increase the odds of success but that the need for a vision is immense and the proposed techniques are only ways to reality-check and optimize the road to that vision.

2.7 Effectuation

The notion of effectuation was created to explain the creation of firms, organizations and markets. *Effectuation* is defined by Sarasvathy (2001a) as processes that "take a set of means as given and focus on selecting between possible effects that can be created with that set of means" in contrast to the notation of causation as the process that "take a particular effect as given and focus on selecting between means to create that effect". *Effectuation* is a tool to use in highly uncertain environments in order to pose control over the future. To know when effectuation is an appropriate tool to use, Sarasvathy (2001b) introduces the notion of the suicide quadrant, which represents the situation where a new product is launched in a new market. This combination creates a situation of very high uncertainty which managers to the fullest tries to avoid, thus the name suicide quadrant. In other situations, causation is a relevant mind-set, but when entrepreneurs try to innovate they often enter the suicide quadrant and to navigate in that environment effectual thinking is needed.

Some key principles of *effectuation* constitute the core of effectuation:

1. The Bird-In-Hand Principle.
   The given means that are used to create effects can be found by asking yourself three questions. The answers to these questions can be sorted into three different categories; the individual level, the firm level, and the level of economy:

   I. Who am I?
   Individual level: Traits, tastes and abilities
   Firm level: Physical resources
   Level of economy: Demographics

   II. What do I know?
   Individual level: Knowledge corridors
   Firm level: Human resources
   Level of economy: Technology regimes

   III. Whom do I know?
   Individual level: Social networks
   Firm level: Organization resources
   Level of economy: Socio-political institutions (Sarasvathy, 2001b).

2. The Affordable Loss Principle
   Sarasvathy (2001a) means that one should calculate the affordable loss rather than expected returns. This means that one should determine the amount of loss that is affordable and experiment as much as possible until that amount is met.

3. The Crazy Quilt Principle
   Strategic alliances should be formed rather performing competitive analyses. Forming strategic alliances and pre-commitments is a way to raise competitors' barriers to entry and to lower uncertainty (Sarasvathy, 2001a).

4. The Lemonade Principle
   Contingencies should be exploited rather than focusing on pre-existing knowledge. In an uncertain environment, effectuation works well to exploit contingencies that arise unexpectedly over time (Sarasvathy, 2001a).

5. The Pilot-In-The-Plane
   Controlling an unpredictable future is favourable before predicting an uncertain one. Instead of buying into the market, one can create and control the market together with stakeholders (Sarasvathy, 2001a).

2.8 C-K Theory

C-K theory is a step-by-step method to concretize the activity of brainstorming and is developed by Agogué et al. (2014). *C-K theory* distinguishes between two spaces that members of the C-K session has to iteratively move between; the so-called knowledge space (K-space), which is the collective knowledge of the members, and the concept space (C-space), which consists of all the creative ideas with no logical status that the members come up with.

The members of the *C-K session* can move in several directions within and between these two spaces. They can move accordingly:

- K to C: Disjunction. This movement removes properties from K to create concepts in C.
- C to K: Conjunction. This movement seeks for knowledge that can give logical status to the concepts.
- C to C: Partition. This movement can either restrict or expand the concepts that have been created.
- K to K. Expansion. This movement collects new information which increases reliability of the K-space (Agogué et al., 2014).

Following this structure will help participants brainstorm in a structured way, thus being more successful with reaching new ideas than during an unstructured brainstorming session (Agogué et al., 2014).

3. Research Method

The purpose of this study is to bring different bodies of entrepreneurial theory together in order to build a refined framework adapted to find a new product-market fit for an existing product, and thus allow companies to grow horizontally. According to Edmondson and McManus (2007) this kind of research, when several bodies of theory that have previously been studied are put together in a new context, is called intermediate theory research. This kind of research constitutes for specific research elements in order to achieve what is called a methodological fit.

3.1 Literature Search

A literature review serves a number of purposes. It helps researchers to

- learn from previous research,
- provide a context for a research project,
- refine the research projects topic,
- highlight flaws in previous research, and
- outline knowledge gaps (Easterby-Smith, Thorpe & Jackson, 2015, p.13).

The literature used in this study was chosen through a literature review process explained by Easterby-Smith, Thorpe & Jackson (2015). The process is divided into three stages: The first step is to establish the topic, scope, and aim of the literature review. This study's purpose is to fill a gap in existing entrepreneurial literature which limited the literature review to this and surrounding subjects. The second step is to find literature within the set limitation and to record and evaluate it. While collecting literature that is within the limitations, its relevance, acknowledgement, and addition was continuously evaluated. Due to these conditions, the starting point for the literature review was the entrepreneur and professor Steve Blank who is referenced to by many scholars within the field. Students of his has also become highly cited in the subject and several books and articles are based on his and his students work. The most prominent work of these scholars were chosen as literature for this study. Another scholar that is more or less disjoint from Steve Blank but writes in the same theme and has gotten a considerable amount of attention is Saras Sarasvathy, whose early work was also added to the list of literature. Furthermore, literature about organizational design for innovation was needed and therefore frameworks for innovation units were added. The third and last step of the literature review process was to summarize and organize the literature around different themes. This was done in chapter *2. Literature Review.*

3.2 Choosing Method

An appropriate method for theory building is to perform a case study (Eisenhart & Graebner, 2007). A single-case study can deeply study a phenomenon and richly describe all the aspects while a multi-case study builds a more generalizable and reliable base for emerging theory (Eisenhart & Graebner, 2007). In order to get the right level of detail from the case to enable theory refinements, and due to the difficulties of finding similar cases and the time constraints, a single-case study was chosen.

Sampling of cases for a single-case study is made by choosing an "unusually revelatory, extreme exemplars, or opportunities for unusual research access" (Eisenhart & Graebner, 2007,

p. 27). Since access to Icomera was ensured and the phenomenon was distinct, it was decided that this case was appropriate.

3.3 Performing the Study

In order to build the refined framework, a set of entrepreneurial methods for finding product-market fit were used when working on the business development project connected to Icomera's big data software tool Discovery. During the course of the project of finding the product-market fit, the entrepreneurial methods were combined and altered to allow us to use them in the context of already having a pre-existing product.

We worked hypothesis-driven to either find a product-market fit according to the Lean Startup (Ries, 2011; Eisenmann, Ries & Dillard, 2011) or to find a situation where a product-market fit can be created according to the logic of effectuation (Sarasvathy, 2001a; Sarasvathy, 2001b). The hypotheses were either rejected or verified on the basis of newly gained information through interviews and secondary data collections.

During the study of analysing the business development process to be able to propose a refined methodology, another report was simultaneously created for Icomera. The aim of this second report was to provide all relevant information collected about future applications, business opportunities and potential value for Discovery in new product-markets. Findings from this latter report are summarized in this study's empirical findings to support the narrative story, but sometimes information is either sorted out or anonymized because of confidentiality.

3.4 Data Collection

In order to achieve methodological fit, the collected data should be of a hybrid nature, which means that both quantitative and qualitative data can be collected to complement one another (Edmondson & McManus, 2007). The process of finding a product-market fit was examined through observations and a refined framework was later developed on the basis of key events. Observations were made through the lenses of the existing literature.

The main part of the qualitative data came from our own documentations about the work process and the quantitative data was collected by e.g. comparing the number of interviews we were able to get by going through, on one hand Icomera's own connections and channels, and on the other hand by not going through any official channels. By gathering data in these ways, it was investigated which approaches were more successful, and the reasons for this, and we could adapt the theoretical frameworks accordingly.

3.5 Data Analysis

The goal of the data analysis was to test new propositions in an exploratory manner. Since there was an exploratory nature of the analysis, in contrast to an explanatory nature, patterns were identified rather than statistically concluded. To achieve methodological fit, a range of data analysis methods could be, and were, used such as content analysis, exploratory statistics, and preliminary tests (Edmondson & McManus, 2007).

Both interviews and observations were analysed by a technique proposed by Constable (2014). He proposed a method that involved entrepreneurs to read through the notes or transcripts and write down interesting observations on post-it notes which they put up on a wall. When the entrepreneurs have read through the material they start to arrange the post-it notes in groups to reveal patterns. After some time, a few overarching phenomena will be unveiled.

3.6 Validity, Reliability and Generalizability

The study seeks to explain the environment in a business development project through the eyes of corporate entrepreneurs. This makes the findings subjects for interpretation depending on which lens the observer are looking through, may it be an entrepreneur, or a manager. The study thereby has traits of a constructionist epistemology (Easterby-Smith, Thorpe & Jackson, 2015). The type of epistemology that the research is characterized by has implications on how to interpret the notions of validity, reliability, and generalizability.

From a constructivist point of view these notions can be treated by answering the following questions. *Validity*: "Have a sufficient number of perspectives been included?" (Easterby-Smith, Thorpe & Jackson, 2015, p.103). To strengthen the validity of this report, multiple bodies of theories have been used to provide different perspectives of the business development process. For example, instead of only grounding the literature review on *Hypothesis-Driven Entrepreneurship*, several other connected frameworks and methods were complemented. Also, the perspective of *Effectuation* and of *Innovation Units* were included. *Reliability*: "Will similar observations be reached by other observers?" (Easterby-Smith, Thorpe & Jackson, 2015, p.103), *Generalizability*: "Is the sample sufficiently diverse to allow inferences to other contexts?" (Easterby-Smith, Thorpe & Jackson, 2015, p.103). Since it was decided that the level of detail that could be acquired from a single case to build the framework was prioritized over making the framework as general and reliable as possible (Edmondson & McManus, 2007), it was recommended to make further evaluative tests to examine its reliability and generalizability. However, the robustness was tried to be maximized by using both quantitative and qualitative measures when evaluating different phenomena. Qualitative measures could be impressions from interviews and observations, while quantitative measures could be the frequency of a certain word by an interview subject or other source, or by comparing the number of successful contacts that were made by going through two different channels. Even if many perspectives from the rail and train industry have been included, no perspectives from outside the industry has been taken into account. Neither have we been working from within another company than Icomera which increases the risk of the findings to be firm and industry specific.

4. Empirical Study

The empirical study is presented as narrative story in which we present the course of events from our own point of view in order to make the level of detail of the different phenomenon visible. These details, may it be observations, sentiments or others, all help to form the new method that will be developed. The empirical study is divided into six sub-chapters which represent six sprints performed during the project. A sprint is a period of the project with certain objectives to work towards. In this project every sprint ends with either preserving or perishing hypotheses and formulating new hypotheses. An exception is the last sprint which consists of work connected to formulating a comprehensive business model. All subchapters, except the sixth subchapter, are further divided into two parts: Firstly, the personal narrative story, based on project diaries, is presented; and secondly, the gained insight and knowledge that was made during this time period will be presented.

4.1 Stating the First Hypothesis

When we, the scholars of this paper, were introduced to the company Icomera, the assignment and mission was to explore alternative business opportunities for one of Icomera's software tools, Discovery, which was under development. The 15th of January we met with all supervising stakeholders to the project, representing both Chalmers and Icomera, to specify a plan and to get some necessary background to the company's current business and the initial business plans for Discovery. The interpreted description of Discovery at this point was a diagnostic tool developed for their current Wi-Fi products in order to increase the up-time and quality of the service.

The first milestone was set two weeks ahead, to January the 31st, when a workshop session together with the stakeholders was scheduled. The purpose of this session would be to collect, generate and develop business ideas for Discovery and the time until the workshop would be spent generating ideas without any restrictions. One supervisor at Icomera, added some complimentary wishes, though, that we noted as limitations to the idea generation. Although we were encouraged to bring all kinds of ideas to the workshop, he explained that the common saying "there are no bad ideas" is not completely true and the workshop session would be an opportunity to evaluate which ideas could be of interest for Discovery and Icomera. He encouraged us to search for low hanging fruit and sweet spots. These were interpreted as problems that do not need advanced additional code or sensors but still could generate as much value as possible for the customer. We noted these guiding principles as reminders which would be used to guide our ideation process.

The following days we were left to work on our own, although possibilities to talk to supervisors existed both at the office and by calling them. The feeling of being partly lost in both the domain of the technology and Icomera's current business pushed us to spend most of the time reading at the company's web site, search for all available news articles about the company and googling all technical terms we did not understand. We noted that what Discovery does in practice is to automate parts of the maintenance procedure for Icomera's hardware. This made us look into what other types of maintenance existed which resulted in a dynamic document which developed into a small report: *Maintenance*, which presented a theoretical background to general industry of maintenance. The Maintenance report started out, the first days, as a collection of descriptions and texts, mostly from Wikipedia and YouTube movies, about maintenance strategies and methods that we tried to match together into a holistic picture of the field. Later, we reached out for reading tips from students at the Production Engineering programme at Chalmers and could replace and complement the report's content with material

from the article Impact of Maintenance (Mobley, 2008). This more rigorous material gave us a more in depth understanding of the maintenance domain.

The learning curve was at that point steep, as we felt that we were making us more comfortable with the specific business linguistics. We were able to have more concrete discussions with the supervisors who lectured us about different products developed within the organization as well as a more in-depth description of the initial purpose of Discovery which was to automate and make troubleshooting more effective. The reality for Icomera have been to analyse different data inputs manually translate these data illustrations into actionable troubleshooting reports. More qualified analysts could potentially find more hidden issues, but with the help from Discovery even deeper insight about their equipment can be made automatically. Apart from the dynamic report produced, an industry analysis according to Porter's six forces framework and an environmental analysis according to a Pestel framework were made to further support our broad understanding of Icomera and the industry it operates within.

The broad readings about Icomera and maintenance prepared us for a series of pre-workshops the 29th and 30th of January. During these days a structured brainstorming session was performed. The structure followed the process of CK Theory (Agogué et al., 2014). The first input used for the CK sessions was the knowledge about Discovery collected through unstructured interviews with the Innovation Manager and one of the Innovation team members during the first two weeks. We could distinguish the core functions and attributes of Discovery and label them as rare and valuable resources. These attributes and also the starting point for the CK analysis were: *Detection of deviations in data*, *Wi-Fi maintenance*, *geographically trackable system*, and *implementation on public transport*[2]. The first concepts to be explored were developed from the idea that they should generate data where deviations could be of interest; Weather, Mechanics, and Health. These three areas were then explored until more specific areas were recognized which either ended with a concrete idea, need for new knowledge, or an area of no interest for further exploration at that moment. The relevant outcome of this session is illustrated, in broad terms, Appendix A. All ideas were collected and saved for the workshop session.

