CHALMERS
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Managing innovation fueled by the Industrial Internet of Things

Master of Science Thesis in the Management and Economics of Innovation Programme

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Abstract

Performing an Industrial Internet of Things (IIoT) driven transformation is challenging from an innovation management perspective, since it will result in major changes for several stakeholder groups in the organization aiming to implement IIoT. Since the phenomenon of IIoT is fairly new, and because of the changes it implies, organizations require guidance regarding how to manage these changes. The purpose of the study was to understand, analyze, and advice on the various aspects an organization needs to consider when undertaking successful innovations fueled by IIoT. Two major types of organizations were considered; organizations using IIoT in their direct operations and organizations providing products and services incorporating IIoT to their customers.

By using an exploratory inductive methodology, a literature review combined with a comparative case study consisting of eight case studies were conducted, in order to be able to compare between the literature and the experiences of implementing IIoT in the participating firms. The case studies concern the firms Ericsson, ABB, Volvo Cars, Hecla Mining, Songa Offshore, IFS, Accenture, and Cybercom Group. The empirical findings from the comparative case study revealed commonly experienced benefits, costs, risks, and challenges of implementing IIoT. Firms providing IIoT generally obtain benefits related to increasing revenues and customer value, while firms using IIoT in their operations rather tend to focus on increasing efficiency and decreasing costs. Moreover, the firms providing IIoT tend to encounter challenges related to changing the business model and data sharing, while the firms using IIoT in their operations are more likely to be impeded by organizational challenges and technical complexity.

The empirical findings were analyzed in combination with the literature review in order to determine possible mitigation strategies related to the challenges. Moreover, the weight of each challenge was assessed in order to determine their relevance. In the discussion a general implementation guide was presented, based on the results in the analysis.

The guide emphasizes the importance of planning and researching thoroughly prior to initiating an IIoT project, initiating small projects with employees who are evidently interested in the technology, gaining support for the project from the top management, engaging employees, integrating all technology to reach standardization and centralization, assigning responsibility and ownership of the architecture, and considering cyber attacks and data sharing. Moreover, it is important to acknowledge that IIoT constitutes a competitive advantage and will become a necessity in the future. Hence, the firms initiating IIoT projects early will have an advantage in mitigating the prevalent risks and handling the projects with success. Further, the firm aiming to implement IIoT needs to contemplate whether to use it internally, or provide it to customers externally. The choice depends on the nature of the firm, and the industry in which the firm operates. However, implementing IIoT both internally and externally may generate synergies for the firm.

Key words: Digitalization, Industrial Internet of Things, Industry 4.0, management of innovation, digital strategy

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1. Background and problem statement

More and more enterprises are rushing to undergo digital transformation in order to stay competitive (McKinsey, 2014). The term 'digital transformation' is difficult to define since it is applied differently in every organization. According to The Enterprisers Project (2017) it refers to the integration of digital technology into all areas of a business, which results in fundamental changes regarding the operations of businesses and how value is delivered to customers. Moreover, digital transformation may compel organizations to move from trusted business processes that have been utilized for a long time, to new processes that are yet to be defined.

One of the many ways to strive towards digital transformation is utilizing the Industrial Internet of Things, hereafter labelled IIoT. IIoT refers to the industry connecting equipment, products, and assets, bringing together informational and operational data (IFS, 2016). It incorporates various trends and shifts such as Big Data, Internet of Things (IoT), Machine Learning, and Machine-to-Machine Communication (Accenture, 2017).

According to IFS (2016), data collection in organizations is becoming increasingly advanced, as the technology develops, and gains acceptance and awareness among organizations. Simultaneously, it is becoming increasingly important to achieve digitalization by utilizing data stemming from the Internet of Things and processing the data to produce valuable insights. According to IFS (2016), the use of IIoT in organizations is increasing, and the amount of Internet of Things data is expected to multiply by seven in five years. The main drivers for using IIoT in organizations are the possibility to optimize productivity of assets and people, create new revenue streams, and create new output-based services (IFS, 2016).