The CK session let us be creative in an organized way and the results of the session were further developed during the following days as we continued asking the same questions, about what knowledge that needs to be collected in order to understand formulated concepts and what new concepts that can be formulated out of new knowledge, to push our knowledge base and concept formulation further. This period felt like a breakthrough as we started to generate a list of own ideas.

The results of the CK analysis were then taken to the workshop with representatives from both Icomera's innovation division and from Chalmers the 6th of February, as the workshop had been delayed one week. The workshop had been announced by the head of the innovation division and he chose and invited the participants from Icomera. The purpose of the workshop was to reason around which customer segments to focus on and what problems that Discovery can solve and finally narrow down the alternatives to the most feasible to be investigated further. The result of the workshop was that the most feasible and potentially profitable options was to target the freight industry in the markets where the freight train operator and the rail owner is the same actor. The reasoning behind the result was that to be able to use Icomera's resources and contacts, Discovery should not be moved too far from Icomera's current business area, which is transportation and substantially the train operating industry. According to the head of

[2] Interviews with Mats Karlsson & Rikard Reinhagen, Icomera, 2018-01-15 - 2018-01-25

innovation, only about 6 % of the delays for the Swedish train operating company SJ were due to faults in their own trains and planning, the rest were due to other train operating companies and faults connected to the rails. This led to two lines of reasoning, either Discovery could be used to further expand Icomera's ecosystem on passenger trains, which is potentially a highly profitable but crowded segment of the market with many powerful actors, or Discovery could be used to solve obvious problems in the less profitable but underserved freight industry. It was finally decided that business opportunities for Discovery should be investigated within the rail industry, both for applications in the infrastructure and on train cars and locomotives. The first step would be to seek the pain-points within this industry and what factors that drive the costs.

Ideas we had presented that could be considered *out-of-the-box* or with an experimental character would not be further explored during the session and it was again emphasized that the project should focus on *low hanging fruit* and *sweet spots*, as described above. Although we felt that the project was more steered by the stakeholders than we initially thought it would be, we felt relieved that we during the first weeks had gained a lot of understanding about Icomera and Discovery, and that the objectives to aim for were all clear to us as we could continue the project. The day after the workshop, we summarized the session and made a plan for our future work. The head of Innovation at Icomera stated during the workshop that there are major problems in the maintenance of several aspects of rail and trains. As we had planned to work hypothesis-driven, as proposed by Ries (2011), we formulated a first hypothesis to investigate this: *Insufficient maintenance accounts for large costs in the train and rail industry*. This hypothesis would guide our research during our next sprint and hopefully give insight in what kind of maintenance that is most costly and what can easily be solved by Discovery.

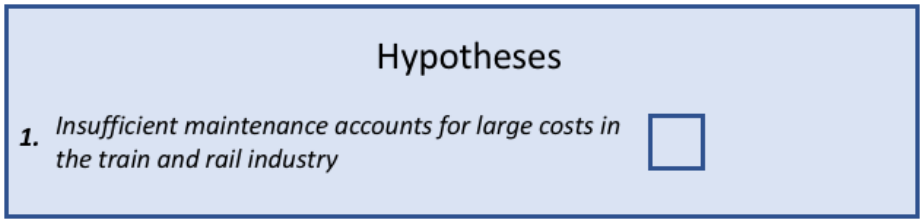

Figure 3: Hypotheses formulated during the first sprint.

4.1.1 Gained Insight

This sub-chapter provides a brief summary of key information and insights collected during the project's first sprint. Firstly, an Industry and a Pestel analysis are presented, secondly a short report about Maintenance gives a background and some definitions to this domain, and thirdly the CK analysis used for our ideation process is presented.

Industry Analysis and Pestel Analysis

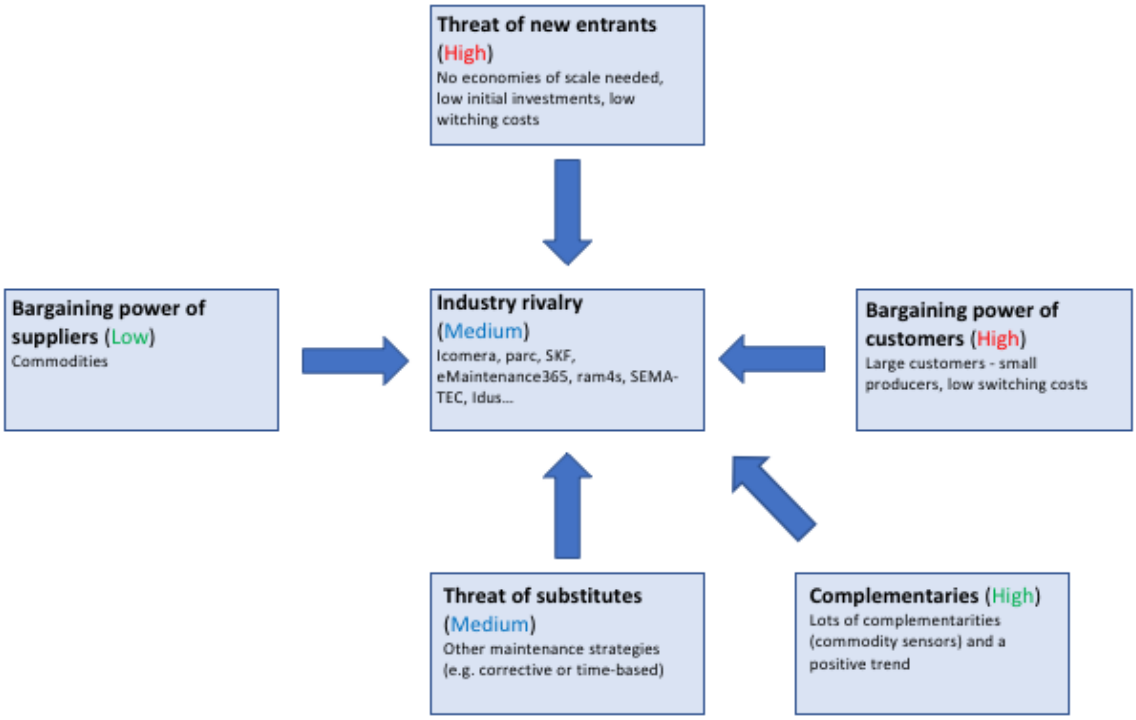

Figure 4: Industry analysis produced during the first sprint with focus on companies providing predictive maintenance solutions.

The Industry Analysis performed according to the Porter's six forces provided a first glimpse of the competitive landscape for actors trying to compete with predictive maintenance solutions for the rail industry. The framework was not used for deep analysis, but rather used as a structured tool to gain initial understanding about the industry. It is clear that there are companies that talk about using predictive maintenance within different industries, both in Sweden and abroad. There are other competing strategies used in industry, instead of predictive methods. These might be more suitable in some cases, but it all comes down to the costs of performing every strategy and what risks the methods carry, in terms of what happens when they fail. There is a high risk of new entrants as economies of scale isn't needed, niche solutions without high investments are possible to appear and the switching costs are low in this early stage. Suppliers of sensor technology act in a highly competitive environment and have low bargaining power on predictive maintenance IT companies, but customers who demand these solutions are often large compared to the providers and they have, again, low switching costs.

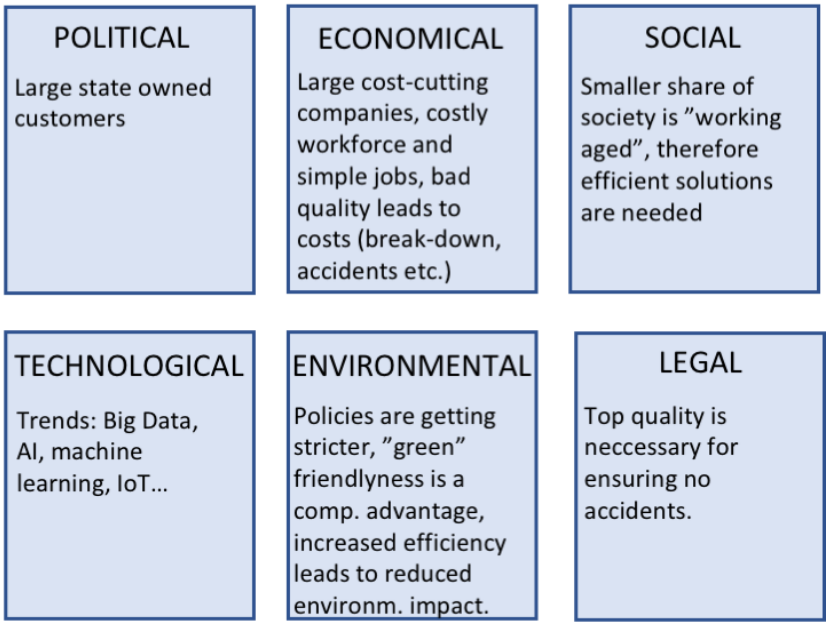

Figure 5: Pestel analysis produced during the first sprint focus on maintenance companies within train and rail.

The Pestel analysis provides a brief summary of the industry's environment. In this case, the analysis is made with rail maintenance companies in mind. This analysis is also performed in order to provide a rough understanding of the industry, and not to provide detailed facts. What stands out as important is to decrease breakdowns and costs, but at the same time top quality is needed in order to ensure safety. Owners of rail are large organizations owned by the state, which hypothetically can affect the way business is done and developed as states seldom are considered to be fast adopters of new technology and business models. Economic consequences within this large industry are probably a lot of waste which needs to be cut down and bad quality which at the same time needs more investments. This should also be closed connected to environmental factors in the industry as regulations are getting stricter every year within transportation overall. Another issue might be that a large workforce is needed to perform simple jobs, but the group working ages people is decreasing compared to the total population. Finally, the big trends in society now are big data, artificial intelligence, machine learning and internet of things, among others. These should also be important to considered within the industry of railway maintenance.

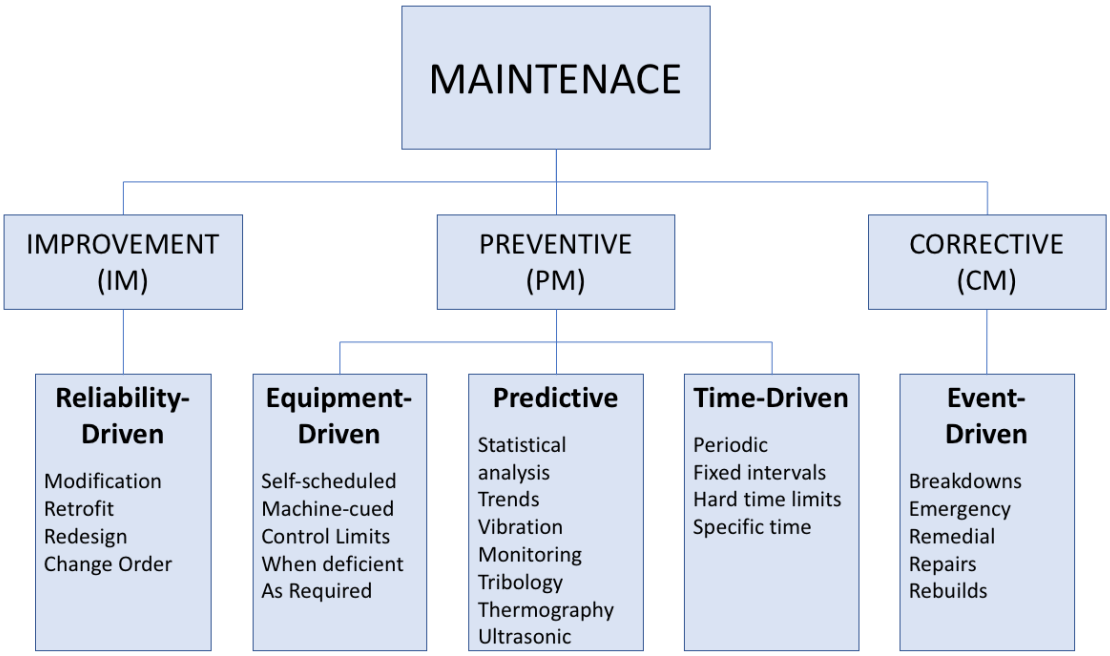

Figure 6: Maintenance overview illustrating different methods and strategies for maintenance.

Maintenance strategies can be divided into different categories. Corrective maintenance is the riskiest strategy which applies maintenance when a breakdown has occurred. The opposite is to apply preventive maintenance with the aim of preventing breakdowns. The downside, though, is that often too much time and resources can be spent on maintenance. The most effective strategy is therefore to optimize the time when maintenance should be performed. To enable usage of this strategy it is necessary to monitor the condition of components and analyse all data in order to create a credible and dynamic maintenance plan (Mobley, 2007).

Total maintenance reliability is considered one of the key factors to achieve operational excellence, and optimization of preventive and condition-based maintenance is crucial as companies should aim for elimination of sources to loss (Laurens & van der Molen, 2009).

The terms Condition-based maintenance and Predictive maintenance are often spoken about in similar cases. The difference between them both could be interpreted as: Condition-based maintenance is based on condition data and enables preventive actions to be performed before a breakdown occurs. Predictive maintenance, on the other hand, also tries to predict when a breakdown will happen. The choice between these two methods should be based on which method most cheaply and efficiently will prove positive results. Sometimes simple monitoring of conditions is enough, other times predictive analyses with the help of different data sources might be a better choice (Kovacevic, 2015).

4.2 Getting a Grip of the Industry

As the previous sprint was ended with a narrower scope for the project than earlier and the following hypothesis was formulated: "*Insufficient maintenance accounts for large costs in the train and rail industry*", we could focus our efforts on collecting information. The work was still in the first of Furr and Dyer's four steps, which is collecting insight, but with a narrower focus this could be done more effectively.

The head of innovation at Icomera provided us with two contacts that could be used to either interview, or to channel us through their respective organisation to knowledgeable people who

could provide valuable information and insight. The contacts worked at Trafikverket and SJ, which were both considered highly relevant organisations for the project. We were at this point filled with a strong sense of the power of being a part of an incumbent organisation.

It was soon discovered that the received contacts were not suitable interview subjects due to their roles in their respective company. The hope that they could guide us through the organisation was however still there, but the contacts proved to be less than willing to cooperate with us. One of the contacts did not want to put us in contact with other people in the organisation and the other did not respond to repeated attempts to get in contact. After some time, we started to realise that we would have to start an attempt to get interviews on our own, through official channels.

In order to know who to contact, we started to map out the major actors in every field of the train and rail industry. The conclusion was that the industry is mainly made out of predictive maintenance system providers, train operators and maintenance contractor. As contacts with a government agency and a train operator already had been gained, it was clear that maintenance contractors as well as maintenance system providers should be contacted to get a full picture of the problems in the industry. This pushed us to make first contact with the two largest maintenance entrepreneurs on the Swedish market; Strukton and Infranord.

During the meantime as we were trying to get in contact with knowledgeable people in the various fields of the industry we researched the area of maintenance of rails and trains. This research led to the valuable insight that insufficient maintenance leads to faulty rails, switches and crosses which in turn lead to huge delays and repair costs. Insufficient maintenance on the rail and on trains also leads to damaged wheels that also causes massive delays and additional costs. These insights were considered enough evidence for the previous set hypothesis "*Insufficient maintenance accounts for large costs in the train and rail industry*" to be considered verified, but too broad in its character for being able to validate a product-market fit which made us persevere and formulate a new hypothesis to test. The gained insight from the research of maintenance costs woke interest in how much of the cost of insufficient maintenance can be avoided by condition based maintenance. Since the initial research showed that condition based monitoring has not been widely implemented throughout the industry, quantifying the exact cost saving can be difficult and instead the second hypothesis was formulated: "*Condition based maintenance of trains and rail is a suitable method for solving problems in the industry".*

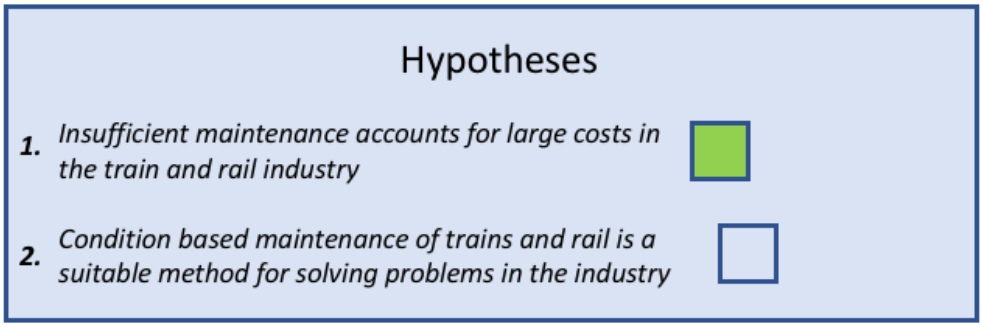

Figure 7: Hypotheses formulated and verified during the second sprint.

4.2.1 Gained Insight

During the second sprint, the search for knowledge and insight was focused on actors and getting a picture of the costs of maintenance within the rail industry. Firstly, a section about

some of the actors found which aim at providing predictive maintenance systems for rail is presented, followed by two chapters about Swedish actors within train operations and rail maintenance. Finally, a chapter gives brief insight about the costs within the rail industry.

Actors within Predictive Maintenance Systems

When looking into the actors of predictive maintenance, a myriad of companies appears, large and small. A distinguishing factor for this industry seems be just that firms has discovered that there is a demand for predictive maintenance solutions, which has led to the attraction of both technological giants and startups.

eMaintenance365 Analytics is one of the newcomers that stems from a research project in predictive maintenance at Luleå University of Technology. The company was founded 2013 and employed nine people in 2017, including the six working founders (Thoresson, 2017). They provide a graphical user interface used to analyse, predict and present the remaining useful life (RUL) based on real-time data (eMaintenance365, 2016).

eMaintenance365's tools are tested by Trafikverket, SJ, and LKAB in Sweden and companies in Australia are showing interest in the solution as well. During the beginning of 2017, a subsidiary in Australia was founded in order to reach a larger market and the goal is to grow both in the railway industry and process industry (Håkansson, 2017). In January 2018 the company closed a deal with the Swedish company Norrtåg which operates in the northern parts of Sweden as a train operator. Norrtåg will use the analytical tool together with the operator and maintenance provider. Prior to this, eMaintenance365 also closed deals with LKAB and Cargonet (Håkansson, 2018). During 2016 the company had a revenue of 3.7 MSEK and a positive result of 41,000 SEK compared to the numbers of 2015: 3.3 MSEK revenue and 211,000 SEK profit (Alla Bolag, 2018).

Another newcomer is the startup Konux that is a Munich-based IoT-company monitoring and analysing data from assets and infrastructure in the railway business. The goal is to reduce maintenance costs by decreasing the number of unplanned stops and improve processes by an increase of efficiency. Their solutions are built both for rail (infrastructure) and industrial applications. Konux use an approach in four steps: Measure, Connect, Analyse, and Act. Firstly, the need for data is explored in order to be able to create valuable insight. The right sensors are installed if all needed data isn't yet collected. In the next step data is connected by a wireless system. In the next step, all data is analysed using algorithms, AI and machine learning. Lastly, the information created from the analysis is presented in a comprehensible way (Konux, 2018).

Deutsche Bahn is digitizing switches and crosses in collaboration with Konux. Instead of the traditional way of checking switches' health in fix intervals, Konux is helping DB to monitor the health and thereby improving availability (Konux, 2017).

Firms from other industries also enters the predictive maintenance market. These are firms that perform statistical analyses such as SAS - Statistical Analysis System and Bentley, firms already active in the train and railway industry such as Railnova and SKF, and technological giants such as IBM, Siemens and Hitachi.

Statistical Analysis System is a company that started as a North Carolina State University project aimed at analysing agriculture which ended up with the company foundation 1976. They have developed a platform for analytics which creates insight from connected data and consider themselves to be more of a whole solution than many of their competitors: "Plenty of companies

offer point solutions, focusing on one part of the whole. But we have always stood back and considered the entire sweep of the messy and fragmented analytics landscape in an effort to predict the future of analytics" (SAS, 2016, p.3).

SAS has established customers such as major vehicle manufacturers which they help to equip cars and trucks to be safer and more responsive to human needs and interactions. Another example of a business that SAS offers is to analyse biometric data streaming from wireless, wearable medical devices that allow patients to remain at home while under surveillance of a physician. Other industries that SAS operate within are commercial banking, pharmaceuticals, health insurance, electricity, retail banking, telco and service providers, hotels, and food services. They are also a major actor within the train and rails business Customers include VR Group that uses SAS Analytics to identify causes of failure and provide on-time service by looking at new and historical data which helps VR Group to optimize maintenance intervals and thus reducing the amount of maintenance costs by a third (SAS, 2016).

SAS's revenue was during 2016 $3.2 billion (50% America, 36.6% Europe, Middle East and Africa, and 13.4% Asia Pacific). 12% respectively 6% of the revenue came from Service and Manufacturing industries (SAS, 2016).

Railnova has developed a product which lets you monitor the health of the train fleet and provides actionable insights and support. Automatic fault codes and alerts are sent to notify relevant abnormalities in the data. Further, Railnova lets you monitor the location of your fleet in real time using Railster GPS and it is possible to digitize the maintenance on Railfleet. Railnova has established customers such as Eurotunnel, Lineas and DB Cargo (Railnova, 2018).

Bentley provides a solution that combines asset condition data with environmental, financial, and design data. It collects, views, analyses, and manages every dimension of the railway infrastructure and its conditions over time. Bentley combines different software products and services to build a specific solution for each case, e.g. at Hallandsåsen for keeping track of the process and minimize environmental impact, and at London Vauxhall Cross for providing insight about existing conditions (Bentley, 2018).

SKF, the Swedish manufacturer of bearings, are now developing condition monitoring systems for rail. Their aim is to increase maintenance intervals and uptime by collecting data from their sensor systems on the boogies, analysing the data with their algorithms and finally present the condition (SKF, 2018). The boogie testing includes condition tests of the TSI boogie, cardan shaft, traction motor, derailments, axle bearings, TSI hotbox, axle box, wheels, gearbox, gearbox oil, and gearbox oil levels (SKF, 2012a). Temperature monitoring of boogies are another product SKF are offering which includes sensors and a warning system for malfunctioning components when both new train installations and retrofitting (SKF, 2012b).

SKF Insight is a wireless CBM system. The sensor nodes are equipped with sensors monitoring bearing health and temperature, including GPS, accelerometers, movement sensors, vibration sensors, and a clock. The system can also detect wheel flats from the data in early stages. Data is transmitted from the sensors, by mobile data without the need to mount a router on the train, to the SKF cloud. Customers connect to SKF Remote Diagnostic Services where they access the monitoring systems and dashboards. Tests of SKF Insight were made during 2015 and during 2017 the business were supposed to be scaled. The rail sector is still considered a pilot

(mainly together with SJ), but the technology is already implemented in other industries, e.g. wind turbines (SKF, 2017).

In addition to the mentioned actors, a number of large technological companies have been seen to be active in producing solutions for predictive maintenance. *IBM* provides cross-functional IT services and pinpoints the need and value for railway companies to adapt to preventive maintenance strategies (IBM, 2013). *Siemens* has a vast range of products for railway systems one of which is Railigent, a digital tool that uses big data analysis to optimize maintenance and operation planning (Siemens, 2018). *Hitachi* also states that they have produced systems in predictive maintenance (Hitachi, 2018).

Swedish Train Operators

SJ, MTR Express and *Arriva* are the three largest train operators acting in Sweden (SJ, 2017). *SJ*, Statens Järnvägar, is a public company owned by 100% the Swedish State with 4500 employees and 130 000 passenger every year. The company has two different business approaches. The first approach is independent commercial services under the SJ brand and the second approach is tendered public transports under its own brand or tender's brand (SJ, 2017).

MTR Express is a subsidiary to *MTR Nordic* which is owned by the Hong Kong state through MTR Corporation (MTR, 2018). The company operates a fast train between Gothenburg and Stockholm and they are responsible for the subway system in Stockholm where they operate commuter trains (SJ, 2017).

Arriva is owned by the German company Deutsche Bahn and operates 150 trains but also 900 buses and 90 trams (Arriva, 2018).

VR Group is another large actor which is divided into three business units, but they don't operate any trains in Sweden. VR handles passenger traffic in Finland and coordinates all traffic. VR Transpoint handles Logistics and offers freight solutions mainly for wood-, metal- and chemistry companies. VR Track builds railway and provide services in the whole value chain of rails in both Finland and Sweden (VR Group, 2018). They use SAS Analytics to lower maintenance costs and increase uptime. The goal is to reduce the amount of maintenance work by one third and the company has recently started to put sensors on the train, initially on boogies and wheels, and they believe every component will be connected to sensors in the future (SAS, 2018).

The largest freight operator in Sweden is *Green Cargo* which, as SJ, is owned by the Swedish state. Green Cargo operates 360 locomotives and 5000 railcars and employs 1900 people (Green Cargo, 2018a).

Other actors operating trains in Sweden are *Hector Rail* (Hector Rail, 2018), *Transdev*, *Skånetrafiken*, *Västtrafik* (Västtrafik, 2018) and *Norrtåg* (Norrtåg, 2018) among others.

Rail Maintenance Actors

Rail maintenance is defined by Trafikverket as ongoing maintenance of the railway infrastructure. Tasks that are included in rail maintenance are inspections, changing of railway sleepers, snow shovelling, contact wire maintenance and more (Ericsson, 2015).

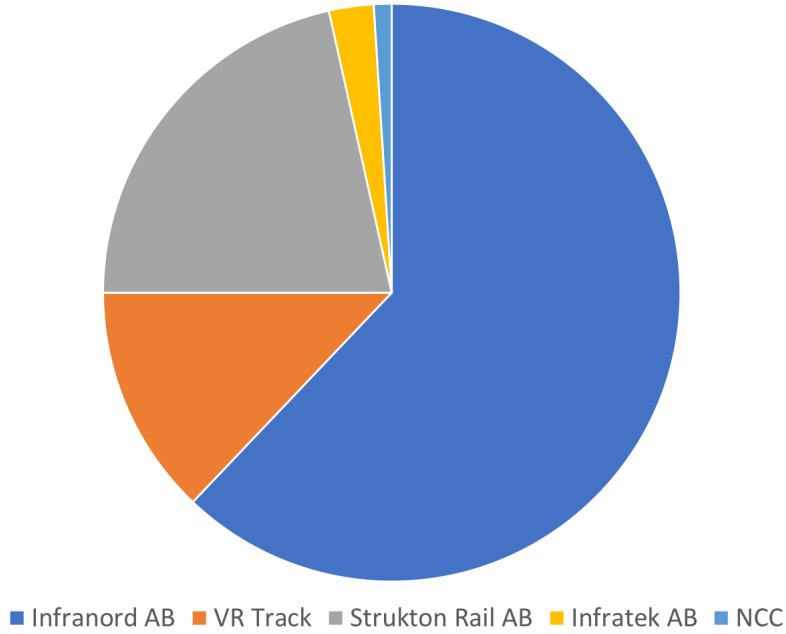

Figure 8: Market shares within Swedish rail maintenance.

Infranord AB is owned by the Swedish state and has a revenue of 3.9 billion SEK. It is thereby the largest railway maintenance in Sweden and one of the largest actors in Norway. One service they offer is to measure the railway with one of their five special locomotives. They can analyse static and dynamic overhead, the profile of the ballast, railway wear, overhead time, video analysis of rail and surrounding, and grooves and waves. In other words, these services can be performed when ordered, but they provide no real time monitoring. Though, they are also performing preventive maintenance work as a daily routine (Infranord, 2018).