There are several different emerging innovation trends related to IIoT. Two of these regard internal use and external provision of IIoT. Internal use of IIoT refers to innovation to improve operations activities of equipment being used in direct operations. One example is using IIoT to accomplish predictive maintenance. Predictive maintenance refers to placing sensors in equipment to detect developing problems in order to conduct service only when it is required (Mobley, 2002). External provision of IIoT refers to innovation for serving customers by incorporating IIoT in products and services sold to them. This is often used to provide additional services for the customers, which can be considered as a step towards servitization. Servitization is a term for traditional manufacturers becoming service providers, meaning a transformation from selling products to providing solutions including goods, services, support, and knowledge. This originates in the idea that customers want solutions instead of the actual product (Lay, 2014).

According to IFS (2016), 86% of senior decision-makers in firms are aware of the importance of conducting digital transformation and using IoT, but 40% have no strategy for utilizing these technological innovations. IIoT is a prerequisite for digital transformation in industry and a catalyst for these types of innovation. However, performing an IIoT driven transformation is challenging from an innovation management perspective (IFS, 2016).

One main challenge is that management in firms aiming to implement IIoT is subject to skepticism towards the possible benefits of digitalization, which creates resistance thereof (Li, 2015). Further challenges are that digitalization requires quicker responses to change, it may create cultural changes in the organization, and the vast supply of different IoT tools leads to difficulties in deciding on which ones to acquire (Demailly, 2016). Consequently, IIoT projects entice uncertainty and complexity, as it may imply an organizational transformation (Uhl and Golenia, 2014).

When initiating IIoT projects, a trusted business case is important, and the transformation of the organization may result in major changes for several stakeholder groups in the firms aiming to implement IIoT. Internal and external use of IIoT generates different effects and changes throughout organizations. Internal use of IIoT often entails process innovation, meaning changes in production methods, equipment, and software (The Innovation Policy Platform, 2017). External use of IIoT instead may require the organizations to partly change the business model (Kindström, 2010).

Hence, internal and external use of IIoT may include changes in management and operations of the organizations implementing IIoT, and may even result in a loss of jobs, changes in business models and revenue streams, exposure to new risks and liabilities, and legal aspects regarding data processing. Since these phenomena of digital transformation and IIoT are fairly new, and because it involves many organizational changes, these organizations require guidance regarding how to manage IIoT projects.

2. Purpose and research questions

The purpose of the study is to understand, analyze and advice on the various aspects an organization needs to consider when undertaking successful innovations fueled by the IIoT. Two major types of organizations are considered; firstly, organizations using IIoT in their direct operations, and secondly, organizations providing products and services incorporating IIoT to their customers.

In order to understand these two categories, the following research questions will be answered;

- How can the IIoT fuel innovation in organizations, either using IIoT in direct operations or providing IIoT products and services to their customers?
- What are the associated benefits of utilizing IIoT in organizations when either using IIoT in direct operations or providing IIoT products and services to their customers?
- What are the associated costs, risks, and challenges of utilizing IIoT in organizations when either using IIoT in direct operations or providing IIoT products and services to their customers?
- How can the associated risks and challenges of utilizing IIoT in organizations when either using IIoT in direct operations or providing IIoT products and services to their customers, be overcome?

3. Methodology

In the following chapter, the research methodology used is presented. Firstly, an overview of the research process is provided, whereafter the research strategy is elaborated upon. Thereafter, the research design will be presented and finally the research quality and a critique of the research methodology will be discussed.

3.1 Research process

The research process can be represented by a nine step model, which was undertaken in an iterative manner, see figure 1. The nine steps are divided into three phases; the planning phase, the data collection phase, and the data analysis and synthesis phase. The research process overview benefited the study by providing an overview of the actions to be undertaken, whereafter time could be allocated accordingly.