Strukton Rail operates and performs service and maintenance on the railway system in Sweden, especially in Stockholm. This include rails, electricity, signals, and tele (Strukton, 2018). The company is the largest railway maintenance provider after Infranord (Ericsson, 2015).

Infratek, is also worth mentioning, which is a supplier of services within construction, operation and maintenance of electricity, lighting and rail in the Nordic. Infratek employs about 1350 people (Infratek, 2018).

Costs Within Rail

Two of the most important problems on the rail are wheel failures and, switches and crosses. Wheel failures caused 1200 hours of delay during 2013 (Asplund et al., 2014) and switches and crosses are related to 13% of all maintenance costs within the rail infrastructure at the Swedish organization Banverket and they are also acknowledged for the most frequent cause of train delays on the Swedish railway (Nissen, 2009). The railway infrastructure was in 2006 made up of 13.000 km of track and approximately 12.000 switches and crosses. During 1994-1999 the total costs for operations and maintenance of switches and crosses was almost 200 Million SEK per year and during 2001-2004 the total costs was about 250-300 Million SEK per year (Nissen, 2005). The maintenance costs are primarily related to the traffic, speed, axle weight, and total amount of traffic in gross metric tonnes (Nissen, 2009).

The maintenance strategy of switches and crosses at Banverket is both corrective and preventive. The preventive maintenance is divided into condition based and predetermined maintenance. Predetermined maintenance of switches and crosses is based on time, distance,

and load, and result in adjustment and cleaning of joints, and greasing of slide chairs and parts of actuators. The largest costs within predetermined maintenance are connected to inspection. Condition based maintenance is performed when inspections and measurements are made, and it deems necessary to perform maintenance. Finally, when maintenance is needed within two weeks after the inspection or measurement, the maintenance is considered to be corrective (Nissen, 2009).

2005 a study of maintenance-related losses at the Swedish Rail was made which analysed the causes of 666 documented derailments and collisions occurring between 1988-2000. Of all accidents, 39% were related to rail and track, 47% were related to rolling stock, and 14% were related to incomplete information. The causes of rail and track accidents were maintenance (30%), railway operations (30%), sabotage (27%), and uncertain (13%). Further, the maintenance causes could be divided into two categories: execution (9.2%) and lack of maintenance (2.4%).

4.3 Realizing the Potential of Maintenance

After it was concluded that insufficient maintenance causes large problems in the train and rail industry, we started to feel optimistic about Icomera's chances to disrupt the market of maintenance in this industry. The next logical step was to investigate if the type of maintenance that Discovery can be used for, which is called condition based monitoring, is in fact as promising as the head of innovation hopes. The second hypothesis was therefore formulated: "*Condition based maintenance of trains and rail is a suitable method for solving problems in the industry"*.

The process of getting in contact with knowledgeable people within the industry in order to hold interviews was, on the other hand, slow. We got feedback from our supervisor about how to get interviews and got the advice to seek other people within Icomera to get contacts from. This advice was taken and several people at Icomera was asked about people in the industry to contact who could answer a set of questions. This resulted in contact information to several people in different companies. They did however not respond to our attempts to contact them by mail and phone. This filled us with a sense of lack of influence over the project's progress and the feeling of power of being in an incumbent company was at this point starting to eradicate.

While trying to get in touch with potential interview subjects, further research about condition based maintenance was conducted. A podcast published by Trafikverket called "Järnvägspodden" was listened to which gave much insight in the complexity of the industry. By searching for reports about condition based maintenance and cases where this had been used in both train and rail, as well as other industries, it was getting obvious that this type of maintenance is the aim in almost all industries. Reports and cases show that condition based maintenance increases safety and decreases costs. These insights led us to verify the hypothesis "*Condition based maintenance of trains and rail is a suitable method for solving problems in the industry"*. Still, we did not think this hypothesis validation was enough for proving a product-market fit, so we persevered and went back to formulate new hypotheses focused on finding a concrete customer problem suitable for Discovery to solve.

In the podcast "Järnvägspodden", a recurring subject was cooperation within the fragmented industry and planning of time slots on the railway. They stated that inadequate maintenance is a major problem but still say that cooperation and planning is more important than technological progress. This lead us to believe that new maintenance technologies such as condition based

maintenance has not been implemented in train and rail maintenance in Sweden. This is why we stated our third hypothesis: "Condition based maintenance is an unexplored method in the train and rail industry". When getting more familiar with the competitive landscape we could distinguish a difference between Icomera and companies providing condition based maintenance solutions, namely that Icomera has a larger competence in connectivity and real time transfer of data. That is why we stated our fourth hypothesis: *"There is a need for real time transfer of data for maintenance of rail"*.

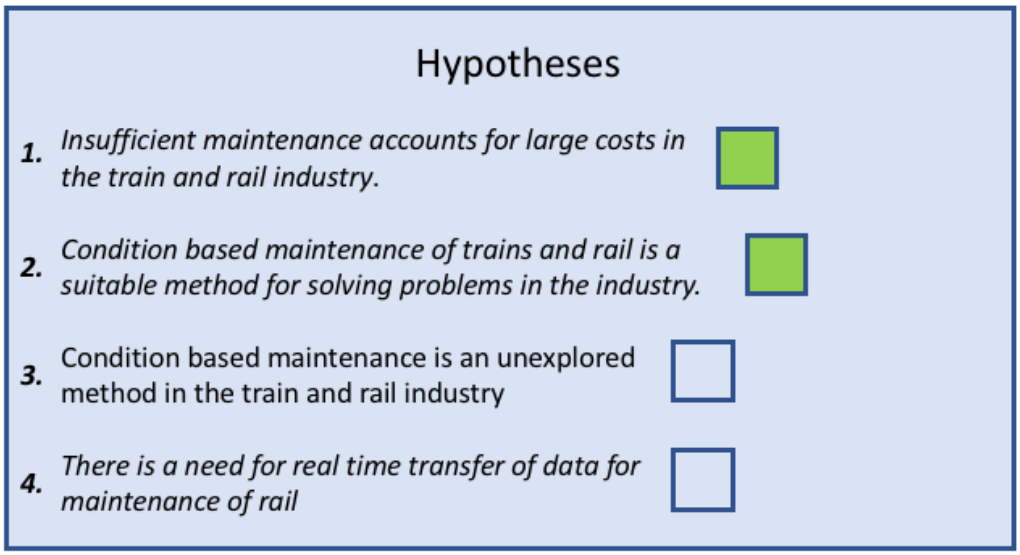

Figure 9: Hypotheses formulated and verified during the third sprint.

4.3.1 Gained Insight

During the third sprint we sought information about the progress of predictive maintenance within the rail industry and also getting a more nuanced picture of trends and topics that are emphasized within the Swedish train and rail industry.

Predictive Maintenance Trends within Rail

To reduce total cost of ownership, condition-based monitoring and predictive maintenance could mean promising opportunities and it is possible that the global industry efficiency could increase by 10-15% and potentially save EUR 7.5 billion per year by implementing condition-based maintenance. Implementation of predictive maintenance could increase efficiency even more (Stern et al., 2017). Digital technologies that are implemented to enable condition based monitoring and predictive maintenance may also enhance access to real-time information and better quality of data among other gains which all can be create new business opportunities (Lundqvist & Hjerpe, 2015).

In Spain, Siemens are operating a predictive maintenance system for high-speed trains between Madrid and Barcelona. Benchmarks they are putting are e.g. 99.9% of all trains on-time which means: "Extremely high reliability and availability of trains" (Lundqvist & Hjerpe, 2015, p.11), as well as: "Cost efficient service delivery from optimized utilization of staff and extended lifetime of parts" (Lundqvist & Hjerpe, 2015, p.11).

Another case presents savings of at least 30,000 man-hours per year by leaving benchmarks as a tool for scheduling maintenance to develop a prioritized list using condition data (Levene et al, 2018).

In Japan, a change program was performed in order to implement condition-based monitoring. Beforehand, maintenance inspections were based on time intervals, but condition-based maintenance will change the industry and prepare the country for declining a population, declining number of passengers and probably declining revenues from railway (Fujita, 2017).

Parc is a company that both has developed a condition monitoring system and started to implement it as a step towards self-aware, self-adapting systems. The train industry is just one industry among other Parc is focusing on, and East Japan Railway is one of their large customers in this segment (Parc, 2018).

SKF has developed their own condition monitoring system, specifically designed for bogies on trains, as described in chapter 4.2.1.1. The aim is to monitor equipment's condition and detect anomalies thanks to data processing algorithms. Implementation of these systems will enable better maintenance planning and decrease life cycle costs and total cost of ownership (SKF, 2018).

Swedish Rail Trends

By listening at the content of the first two seasons of the podcast Järnvägspodden, a picture of what is prioritized on Trafikverket's agenda could be made. The analysis was performed by listening to the first two seasons of Järnvägspodden and analysing the frequency of different categories of topics. The frequencies are presented in Table 1. We want to emphasize, though, that conclusions drawn from this analysis are treated as indicators rather than proof of facts.

Clearly, there is a strong focus on the need for collaboration and planning together with all involved actors. These topics are often closely discussed together with the complexity of the industry and the need for new processes.

Infrastructure projects and maintenance are also frequently discussed. In the majority of these cases it is rather the process of planning and minimizing the disturbance for traffic that is the core issue, though. Only a minority of the discussions touch upon the importance of maintenance of infrastructure and the costs connected to this or the investments that are needed in order to secure the quality that is wished for. Sven Ödeen, chief of railway maintenance at Trafikverket, points out that not enough money is spent on maintenance of the infrastructure at the moment (Ödeen, 2017, ep.5) and Anna Lundman argues that 10 billion SEK per year is needed for maintaining the current state of quality, but 13 billion SEK per year during a period of 12 years is needed to fix the "maintenance debt" Sweden has built up. In reality the budget plan, at the point for this interview, was 9 billion SEK for 2017, 8 billion SEK for 2018, 9 billion SEK for 2019 and 10 billion SEK for 2020 (Lundman, 2016, ep.9).

Other frequent topics that are discussed is the need for higher capacity, new systems and processes that are about to be implemented (related to IT or standards), but also specific cases are presented to give a picture and a story of events that have occurred.

One interesting detail is that Trafikverket puts a lot of focus on large topics connected to collaboration that directly affects all actors and are considered to be key components of a future well-functioning industry. When people in the field, engine drivers to be more exact, are participated in a poll about improvements within rail infrastructure maintenance, results are showing that Trafikverket apparently have not fully understood the width, the depth or the exact characteristics of the issues related to maintenance and how these issues affect employees in the field. An example is the need for clear signals that Trafikverket not thoroughly had realized,

and when the interview continues, the representative from Trafikverket yet seems uncertain about what exactly "clean signals" mean. Further, 7 categories of improvements were identified from the poll. These categories involve better information distribution about sight, fences and track position among others. The representative ends the interview with expressing the great interest among the engine drivers to participate and that this is the way Trafikverket wishes to work in the future, in closer collaboration with the actors. This sums up the situation, which was also collected from the content analysis, where Trafikverket emphasizes broad actions for collaboration and that Trafikverket, at least at this point of the interview, do not work close to the people in the field and therefore may not share the same view of the *reality* as them.

Table 1: Categories of problems or challenges mentioned in Järnvägspodden

Categories of problems or challenges mentioned in Järnvägspodden	**Frequency**
Involve actors in planning, cooperation, dependency, information sharing	20
Infrastructure projects create disturbance, optimise maintenance actions to minimize disturbance, bad quality causes delays	9
Capacity	8
New systems and processes	7
Specific technical problems/issues in operations	5
More maintenance needed, maintenance is expensive	4
Complex market/industry, deregulated market	4
Punctuality	3
Competitiveness	2
Safety	1

4.4 Getting Out of the Building

A deeper understanding of the customers' problems was tried to be acquired and pain points were tried to be found through interviews as proposed by Furr and Dyer (2014), and Constable (2014). A possibility to find many potential customers, and to gather data from many different points of view appeared when we found out about a conference about the problems in Swedish rail and results from the industry's prior actions was taking place in Stockholm. The conference contained a full day of speakers from different organizations within the Swedish train and rail industry, including the release of this year's report about the state of the industry. Except for listening to speakers, the day was characterized by informal conversations with industry stakeholders. The conference gave many different perspectives of the challenges that the railway industry is facing. The attending speakers were representatives from the department of commerce, Trafikverket, SJ, regional interest groups, The Swedish Transport Agency and the trade organization for maintenance contractors. The conference also gave opportunities for informal conversations with people from several of these groups and one unstructured interview with a representative from Trafikverket. The key takeaways from this conference was that Trafikverket states that the industry is fragmented, and the major concern is to organize

cooperation. This further strengthened our belief that the importance of maintenance information technologies accessible for many actors simultaneously is overlooked and that the work of implementing condition based monitoring is at a very early stage.

After the conference, we established contact with two representatives from the two largest maintenance contractors in Sweden, Strukton and Infranord. They were contacted by calling the telephone exchange at the respective company and getting sent from person to person until the individual with the right competence had been reached. They were very open to be interviewed so arrangements were made so that we could travel to their offices to hold interviews face-to-face. These interviews gave much technological insight in rail maintenance and the problems facing the industry presented by the interview subjects were much different from what Trafikverket stated at the conference and in their podcast. After the interviews were done, we followed a method presented by Constable (2014) on how to summarise and recognize patterns in interviews. We appreciated the structure and result of the method and could distinguish several major problem areas in the industry. For example, the design of the current contracts has a built in incentive structure that do not encourage maintenance contractors to develop tools to work predictive, or even preventive. Another problem in the business was that new effective, but expensive, machines were not available to rent in Sweden, which means that maintenance contractors will have to buy them, which they cannot afford in most cases. Unfavourable incentive structures and expensive machinery both lead to suboptimal maintenance on the rail which in turn lead to problems with the ballast, the track position, short circuiting the positioning system and strains on the contact wires. Organizational trends that were identified were that technological progress in the train and rail industry is hindered by complex processes, rigorous safety regulations and an increased degree of outsourcing of maintenance combined with unfavourable incentives. The interview subjects also addressed the issue of data. They stated that plenty of data is collected and resided in different systems, but it is hard to consolidate this data and to perform an analysis on it.

We also found out that Strukton, Infranord and Trafikverket are in discussion and/or partnership with several providers of predictive maintenance solutions. We understood that the starting field is full of actors just waiting for the industry to structurally change in order to let these companies in, and during the meantime performing pilot tests with train operators, maintenance contractors and Trafikverket. This information made us reject our third hypothesis "*Condition based monitoring is an unexplored method in the train and rail industry"*. We also asked specifically about how much value real time transfer of data would add to the maintenance work and their reply was unanimous and clear that this is not needed for a long time, the first problem is to even start working preventive, and later predictive and eventually real time transfer of data could add some value. This was enough for us to understand that real time transfers will not lead to major advantages or cost savings today and thus we rejected the fourth hypothesis, *"There is a need for real time transfer of data for maintenance of rail"*, as well. In conclusion, rejecting the third and fourth hypothesis pushed us learn from the gained insight which made us persevere and go back to formulate new hypotheses.

One piece of information that made us find a potential business opportunity for Discovery was the fact that data is collected, but not used to its fullest extent since it is spread out and locked in separate systems. The thought was that Discovery could be used to aggregate the data and analyse the collected data in order to perform predictive analyses. That is why we stated our fifth hypothesis: *"There is a need for an aggregating platform for performance data in the fragmented train and rail industry"*.

From speakers in the conference in Stockholm we got the information that freight transports were responsible for many of the delays on the Swedish railway and that their punctuality is substantially lower than the passenger transports. Based on this information we stated our sixth hypothesis "*There is an increasing demand for maintenance technologies and methods not being met in the freight train industry*".

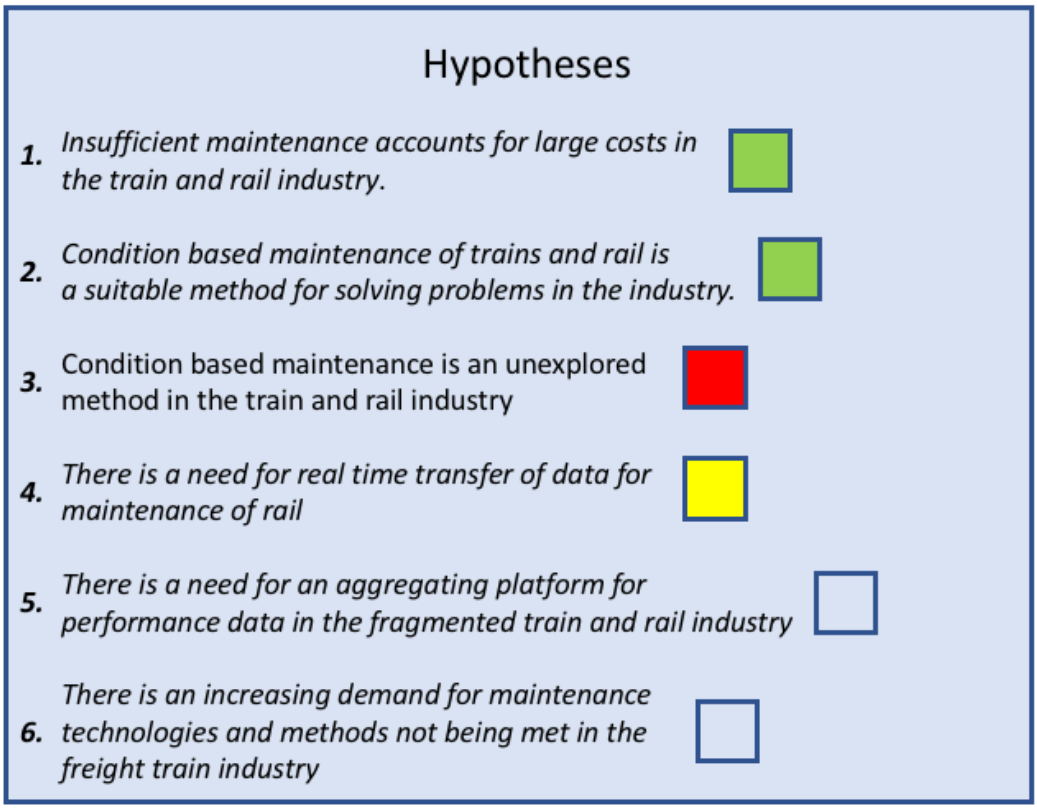

Figure 10: Hypotheses formulated and verified or rejected during the fourth sprint.

4.4.1 Gained Insight

The fourth sprint consisted of a number of meetings with industry people. Insight and knowledge gained from these occasions are summarized here, starting with a rail conference and interview with a representative from Trafikverket, followed by two interviews with representatives from the two largest rail maintenance companies in Sweden; Strukton and Infranord.

Rail Conference & Interview with Chief of Rail Maintenance at Trafikverket

During the Result Conference in Stockholm several actors expressed their view of the industry's challenges. Operators pointed out the need for certain competencies, Trafikverket emphasized the need for larger investments from the state and called for higher degrees of collaboration from all actors. At the same time passenger operators blamed freight operators of causing the majority of all delays, but some operators acting at smaller regions opened up for collaboration in order to help the freight industry to improve their operations. Trafikverket blamed the public of having a false picture of the industry and the quality of operations. According to them, the public have a perception of more delays than reality. Independent examiners of Trafikverket's projects points out that the methods Trafikverket uses to collect information and to draw

conclusions can be questioned as they do not account for all aspects of the quality. According to them there is no clear correlation between punctuality and disturbance.[3]

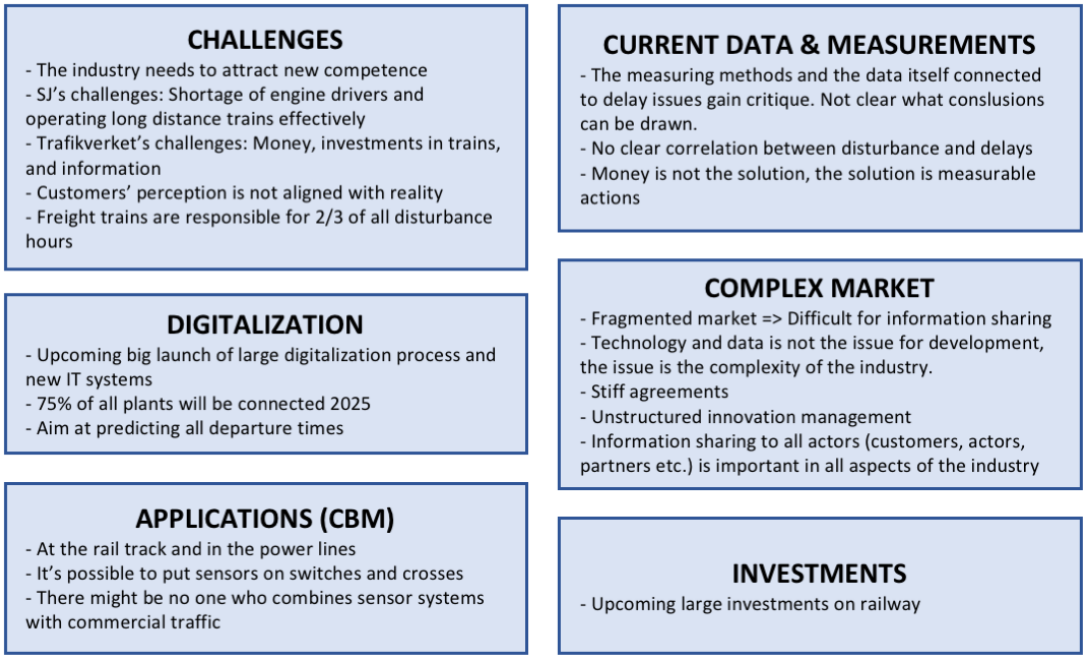

Figure 11: Key take-aways from the JBS conference.

Interview with Chief of Innovation and Development at Strukton

An interview with the Chief of Innovation and Development at Strukton AB provided insight about the rail industry in the perspective of a rail maintenance company. Again, emphasis was put on the complexity of the industry because of a fragmented market, and hurdles to share information. He also accounts the design of contracts between Trafikverket and maintenance companies to be one reason for slow developments within the industry. Today contracts specify the frequencies of inspections and when maintenance should be performed. The maintenance company that takes home the deal is the one offering the lowest price. The time available on the track to perform inspections and maintenance is also very limited. With processes designed for inspections rather than preventive work and limited time, there are weak incentives for maintenance companies to perform preventive maintenance and minimize the risk for urgent issues. The result is all too often "fire brigades" to solve acute problems which drive costs for Trafikverket. He would rather like to see contracts where maintenance companies are responsible for ensuring a certain level of quality. This would probably push for preventive maintenance which would lead to better quality of the rail and decreasing costs over time.[4]

When inspections are made, faults and damages are categorized into four categories depending on the level of emergency: *Note Inspections*, which need to be fixed within three months; *Months*, which need to be fixed within one month; *Weeks*, which need to be fixed within one week; and *Acutes*. Strukton never wants to end up with *Acutes* or *Weeks*. When inspection delivers *Months*, the planning process does not prioritize the most important issues, but only the most acute ones. The simple explanation to this is that there is a lot of work to do and all data is not analysed in order to report which problems are the most important. The goal is to detect problems three months before they need to be fixed by working with more focus on

[3] Rail Conference: "JBS Resultatkonferens 2018", 2018-03-21
[4] Interview with Otto Nilsson, Strukton, 2018-03-27

preventive work. He describes a "maintenance circle" Strukton aims to work according to: Firstly, measurements are made by different sensors for example and the data is processed to detect anomalies; secondly, anomalies are further analysed together with historical data; thirdly, an assessment is made before; fourthly, maintenance actions are prepared. This is, however, again not the way Strukton works currently, though.[4]

Strukton recently invested in a new measurement railcar, Hedwig. This will enable them to speed up and replace a lot of the inspection work. What differs Hedwig from other alternatives is that it can measure switches and crosses as well. All data is put into databases and the idea is that this data also will be complemented with other data and put into IBM Maximo and Microsoft Navision. Information will then be sent to Eurailscout, which performs analyses to serve companies' asset management. Finally, the IRISSYS, a software service, will produce an analysis pointing out which switches and crosses need to be inspected and the fastest way to get there. Every part of this process is theoretically working except for the IRISSYS part.[4]

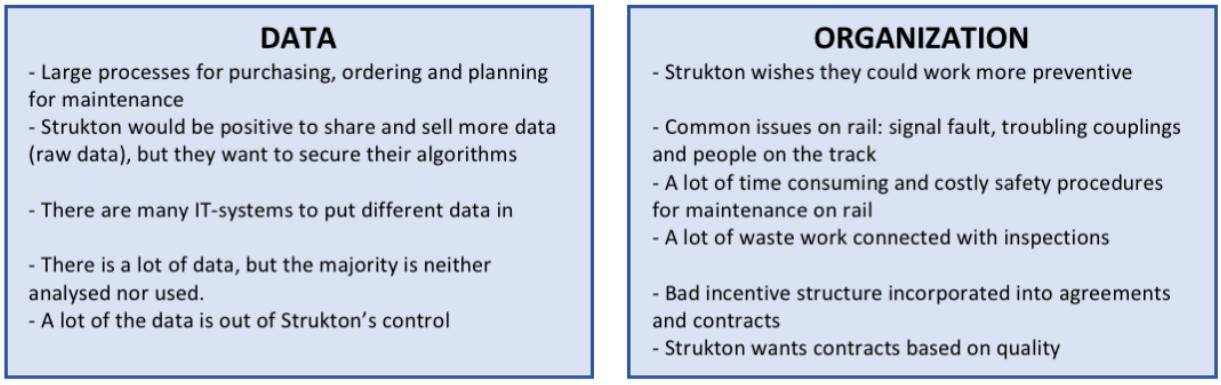

Figure 12: Key take-aways from the interview with Strukton.

Interview with Chief of Technology at Infranord

The Chief of Technology at Infranord describes the Swedish rail industry as extremely cost oriented since the deregulation of the market. The problem occurs when Trafikverket seek the cheapest bidder and all actors need to lower costs to be able to compete instead of investing in new machines and better methods. The global market offers a lot better machinery than Infranord and other Swedish actors own at the moment, but unfortunately no one has the ability to use them for economic reasons. Roland suggests that Trafikverket should invest in a machine pool that maintenance companies can use. This would not only increase the quality of the performed maintenance, but also creates a market which better invites competition.[5]

Further, he points out several times during the interview that the true core problem at the rail is the track position and sags in the ballast. Normally when the track is adjusted during maintenance, the track position is good up until the sags are appearing in the ballast. This happens if the ballast is not correctly designed, if the ballast is stirred up during the rail maintenance or if the ballast is not cleaned regularly. When sags appear, the ballast cannot support the track which causes the track to deform. This deformation damages the track itself, but also the trains and the signal systems. The fault code that is given is very often "signal fault", but this is only the symptom of a bad track position. When the time slots for performing maintenance is decreasing, Infranord is forced to perform maintenance on short segments at a time. This is also a factor which increases the risk of sags in the ballast when there is not enough time to also maintain the ballast. Because of the way maintenance is performed in Sweden the

[5] Interview with Roland Bång, Infranord, 2018-03-28

last decades, it is almost impossible to readjust the rail at certain parts. Other factors, affecting the ballast are e.g. ground frost and weather.[5]

He illustrated the importance of taking care of the ballast by telling a story about a project Bombardier was responsible for. Bombardier was installing sensors onto sleepers to detect vibrations when trains passed by. In order to install the sensors, they needed to dig around the sleeper before they could attach the sensor and finally put the macadam back to place. Soon after Bombardier's instalments, reports about signal faults started to appear in the same rail segments. What had happened was that sags in the ballast had started to appear which in turn caused deformation of the track with the results of short circuits at the joints which triggers the "signal fault" alarm.