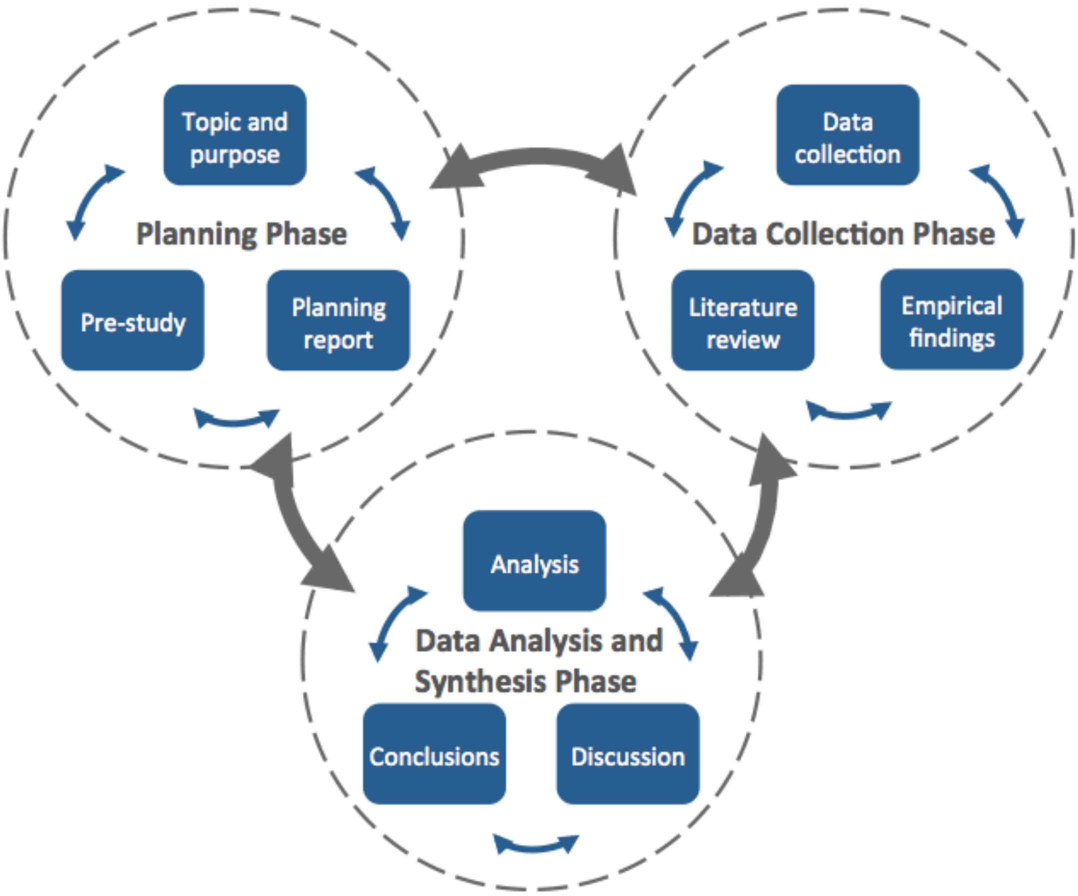

Figure 1. A visualization of the nine-step research process used in the study

In the planning phase, firstly, a pre-study was conducted where the topic on hand was investigated in order to gain an understanding of potential research areas of interest. Secondly, the thesis research topic, purpose, and research questions were specified in accordance with IFS and Chalmers. Finally, a planning report was compiled and written describing the research background, the purpose and research questions, the research methodology and the research time plan.

The research process did thereafter proceed to the data collection phase. The literature review was conducted using books, published academic articles and web sources, such as consultant reports and market analysis reports. The objective of this step was to gather knowledge fed into the literature review. Furthermore, the literature review demonstrated the current knowledge gaps that the research aimed to fill. This is in accordance with Bryman and Bell (2015) who argue that the thesis' credibility can be increased by linking the research to relevant literature. The empirical data was gathered through primary sources by conducting case studies of relevant companies. Finally, the empirical findings of the data was described and categorized.