He also describes a success case at the LKAB's Ore line. Thanks to the less complex market structure, better plans and contracts could be signed as the company LKAB is both operating and owning the rail. The infrastructure was built according to the designs that Roland advocates with focus on high quality and a well-designed ballast. After twelve years the quality is still extremely good compared to other Swedish rails, even though the weight of LKAB's wagons went from 20 tons to 30 tons and soon will be increased to 32 tons.

Infranord uses measurement railcars to collect data about the track geometry regularly. Unfortunately, this is done too seldom to be able to prove anomalies and faults. When maintenance is performed there is also no feedback to whether the corrections were satisfactory or not. Infranord would need measurements the following day, week and month to ensure high quality. Due to the design of the contracts, this is not possible, though.[5]

Recently, Trafikverket has started to leave more responsibility for the maintenance companies when designing contracts. This is something Infranord appreciates as the incentives increased to propose improvements and ideas as well as bonuses when high quality is achieved. The teams get more motivated to do a better job and they feel like it is a competition and say: "No trains will stop on my shift". This culture of improving collaborations through contracts is something Roland wants to see more of as it produces better quality for everyone and the companies that perform well are rewarded.[5]

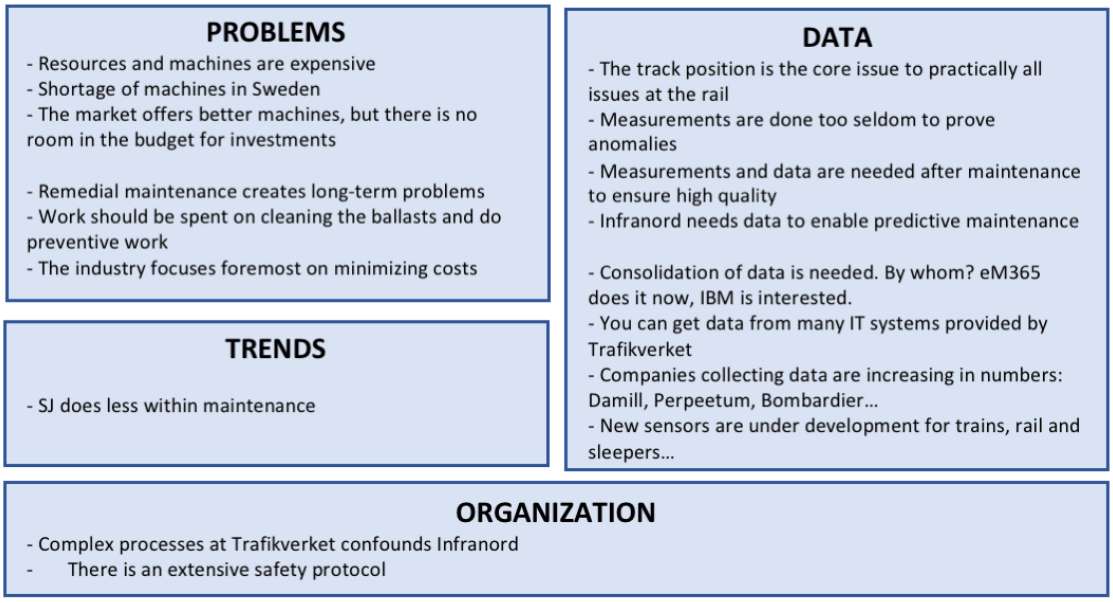

Figure 13: Key take-aways from the interview with Infranord

4.5 Finding the Fit

After the interviews with representatives from Infranord and Strukton, we got in contact with another representative from Infranord, two partners in different startups focusing on maintenance technology, and two representatives working at Green Cargo. These interviews were all arranged by going through telephone exchanges or getting references from previous interview subjects and the results were in line with the gained insight from the initial interviews at Infranord and Strukton.

To examine our hypothesis that there is a need to aggregate data, we mapped out all the relevant data systems to try to get an understanding of which data resides in which system and how they relate to each other. Our conclusion from mapping the data systems was that there were many more systems than we initially thought and that there are already attempts by Trafikverket to aggregate the data. But most important, the data owner is Trafikverket and they have a strong will of controlling the data flows since they have been assigned responsibility over the railway by a political mandate. This made us realize that by trying to build an aggregating platform, Icomera would compete with Trafikverket that has a political mandate on being the aggregating and cooperative actor on the Swedish railway. This is probably not an impossible venture but will require major adjustments which are not appropriate as a first step in finding a product-market fit for Discovery. Thus, we partly rejected our fifth hypothesis *"There is a need for an aggregating platform for data in the fragmented train and rail industry"*.

Our first contact with Green Cargo was with the Vehicle Director. During a telephone interview he gave us information about the state of the freight industry and how Green Cargo works with maintenance. He also gave us the contact information to another representative who provided us with data connected to maintenance. Our conclusion from the information we got was that freight transportations on rail have more problems with punctuality and poor maintenance than the passenger transports. Their work with preventive maintenance is also lagging behind the passenger transports sector. This was viewed as a clear indication that we had found a potential product-market fit as we confirmed our sixth hypothesis "*There is an increasing demand for maintenance technologies and methods not being met in the freight train industry"*.

Discovery could be used in several areas of application at Green Cargo. The vehicle director stated that one of the largest problems that lead to disturbances are that the wheels get damaged, especially in the wintertime. Based on this information Discovery could for example be used to collect and analyse sensor data from the wheels to optimize maintenance intervals. The vehicle director was open to the idea of starting a pilot project to evaluate and develop Discovery further, during which more potential areas of application could unveil.

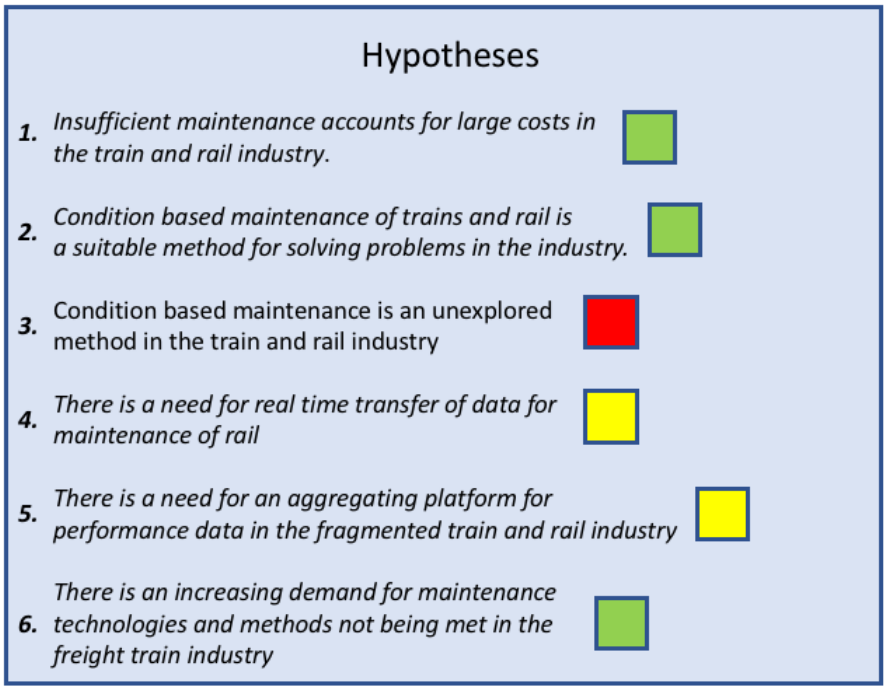

Figure 14: Hypotheses formulated and verified or rejected during the fifth sprint.

4.5.1 Gained Insight

The fifth sprint focused on getting more insight from people in the industry. Here, summaries from five interviews performed are presented. The interviews were performed with representatives from the rail maintenance company Infranord, a young IT company, the freight operator Green Cargo, and Trafikverket/Luleå University of Technology.

Interview with a Site Manager at Infranord

A complementary interview with a representative from Infranord supported the picture prior information collected. Major issues for them is limited time provided by Trafikverket to perform maintenance, often late notices about needed maintenance actions, and it is most often issued connected to switches and crosses on the rail. He believes data and predictive reports would make their maintenance work easier, but he is not aware of any investigations of whether to invest in any of these technologies.[6]

Interview with Director of Market Development at Young IT company

This is an international company specialized in sensor based analytics which has explored opportunities to create value within different industries. The focus on the rail the rail sector was chosen as there exist large asset values for the owners and these are related to a majority of all faults and disturbances on the railway. Other factors making the rail industry interesting is its core objective of achieving high availability, and profitability is only a minor objective compared to this.[7]

The company's solution extracts data from sensors and provides health statuses which is used for decision support in order to decrease unnecessary maintenance and exchanges. As safety is a critical factor in the industry, there are extensive procedures for changing processes and a major issue for companies like this one is to prove that their data and analyses are providing

[6] Interview with Sven-Erik Ljung, Infranord, 2018-04-05

[7] Interview with Anonymous Director at an Anonymous IT company, 2018-04-06

reliable results to act upon. In the end it is the public authorities that decide whether new processes are considered safe. An example of how the procedures can be further delayed is if equipment should be tested during winter, and the winter is not considered to be representative in any way. Then there is a risk that tests need to be done the next winter as well. As the rail industry is not used to neither change nor adapting new technologies these procedures tend to take long time. Education and information sharing is therefore a large part of the company's agenda at this point of their growth.[7]

The interview subject explains that the Swedish organization Trafikverket is an attractive customer as innovative, open to change and are good at providing feedback to the company.

When asked whether the company see a threat in companies such as IBM providing similar solutions, the interview subject explain that they are not afraid of their appearance as they have a horizontal focus. The interview subject sees larger threats in companies like Siemens, though, which has a vertical focus within these industry segments and extensive expertise within this field, but two of the company's advantages are that they are moving first, and they operate more agile than many of their competitors.[7]

Interview with the Chief of Vehicles at Green Cargo

An interview with the Chief of Vehicles at Green Cargo provided insight from the freight perspective of the rail industry. His view was that the freight industry, as the rest of the rail industry, is a lagging industry compared to traditional industry. He believed that about 50% of their maintenance is made according to preventive principles and traditional industries, such as automotive production, applies about 80-90% of all maintenance in a preventive manner.[8]

Some of the largest problems for Green Cargo, connected to maintenance, are related to the winter season and weather. He spontaneously picks snow and ice on rails as one of the major issues as this phenomenon damages the vehicles' wheels and causes expensive repairs. Another problem is overheated engines as the ventilation systems get blocked by ice. The solution to the latter problem is to implement dehumidification systems.[8]

Green Cargo has a lot of data, but not very much is used for data analysis to be able to predict failures. He thinks there is value to find in the data, but he also believes more data will be valuable. The most important action right now is to start implementing solutions that enable preventive maintenance, and as a future step he would like to see forums for cooperation. At the moment Green Cargo has started to look at different solution that provide diagnostic tools for maintenance, but they are still in an early stage, performing initial pre-studies. At this stage pilot projects could be an interesting way to move forward and evaluate alternatives.[8]

Interview with a Vehicle Manager at Green Cargo

As a follow-up from the interview with the Chief of Vehicles at Green Cargo, an interview was held with his colleague, a Green Cargo vehicle manager. He was able to provide us with raw data about historical reasons for rail cars being sent to maintenance workshop. *"The root cause of the error codes is the mystery",* he explains as he sends us the data and hopes that we can find any hidden value.[9]

[8] Interview with Markus Gardebring, Green Cargo, 2018-04-04

[9] Interview with Lars Fehrlund, Green Cargo, 2018-04-06

In his point of view Trafikverket focuses a lot on passenger traffic as this is what interests most people through media, but the economic consequences are often larger when problems occur for freight operators.[9]

Interview with a research coordinator at LTU and Trafikverket

According to a research coordinator from Trafikverket also part time working as Adjunct Professor at Luleå University of Technology, the major reason for the slow adoption of new maintenance technologies is the comprehensive procedures for implementing something new. The reason to these procedures is simply to ensure safety on rail. The industry needs to become better at finding proof of improvements and to be willing to run new systems along with old ones at a switching phase. At the same time, it is important that The Swedish Transport Agency follow this transformation.[10]

It is crucial that top stakeholders, railway owners and infrastructure managers drive the transformation and demand developments from the maintenance contractors and companies. Today the Swedish railway industry is fragmented and there are low incentives for improvements as data often is held proprietary and sometimes it is costly to make improvements for ongoing contracts.[10]

The number of companies showing interest for data connected to rail and vehicles is increasing. For example, Nexala, IBM, BenaVision, Andaldo, Bombardier etc. are companies who develop new maintenance services for the Railway business. The game change is to create analyses from data and combine the analyses with Railway domain knowledge. "What most actors can do is to look in the rear-view mirror, the trick is to look forward, to make use of physical models and look into the future".[10]

4.6 Proposing a New Business for Icomera

As a potential product-market fit was found during the fifth sprint, we continued to explicate our findings to develop a business model that could be presented in the form of a traditional Business Model Canvas (Osterwalder, 2010), see Figure 5.

From prior findings it was obvious that the train and rail industry suffers from losses connected to non-optimal maintenance, and that there is a large potential to save costs if data is better collected, analysed and used to optimize preventive maintenance and planning of maintenance actions. This potential was not only evident from analysing the problems in prior interviews and research. The fact that many companies, both incumbents and startups, show interest for the same issue strengthens the belief that we have found an area of potentially new business for Icomera. On the other hand, this increasing interest from other actors also means increased competition. But the freight train industry looks a bit different, it is a segment where demand for these kinds of solutions are increasing but there are not as many providers active yet, which is why we believe that this would be a suitable segment to target. Green Cargo is the largest freight operator within rail in Sweden and would therefore be a suitable first customer within the freight operating segment of the rail industry to target.

Discovery should be designed to aggregate and analyse data from the freight operators' locomotives and wagons in order to achieve three main objectives; provide a holistic view of the fleet's machine health based on key parameters; provide decision support for what parts that

[10] Interview with Per-Olof Kråik, Trafikverket & LTU, 2018-04-12

should be maintained or inspected; and provide insight and suggest actions about the core problems to why common damages and faults appear on locomotives, trains sets, and rail.

We believe that the initial business should be built in close collaboration with the first customers in order to personalize and optimize the solution to their needs. Only when this is achieved, focus should be put on sales to other companies which automatically will alternate how Icomera should build their customer relations and channels.

The activities for Icomera will be to adapt and develop Discovery to their initial customers' needs of equipment health monitoring, focused on processing and visualizing data as well as integrating relevant decision support functions based on the data and appropriate algorithms. The customers' fleet might also need hardware updates or installations which will be an important activity to perform either by Icomera or by partnering companies, which perhaps have greater competencies within sensor technology if this is needed.

Revenue streams are suggested to be based on the monetary savings the solution creates for the customers compared to before implementation. Therefore, a good idea would be to run pilot projects on a number of locomotives and wagons in order to evaluate both the value creation, i.e. savings, and what exact features that should be developed. The cost structure for Icomera, on the other hand, will mostly consist of R&D costs depending on what hardware installations or updates on the customers' fleet additionally will need, and sales and marketing costs.

During the third sprint, trends within predictive maintenance were investigated. According to Stern et al. (2017) the global rail industry would potentially save between 10-15%, which translates into €7.5 billion or approximately 77 BSEK, of its costs by implementing condition-based and predictive maintenance strategies and technologies. Using this reasoning to, roughly, estimate potential savings for a train operator like Green Cargo would result in 10% of their operating expenses in 2017 of 2.3 BSEK (Green Cargo, 2018b), i.e. approximately 230 MSEK annually. These numbers provide an initial glimpse of the potential value creation and the potential for Icomera to capitalize on their technology, i.e. Discovery, and competence.

<table>
<tr><td rowspan="2">Key Partners

Green Cargo for performing pilot testing and co-creation of a final solution.</td><td>Key Activities

Collection and analysis of performance data as well as producing an action plan.</td><td rowspan="2">Value Propositions

Helping the customer to find the most optimal time for maintenance of locomotives and wagons.</td><td>Customer Relationships

Close relationship that will enable pilot testing and co-creation of a final solution.</td><td rowspan="2">Customer Segments

Green Cargo specifically, and the freight train industry in general.</td></tr>
<tr><td>Key Resources

Sensors, analytics software, and hardware for data transfer.</td><td>Channels

Personal contacts that sustains the close relationship.</td></tr>
<tr><td colspan="3">Cost Structure

Capital expenses such as sensors and hardware for data transfer. Operational expenses in the form of innovation department employee salaries and R&D.</td><td colspan="2">Revenue Streams

Charge an appropriate percentage of the customer's savings in maintenance and operational costs.</td></tr>
</table>

Figure 15: Proposed business model for Icomera's new business within predictive solutions for train maintenance.

5. Analysis

This chapter consists of analyses of the empirical data presented in chapter *4. Empirical Findings*, according to the literature framework. The analysis is divided into three parts; firstly, the project is analysed with respect to the fact that the business development project was executed within an incumbent firm; secondly, the business development process is analysed according to *The Innovator's Method* from the perspective that there already exists a product, i.e. a solution, before the project initiation; and thirdly, the business development process is analysed according to *The Lean Startup* and *Hypothesis-Driven Entrepreneurship* process.

5.1 Going Slower with a Bird in Hand

In preparation to the workshop the 31th of January, many more or less creative ideas for the application of Discovery had been generated. The workshop progressed in line with exploiting the answers to the three questions of the bird-in-hand principle of *effectuation*: Who am I? What do I know? Whom do I know? (Sarasvathy, 2001b). Icomera's competencies in deviation detection, data analysis, displaying data, and Icomera's contacts and knowledge within the rail industry was ruling for the decision of Discovery's focus and vision. During the workshop it was also stated that so called *low hanging fruit* was desirable, namely easy applications for Discovery that maximizes return. This is contrary to the affordable loss principle of effectuation (Sarasvathy, 2001a) since this principle advocates that the entrepreneur freely seeks to realize her vision with a limited amount of resources rather than seeking to maximize returns which most likely will not lead to a disruptive innovation.

The power of the means possessed by Icomera, and more specifically Icomera's personal connections within the industry, turned out to be weaker than first expected. An easy quantitative test measured how valuable Icomera's connections were for finding a new market for Discovery. The test compared how many contacts and interviews that could be obtained through the company's channels compared to how many that could be obtained by going through public channels. The result was clear, all but one of the interviews that were conducted was arranged by going through public channels. By repeatedly trying to go through Icomera's already existing channels, a significant amount of time was lost before interviews could be performed, i.e. the hope of saving time by following this approach turned out to be waste of time.

The proposed reasons for why only one interview was arranged through Icomera's contacts are believed to be two. The first reason is that the contacts weren't relevant for the hypotheses that were set up. The contacts often had a technical role in the company or organization and seldom had knowledge about the major problems for the company and the root causes for these problems. These contacts were not inclined to refer to other, more relevant people in the company either. The second reason is that some key people within Icomera prevented contact with external companies due to possibly conflicting interests.

5.2 Starting with the Solution

The Innovator's Method, consisting of the phases Insight, Problem, Solution and Business Model, that Furr and Dyer (2014) promotes, was aimed to be followed in this business development project. However, since the product was already partly defined, thus making the solution partly defined as well, it was not entirely possible to follow this structure. Instead, we had to work from the conditions that the partly defined solution already limited us to. For example, Discovery is limited to detecting deviations from a normal value and to combine values from different inputs to produce analyses and actionable reports. However, Discovery is

adjustable in order to incorporate signals from practically any input source, whether it is from vibrations, sound, optics or any other. This makes the solution, Discovery, defined but very flexible and adaptable.

The limiting conditions forced a new structure to be followed. Instead of going through the phases in the original order, the first phase of the work process was highly influenced by understanding the solution, its constraints and its possibilities. The process that was followed during our business development project could, in the terms of *The Innovator's Method* (2014), be said to start with a Solution phase, to be followed by the Insight, Problem and Business Model phases.

5.3 Hypothesis-Driven Entrepreneurship with a Twist

Other methods that were aimed to be followed was *The Lean Startup* (Ries, 2011) and *Hypothesis-Driven Entrepreneurship* (Eisenmann, Ries & Dillard, 2011). Ries, Eisenmann, and Dillard promotes a hypothesis-driven approach that step-by-step, through experiments and new insights, brings the entrepreneur closer to a product-market fit. It was soon discovered that with a partly defined solution, what was needed in order to find a product-market fit was to find a problem with a feasible market potential that could be solved by the product, if necessary with some adjustments.

In order to get started with the hypothesis-driven process (Eisenmann, Ries & Dillard, 2011), a basic understanding of Discovery needed to be established, as already mentioned above. This was done by talking to key people who had been involved in developing the product, and searching for information about Discovery, its technology and its current market. After this, an ideation process was performed by using C-K Theory to produce suggestions for new areas of application. These suggestions were then brought to the workshop with stakeholders of the project where decisions on the project's direction and its potential areas of application were made.

After the workshop, a vision was set, according to the first step of the *Hypothesis-Driven Entrepreneurship* process (Eisenmann, Ries & Dillard, 2011). The vision was to focus on maintenance within rail and trains, and the first hypothesis was therefore stated: "*Insufficient maintenance accounts for large costs in the train and rail industry"*. Print screens of Discovery's user interface, with some examples of data illustrations, were printed to be used as MVPs when showed to potential customers, and interviews were performed to test the stated hypotheses. Regardless of them being verified or rejected, the project always persevered the vision and additional hypotheses were tested until the last hypothesis validation produced a satisfactory result and a potential product-market fit was found.

The final hypothesis, "*The actors in the freight industry are lagging behind the rest of the industry in terms of maintenance technology adoption"*, was not only verified, but while testing it through interviews, interview subjects at Green Cargo also showed great interest for Discovery and expressed a demand for this type of solution. This concluded our search for a product-market fit and the project should hereby be focused on entering discussions with them, perhaps initiating partnership relations and conducting pilot tests to further verify this potential product-market fit and develop a comprehensive business model.

6. Conclusion

In this chapter, the analysis from chapter *5. Analysis* is used to draw conclusions and answer the research question of this study: *How may entrepreneurial methods be adapted to help companies enter new product markets with existing products?* Two major conclusions and corresponding solutions will be drawn related to the dependency between the business development team and management, and the design of the refined business development process.

From analysing the process of finding a product-market fit for a product in an incumbent firm, one conclusion could be made about the dependency between the business development team and management. When the bird-in-hand principle of effectuation (Sarasvathy, 2001a) was applied, resources, competencies and contacts that Icomera possessed were exploited which caused a mutual dependency between the group that managed the business development project for Discovery, and the remaining company. The dependency gave management the influence to pull the project from the so called suicide quadrant (Sarasvathy, 2001b), where one tries to launch a new product in a new market, towards more known markets and not make too large modifications to the product. This is an example of causal thinking, which is the opposite of effectual thinking, and works well in more predictive environments in which most incumbent firms operate. Causal thinking is an appropriate approach for most managers and makes it natural for them to try to pull the project to safer grounds (Sarasvathy, 2001a). However, when a company is innovating and is looking to disrupt its current business model in one way or another, it may be worthwhile to explore the suicide quadrant and for this, managers will need to apply effectual thinking. The workshop that was arranged on January 31st proved to be a particularly critical step. This occasion not only set the vision and thus the direction for the entire project, it was also very receptive of influence from stakeholders and management. The workshop was their opportunity to steer the project in a direction of their interest, which limited the project to explore the suicide quadrant (Sarasvathy, 2001a).

A solution to this problem can be to create a larger amount of autonomy for the business development team that works with disjoint technologies and markets, from the rest of the company. Burgelman (1984) suggests that depending on the variables *operational relatedness* and *strategic importance* there are several ways to organize and manage innovation processes to facilitate corporate entrepreneurship. From the project potentially being operational related and strategic important it should be directly integrated to the existing firm, to being completely operational unrelated and strategic unimportant in which case it should be organized as a complete spin off. Between these extremes Burgelman presents a number of more or less separated forms of organizing innovation units. In the case of this specific business development project, with Discovery, the project could probably be considered to be medium operational related and medium strategic important by management, and therefore be treated as a new product/business department or a new venture division.

A second conclusion is that an adjusted version of entrepreneurial methods is needed in order to fit the case that Icomera represents of a company that wants to introduce existing products to new product markets. The first issue with existing methods is that most builds on the assumption that an entrepreneur has experienced a problem and is searching for a solution that will solve it or already has an idea which they want to evaluate (Furr & Dyer, 2014; Blank & Dorf, 2012). Icomera has the opposite situation as they have developed a solution that they believe holds the potential to solve many other problems than it was originally designed for, and they want to find these potential opportunities. Thus, in order to adjust current

methodologies, the new methodology must take its starting point from an existing solution, at least with some room for modifications.

The initial steps of the refined framework, see Figure 16, will therefore mimic what was done during the beginning of this business development project. The first step is to create an understanding of the solution the current product market by doing a number of activities. Suggested activities are to talk to and interview key people involved in developing the product, and to search for information about the product, its current application and the technology. The second step is then to freely generate ideas for areas of application and new potential customer segments within the business development team through structured brainstorming sessions. This ideation process will likely produce many different potential applications for the product that will be useful at later stages. The third step is to organize a workshop with stakeholders of the project who should have some influence over the result. The purpose of the workshop is to involve these stakeholders in the idea generation process and to produce a vision for the project.

The workshop with stakeholders is one of the most critical steps of the process since interaction with stakeholders is necessary for future support but it is important to avoid being steered by them too much as this might delimit the rest of the business development process. One solution to avoid this, as stated before, is to have some degree of independence between the business development team and the rest of the company, and another solution is that the workshop participants should be briefed in advance about effectual thinking. Finally, the workshop itself should be controlled by the business development team who are managing the business development project. It should be explained that the ideas that come out of the workshop will be tested according to the principles of *effectuation* (Sarasvathy, 2001b) and through *hypothesis-driven entrepreneurship* (Eisenmann, Ries & Dillard, 2011). The workshop will produce a vision that guides the rest of the project and at this point, the regular hypothesis-driven entrepreneurship process (Eisenmann, Ries & Dillard, 2011) will take on. One alteration will, although, be necessary for this process: If forced to pivot the vision, the original process states that the vision should be altered, however when the vision is prompted by the steps proposed in this refined framework, it is appropriate to go back and redo the idea generation step in the earlier stages of the process followed by a new workshop to create a new vision.