Lastly, the data analysis and synthesis phase was conducted. The empirical findings were first analyzed, with reference to the literature review. Thereafter a discussion of the analysis followed. The discussion eventually resulted in the generation of conclusions, i.e. the knowledge claims, which could be inferred from the research study conducted.

3.2 Research strategy

Two primary research strategies may be distinguished; qualitative and quantitative (Bryman, 2008). The major distinction between these is that qualitative research collects data consisting of words, which is then analyzed using several techniques, while in quantitative research the data consists of numbers, which are analyzed by statistical techniques (Braun & Clarke, 2013). Furthermore, quantitative research aims to identify relationships between variables, often tends to be deductive in its research design, and generates data with low complexity but from as many respondents needed to ensure statistical security. In contrast, qualitative research seeks to understand data in its context, often tends to be inductive, and generates thick and detailed descriptions from its fewer respondents. As this study gathered data in a contextual setting and aimed to elaborately understand the complexities the studied enterprises experience, a qualitative research strategy was considered to be appropriate.

An inductive research strategy is a theory-generating one where patterns are induced from the analyzed data while a deductive research strategy instead incorporates testing theory, a hypothesis, on data (Bryman, 2008). In this study, the foremost strategy was used as data was gathered in an exploratory manner and thereafter categorized in order to generate theory.

A formal definition of ontology can be stated as "the science or study of being" (Blaikie, 2010). It can be explained as the belief system reflecting the researchers' interpretation of reality (Bryman, 2008). The constructionist view can be defined as "ontological position which asserts that social phenomena and their meanings are continually being accomplished by social actors" (Bryman, 2012). Thus, this thesis used a constructionist view as it was assumed that the understanding of the world is a construction based on subjective perspectives, i.e. that meaning is constructed rather than discovered (Crotty, 1998). The epistemological orientation instead defines the view held in the study concerning the determination of what constitutes acceptable knowledge (Crotty, 1998). According to Crotty (1998) the ontological and epistemological orientations are mutually dependent. Thus, both orientations have assumptions related to constructivism. Schwandt (1994) argues that constructivism can be claimed to be synonymous with an interpretivist theoretical approach. The latter can be defined as “understanding something in its context” (Holloway, 1997). The theoretical perspective of the research is “the philosophical stance informing the methodology” (Crotty, 1998).

Bryman (2008) argues that qualitative research often incorporates an inductive orientation, interpretivism as the epistemological assumption and finally constructionism as the ontological orientation. As these assumptions were valid in the study, which was elaborated upon above, the choice of a qualitative research strategy is further strengthened.

3.3 Research design

Research design can be defined as providing “a framework for the collection and analysis of data” (Bryman, 2008:31). Braun & Clarke (2013) describe research design as the blueprint of the research. The authors argue that the research planning phase is a crucial part of any study.

3.3.1 Comparative design

Comparative design can be defined as using more or less identical methods to study two or more cases (Bryman, 2008). Bryman (2008) argues the design implies a better understanding of the investigated phenomena as it allows comparison between different situations. When comparative design is applied together with a qualitative research strategy it may be described as a multiple-case study, i.e. the number of cases is larger than one (Bryman, 2008). The aim of a case study is to understand how the participants experience the situation in order to earn a better understanding of how the world functions (Yin, 2003). A case study can thus reveal underlying social processes. Bryman (2008) further argues a multiple-case study design results in an improvement of the theory-building process. This is due to the fact that the comparison of multiple cases allows a more efficient establishment of the circumstances in which a theory will hold (Yin, 2003). Hence, this research design was believed to fit well with the research purpose. The study was conducted by performing several case studies whereafter these were compared and contrasted to each other. The research and data analysis methods used in the study is elaborated upon below.

3.3.2 Data collection and data analysis

A research method is the method used to collect data within the frame of the selected research design (Bryman, 2008). One method for data collection frequently used within qualitative research is qualitative interviewing (Bryman, 2008).