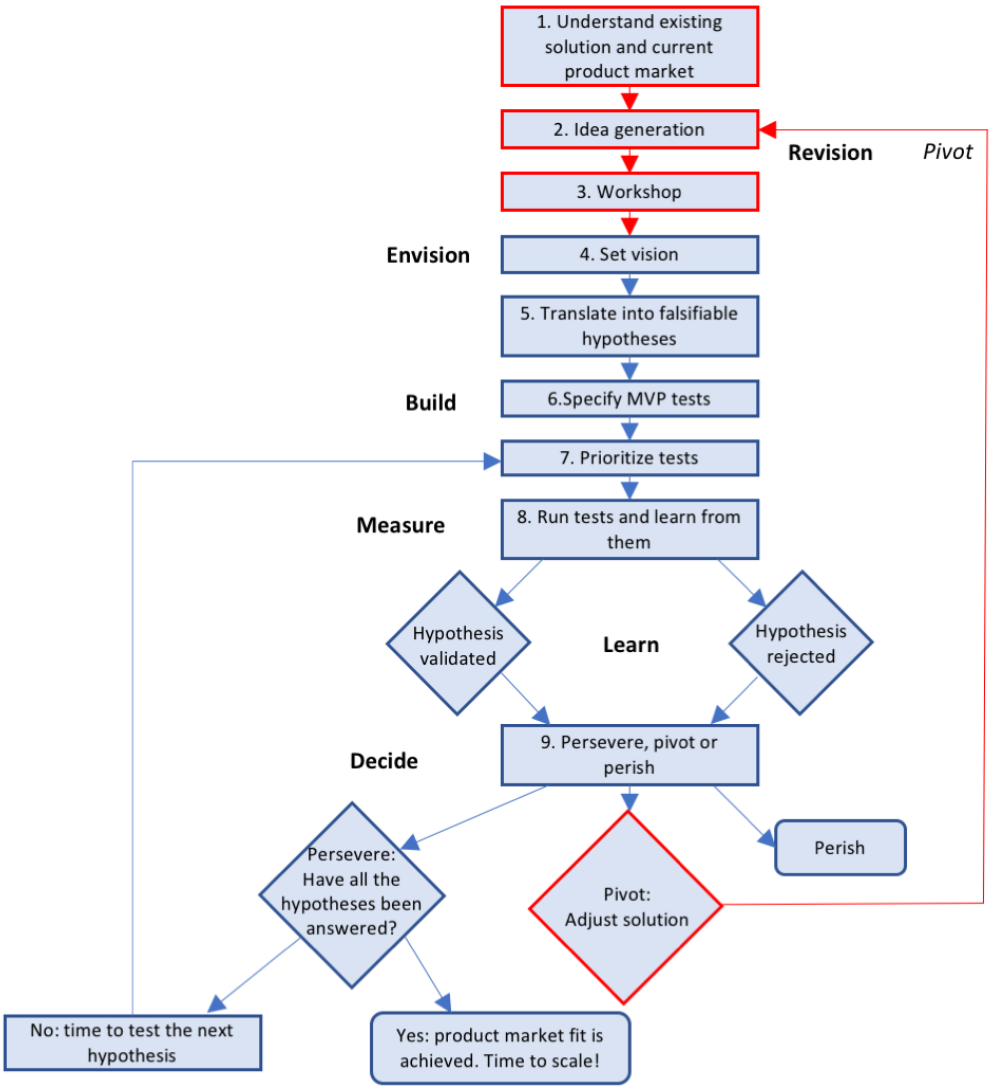

Figure 16: Refined Hypothesis-Driven Entrepreneurship process.

These two major conclusions together answer the research question *How may entrepreneurial methods be adapted to help companies enter new product markets with existing products?* By following this refined framework in an environment that is characterized by some level of autonomy corresponding to the nature of the solution, companies may better capture existing innovation.

7. Discussion

Lean Startup has been seen by many as a holy grail of managing business development. Companies give the book The Lean Startup to new employees to make them think according to Lean Startup's principles (Rikatillsammans, 2018). However, Eric Ries' thoughts are a refinement of his professor Steve Blank's frameworks and principles. Refinements of *The Lean Startup* have, furthermore, been made to adapt the methods for incumbent corporations in Furr and Dyer's (2014) *The Innovator's Method*. What has been done in this study is a further refinement of several frameworks to adapt them to an even more specific case of firms wanting to take existing products and introduce them to new areas of application, i.e. capture existing innovation.

The business development project, that was the case for this study, has come across several interesting phenomena worth discussing. Firstly, the concluding framework that is presented in chapter *6. Conclusion* mainly builds upon the framework of *Hypothesis-Driven Entrepreneurship*. It should be stated, though, that *Lean Startup* and *Hypothesis-Driven Entrepreneurship* describe the formulation of hypotheses to be more concrete and detailed than what was done during this project. This was not achievable as the project's vision also was broader than what is illustrated in these pieces of literature. Also, instead of formulating a lot of hypotheses in the beginning of the project about several business model elements, we formulated one or two hypotheses in the end of every sprint. This was done because we were not sure where a validation or a rejection would steer the project. We believe that if the project would continue at this point, where a potential product-market fit was found, we would be able to formulate more concrete and detailed hypotheses as well as several hypotheses at the same time, corresponding to the business model canvas presented in chapter *4.6 Proposing a New Business for Icomera*.

Another interesting phenomenon occurring during the project was the fact that the company's existing contacts to the industry were both difficult to reach and did not provide the right insight needed to our business development project. We do not believe this is an uncommon phenomenon and the reasons for this, as stated before, might be conflict of interests between our project and other existing projects, and that the external contacts simply were not valuable for our specific project. Our solution to this during the business development project was to contact companies and organization through public channels instead. This is an area that would be interesting to see further research within. Is it possible to make better use of already existing contacts and networks, and how should this then be made?

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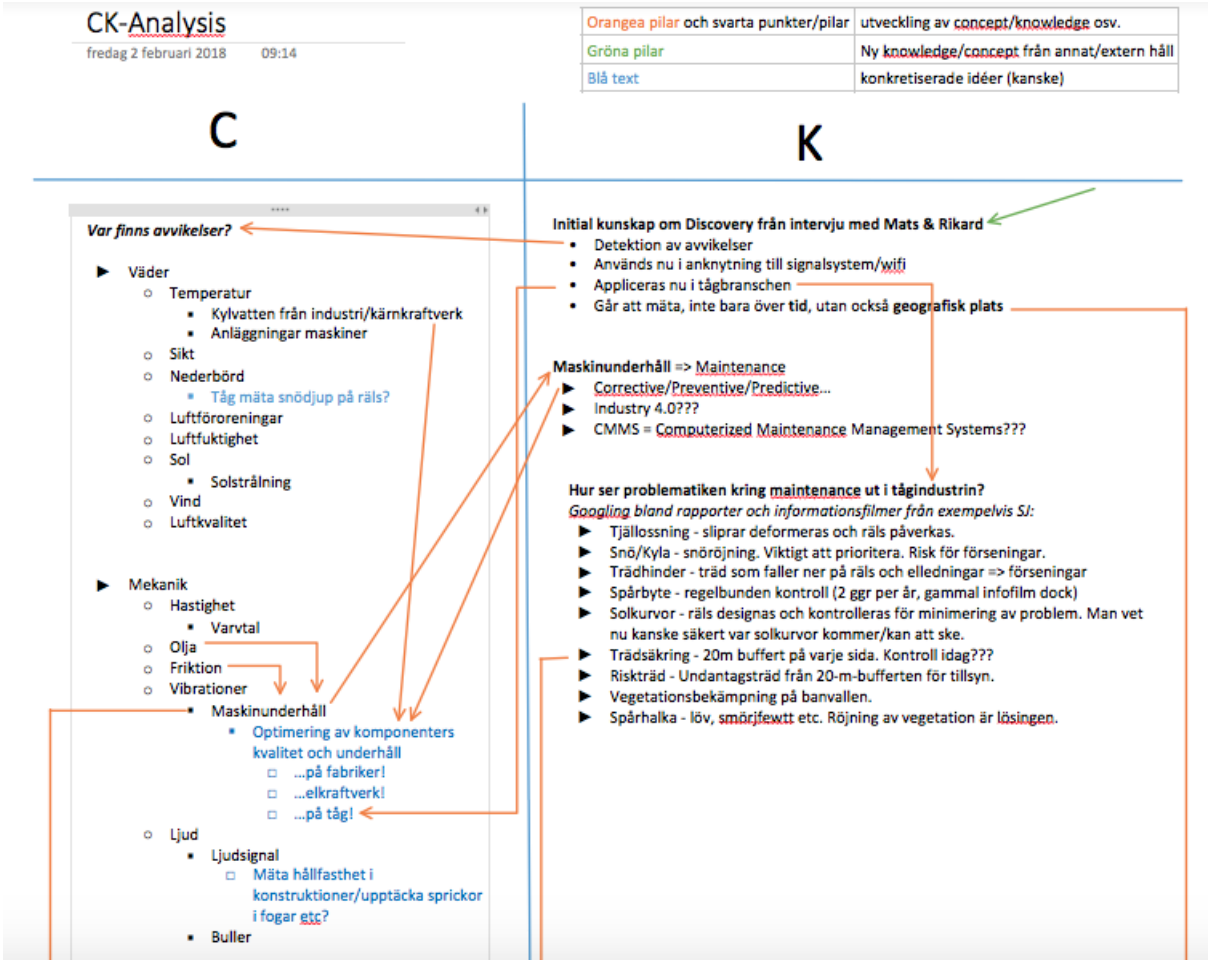
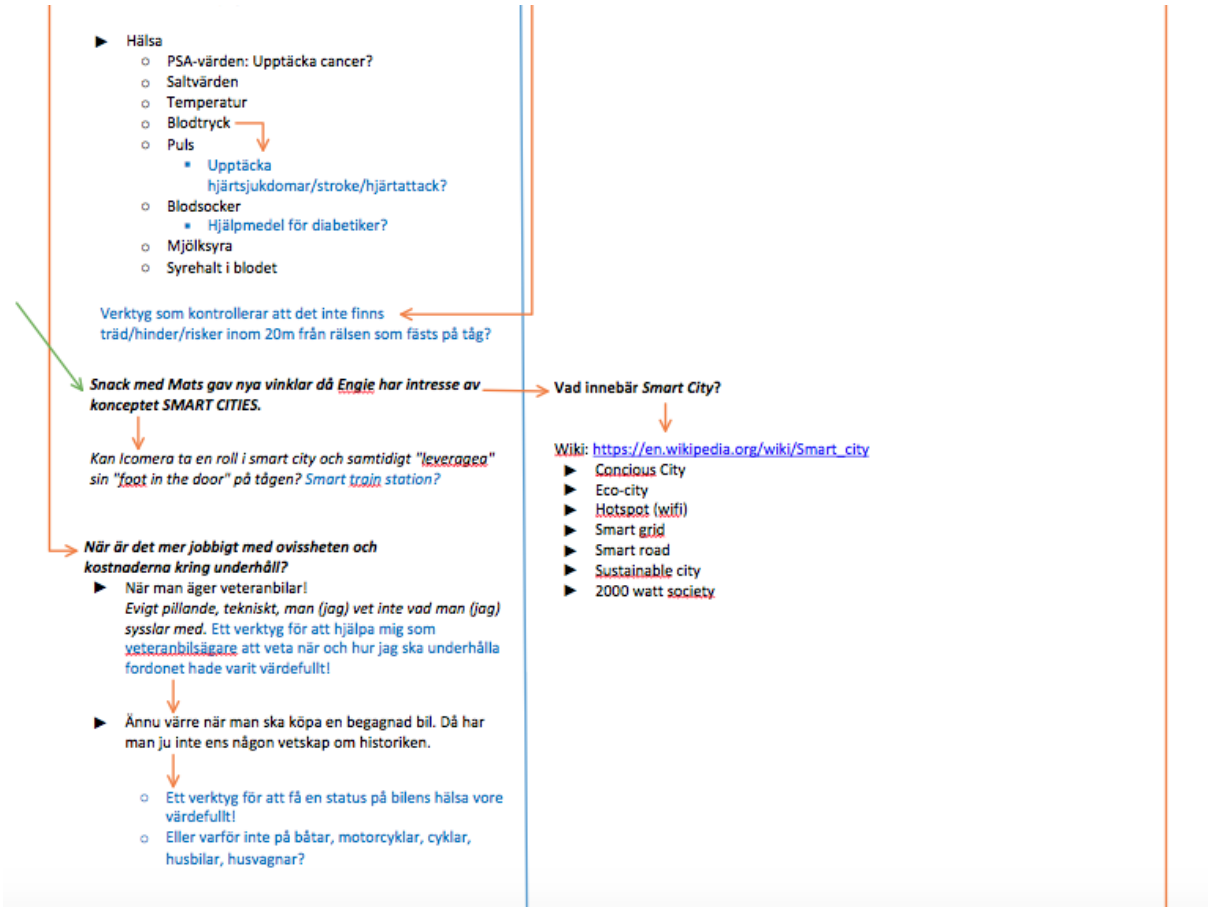
Appendix A: C-K Session




Hälsa
PSA-värden: Upptäcka cancer?
Saltvärden
Temperatur
Blodtryck
Puls
Upptäcka hjärtsjukdomar/stroke/hjärtattack?
Blodsocker
Hjälpmedel för diabetiker?
Mjölksyra
Syrehalt i blodet
Verktyg som kontrollerar att det inte finns träd/hinder/risker inom 20m från rälsen som fästs på tåg?
Snack med Mats gav nya vinklar då Engie har intresse av konceptet SMART CITIES.
Kan Icomera ta en roll i smart city och samtidigt "leverage" sin "foot in the door" på tågen? Smart train station?
Vad innebär Smart City?
Wiki: https://en.wikipedia.org/wiki/Smart_city
Concious City
Eco-city
Hotspot (wifi)
Smart grid
Smart road
Sustainable city
2000 watt society
När är det mer jobbigt med ovissheten och kostnaderna kring underhåll?
När man äger veteranbilar!
Evigt pillande, tekniskt, man (jag) vet inte vad man (jag) sysslar med. Ett verktyg för att hjälpa mig som veteranbilsägare att veta när och hur jag ska underhålla fordonet hade varit värdefullt!
Ännu värre när man ska köpa en begagnad bil. Då har man ju inte ens någon vetskap om historiken.
Ett verktyg för att få en status på bilens hälsa vore värdefullt!
Eller varför inte på båtar, motorcyklar, cyklar, husbilar, husvagnar?

Appendix B: Base Interview Template

- Kan du i korthet beskriva er verksamhet och vad er roll är i att den svenska järnvägen fungerar?
- Vad är de största problemen för verksamheten idag?
    - Berätta gärna om ett exempel på när ett sådant problem gjorde sig påmint senast
- Hur många av de stora problemen är kopplade till underhåll?
- Vad leder till de flesta förseningstimmarna för tågen?
    - Har du något exempel på när ni fick hantera en situation som ledde till stora förseningar senast?
- Vilka är de största mål ni arbetar mot? (exempelvis 95% punktlighet 2020)
- Hur arbetar med ni med underhåll idag? (Tidsbaserat?)
- Har ni börjat kolla på att lösa problem med hjälp av predictive maintenance?
    - I så fall: Vilka leverantörer av sådana tjänster har ni kontakt med och/eller har haft ögonen på?
    - Tror du att nyare metoder så som predictive maintenance och tillståndsbaserat underhåll kan lösa de problem som vi har diskuterat tidigare?
- Berätta hur du tror att de skulle kunna hjälpa dig i din verksamhet?