Qualitative interviews are more flexible than quantitative ones, allowing the interview to shift in the directions aligned with the views of the interviewees (Bryman, 2008). This enables the researcher to collect rich and detailed answers, rather than shallow and easy comparable ones. The two main types of qualitative interviews are unstructured and semi-structured (Bryman, 2008). Semi-structured interviews entail interviews where a series of general questions have been prepared in advance, but the sequence of these questions and contingent additional questions are allowed to vary during the progression of the interview (Bryman, 2008). In contrast, unstructured interviews entails no prepared questions, but rather a set of topics that will be discussed. Bryman (2008) argues that when conducting a multiple-case study research, semi-structured interviews are preferred, as they will ensure comparability across the cases. Hence, semi-structured interviews were used to collect the primary data. The interview guide used during the interviews are provided in the appendix.

The interviews were audio-recorded and then transcribed verbatim. Braun & Clarke (2013) argue audio-recording the interview is of greater benefit than merely note-taking as it is important in qualitative research to have a precise record of the interview.

The sampling strategy often recommended for qualitative research is purposive sampling (Bryman, 2008), hence this strategy was used. The concept of purposive sampling corresponds to a strategy, which is based on selecting interview subjects relevant to the research purpose. The selected organizations were deemed as relevant as they were all engaged in the concept of IIoT, and were willing to share and elaborate upon their experiences.

Regarding the sample size "there are no rules for sample size in qualitative inquiry" (Patton, 2002:244). However, the concept *saturation* is a commonly used rationale for sample size and entails the collection of data until it reaches a point where no new information is generated (Morse, 1995). Yin (2009) instead argues that sampling logic should not be applied for multiple-case studies, but rather a replication logic. He further writes that a use of literal replication, i.e. similar results expected, and theoretical replication, i.e. contrasting results expected, should be considered. The replication approach diminishes the importance of sample size, and instead focuses on the researcher's need to demonstrate different case replications. The latter view was adopted in the thesis. As the study investigated organizations undertaking innovation fueled by IIoT, the focus was on literal replication rather than theoretical. The comparative case study namely aimed to find patterns and similarities among the participating organizations' experiences. The two different categories of IIoT-related innovation, internal use and external provision, were investigated by conducting case studies in each category; three case studies exploring companies providing IIoT, and three case studies regarding companies using IIoT internally. In addition, four experts in IIoT was interviewed, and one seminar was attended, in order to broaden the empirical knowledge base. The data collection process is specified below in Table 1.

Table 1: A description of the data collection process used in the study

Name and title	Company	Duration
Bertil Thorvaldsson, Robotics Product Manager for Software	ABB	90 minutes
Arto Makkonen, Senior Manager Digital Transformation	Accenture	45 minutes
Konstantin Zervas, Director Strategic Partnerships Automotive	Ericsson	60 minutes
Sara Mazur, Vice President and Head of Research	Ericsson	Seminar of 45 minutes
Antony Bourne, Global Industry Sales Director	IFS	Two interviews of 60 minutes each
Tobias Persson, Innovation Lead IoT	IFS	60 minutes
Bella Sörborn, Management Consultant	Cybercom Group	60 minutes
Vardans Saribekjans, Senior Technician of the IT Department	Songa Offshore	One interview of 90 minutes, one interview of 45 minutes
Cato Sola Dirdal, Director of IT and IS, and part of the top management	Songa Offshore	60 minutes
Alan MacPhee, Director of IT	Hecla Mining	90 minutes
Deniel Kostelac, Senior Business Developer	Volvo Cars as an IIoT provider	45 minutes
Anders Carlsson, Senior Adviser & Henrik Ernelind, Manager Virtual Methods and IT	Volvo Cars as an IIoT user	90 minutes joint interview

Throughout the study, data collection and data analysis were carried out in an iterative, cyclical manner. This is in accordance with Seale (1999) who argues that it is beneficial for researchers to cycle between analysis and data collection when building theory upon qualitative data. The general strategy of data analysis used was analytic induction. This incorporates the cycling between formulating a hypothetical explanation and reformulating or redefining this explanation as deviating and contradictory data is identified (Bryman, 2008). The transcribed interview material was coded manually using various first-order constructs. The constructs were derived from the literature review and the data analysis in an iterative manner. Thus, some constructs were decided upon from the start, while others were allowed to emerge as the process progressed. The constructs focused on the second and third research questions, and thus described various benefits, costs, risks, and challenges of IIoT. In the data analysis phase, relevant paragraphs of the interview material were allocated under the corresponding construct. The collected data, sorted by respective construct, is presented in Chapter 5: Empirical findings, and a summary can be seen in table 3 and 4.

By sorting the data according to the constructs, comparability between the different cases was enabled. Thus, in Chapter 6: Analysis, each first-order construct is compared between the participating organizations and analyzed in relation to itself and available literature. In this chapter, the weight of the costs, risks and challenges of implementing IIoT are also analyzed. These sections are based on an interview with Tobias Persson, Innovation Lead IoT at IFS. As he has extensive experience and knowledge from working with various IIoT projects, he is considered to be an expert in the area, ensuring quality of the answers. During the interview, Persson assessed the probability and impact of each construct on a scale of low, medium, and high. This scale was then translated into values, where low is represented by 1, medium by 2, and high by 3. The weight of each construct was thereafter calculated by multiplying the assessed probability with the impact of each respective construct.

The constructs, and the analysis of them, then resulted in mitigation strategies for the risks and the drawing of conclusions. The constructs used in the data analysis, and some examples of allotted paragraphs of the collected empirical data, can be studied in Table 2.

Table 2: The first-order constructs used in the data analysis phase with examples of transcribed data allocated to each construct.

First-order construct	**Example from data collection**
Facilitated access to information	*"It is interesting for the R&D department to receive information of how the products are functioning and how the customers are using them."* – ABB
Improved supply chain management	*"It is very beneficial for our service personnel to be connected. Sometimes they do not even have to visit the customer site, if it is possible to connect to the robot and diagnose the problem remotely. This allows the customer to be up and running quicker. Or if the personnel have to visit the customer, then it is good to bring the correct spare part on the first visit. Normally, service staff need to visit the customer two or three times before the problem is solved, on a typical service mission. This is because they first need to diagnose the problem, before they can bring the appropriate spare part. By having access to good data, the probability of solving the problem during the first visit, is high."* – ABB
Differentiation	*"And as you know, the reason they want to do this is they want to try and improve the service that they can offer to a customer. And why do they*

	want to do that? They want to differentiate themselves in the market, they want to increase profitability and revenues." – IFS
Decreased lifetime cost of products	*"Let me take an example. If I'm building a washing machine, I may put, it's got a 2-year warranty on it, I may put a belt on it that costs 1 Euro. And I know that that'll last 2 years. And then after that, if it breaks, I can send my service engineer out to replace it, but if I start thinking about servitization, then I may spend more on that belt that lasts a longer time. So the cost of the product increases, but I know that I won't have to send service engineers out as much in the future. So that the price is higher, so I'm not going to sell it as a product, but I'm going to sell it as a capability, I'll sell the capability to wash X amount of clothes per day. But then, my KPI will be good, because overall my customer's happier, my true cost is cheaper, but my engineers will be unhappy because they'll have less callouts."* – IFS
New revenue streams	*"I think the case Michelin is good, actually I've been strongly involved in that one as well. And for example with Michelin you learn that with IIoT you oftentimes start with some idea and put that in place and in the end you may end up doing something completely different. And even this tire as a service, I think the original tire as a service model for the fleet has been now a little bit put on hold and Michelin is considering what to do next. What is the best way then to start delivering new revenues with data?"* – Accenture
Standardized and centralized approach for processing data	*"We want to have a standardized and centralized approach on collecting sensor data and distributing required actions instead of having silos."* – Songa Offshore
Removing the human element	*"Computers drive equipment much more efficiently than people do, and we don't want to get people off equipment necessarily, but the IIoT will help us move towards remote controlled equipment."* – Hecla Mining
Better overview of operations activities	*"And this is something that is very foreseeing for the onshore organization when making decisions or understanding the situation, to see the live data or at least closed live data from the rigs, from the assets, despite what communication they might use. Whether they'll be under satellite communication, very cumbersome, or any quicker satellite. So this is also what we want to provide our onshore organization to have the ability to see that everything is ok. Quite often is on that level to see, I think the higher you get in the management the more aggregated data they get back. So at the end of the day the organization relies on the good old traffic light approach. Of course collecting 30.000 sensor data and aggregating that to show green, red, or yellow, it is quite a challenging task that nevertheless will be much appreciated by the onshore organization. It's good to know that everything is ok."* – Songa Offshore
Less workload for employees	*"It's actually something that we would finally be able to reduce the load from existing resources and I think this is what we want to in fact, our resources to be operating not on 100%, but maybe on 80%, so they can*

	actually spend some time on doing something that is not in fault by the system. So that they actually can do their duties outside us telling what they should do. And that in general is beneficial for both, for the employee because I think that employees that are always working 100% are not too happy, eventually." – Songa Offshore
Decreased costs related to layoffs	*"The jobs will change for sure. I mentioned remote control, and as our maintenance is getting more proactive we get into predictive maintenance, then it's possible that fewer people would be needed. But there's never enough mechanics, never enough electricians, right?"* – Hecla Mining
Decreased costs related to fuel efficiency	*"The large driver for Maersk, the shipping industry, is fuel efficiency, saving fuel by using the most efficient path."* – Ericsson
Outsourcing of IT operations and servers	*"You then prove the benefits to the company and then you say "okay, this data is stored in the Cloud, that means we haven't got it installed in servers, we need more space, it can be done in seconds rather than order a new server, training our own IT staff, all that's effectively outsourced, you're paying a regular service charge for that. And it de-risks it for you, so I'll turn on the risk element and say, when our IT manager goes on holiday, that's when I'm kept awake at night, because I don't want this to fall down, it costs me a lot of money to retrain the guy or keep him up to date on the latest qualifications, I don't want that cost anymore. I want to have a regular service level so that I know what the penalties are, so if they don't do it we can have claims against them, but it's de-risking the whole setup."* – IFS
Data backup	*"It can for example be that you want to back up the data that is perhaps the first thing you have in mind."* – ABB
Lack of trust in provider	*"The customers often oppose sharing their data. We have to persuade them that it is worth it to share the data, because what they gain is something they can't get otherwise."* – ABB
Changing the business model	*"We haven't come that far that we are selling the car as a service, in the way that truck companies do. There is a difference between B2B versus B2C ... selling a personal car is more about a sentiment. It is more emotional, and then the customers want to buy fun features. The customers don't regard the car as a tool, in that way. So it's more challenging to talk about for example uptime. But we are looking at how we could package it. That is really where the large turnaround in the future is, in business models."* – Volvo Cars as a provider
Costs related to remote locations	*"We don't have a lot of modern infrastructure underground, and it's a real struggle to even run fiber optics around our mine because it's very expensive and mining tends to be kind of old fashioned, and not a very progressive industry either."* – Hecla Mining

Organizational challenges - Resistance because of layoffs	*"There are some ethical concerns around automation reducing the workforce. It's a good time to talk about this, because just a few days past, on Monday this week, our Lucky Friday mine where David works went on strike. And the source of conflict is that the workforce wants to retain its historical work rules, the company wants to change the environment to facilitate automation, which of course could lead to a reduction in jobs. So the workforce is troubled by that, and the strike is the result. But the very survival of the Lucky Friday mine I think depends on us automation."* – Hecla Mining
Organizational challenges - Resistance in business unit due to insufficient business case	*"So basically we don't have any funding internally for doing this, because nobody understands actually what it is. So when we speak to the management team it's very hard for them to understand what IIoT is, we speak to the board, it's very hard for the board to understand what IIoT is, they just blank out. So we don't have any money to do the project to be honest."* – Songa Offshore
Organizational challenges - Resistance because of lack of trust and knowledge regarding technology	*"Therefore, in the old fashion way change is not good, I don't want the change, I don't want to expose myself from a knowledge point of view in understanding what it can do. And that can be driven from the top down."* – IFS
Organizational challenges - Not realizing it is a transformation of the whole organization	*"Digitalization is not an isolated event. It's not like you have six product categories and are going to develop a seventh. Instead, when you are digitizing, the entire organization is transforming. One needs to organize oneself in an entirely new way. Many organizations work in traditional silos and according to waterfall models, these need to start working together in a completely new way. That can be very challenging for companies."* – Cybercom Group
Technical requirements and complexity	*"Another challenge is of course the technical complexity and technology landscape. I haven't been counting, but I think there are clearly something like 400 IoT platforms out there. And there are vendors, if you go to social media they are arguing who has the real platform and what's the definition of the platform and they argue how you choose the best one. And I think it's quite complex for the clients to understand what platform to pick, and how to best deliver those use cases that are most relevant for every enterprise."* - Accenture
Inadequate focus on generation of value	*"Not us specifically, but the industry in general, tends to collect much data without knowing what to do with it, so it's just stored on a large server somewhere. One thinks that one day it will be valuable for something, but it may never come to use."* – ABB
Cyber attacks	*"The setup in the factory is very sensitive, you don't have to know anything about processes in order to be able to stop it. If someone just enters the network and stops anything, the factory needs to be shut down. So it's a large danger."* – Volvo Cars as a user

Lack of data privacy	*"There is information in the factory we don't want others to have access to."* – Volvo Cars as a user
Integration of technology	*"Some of that equipment is quite old and cannot be retrofitted with smarter diagnostics. So that's another challenge."* – Hecla Mining

3.4 Research quality

In order to ensure trustworthiness of qualitative research Guba (1981) proposes four criteria to be considered; credibility, transferability, dependability and conformability. These will be elaborated upon below. Finally, the concepts of single source bias, and common method variance will be presented.

3.4.1 The credibility of the research

A first criterion for judging qualitative research is credibility, which refers to the congruence between the reality and the findings (Shenton, 2004). A first step to achieve this is to adopt well-established research methods (Shenton, 2004). By deriving the method from previous and similar successful projects this was ensured. Secondly, researchers should familiarize themselves with the participating organizations in an initial phase (Shenton, 2004). This was ensured by accessing relevant documents and performing desktop searches beforehand. Other measures to increase the credibility includes iterative questioning, frequent debriefing sessions between researcher and superiors and peer scrutiny of the research project (Shenton, 2004). All of these measures was implemented in order to increase the credibility.

3.4.2 The transferability of the research

The transferability of the study refers to the degree with which the findings of the study can be applied to other situations (Shenton, 2004). When the authors clearly set the boundaries of the study by providing information on matters such as the numbers of organizations taking part, the data collection methods, the characteristics of the data collection sessions, and the time period, the reader may determine this (Shenton, 2004). As this information has been provided in this chapter, the degree and circumstances of the transferability are believed to be clear.

3.4.3 The dependability of the research

The third criteria which may be used to evaluate qualitative research is dependability, which refers to the degree with which another study can replicate the procedures of the research and achieve similar results (Shenton, 2004). In order for dependability to exist the procedures need to be reported in sufficient detail and be systematic and effective. By carefully describing the research design and its implementation, the data gathering process and evaluating the effectiveness of the project, a high degree of dependability is believed to be reached.

3.4.4 The conformability of the research

The fourth criterion by which qualitative research can be assessed is confirmability, which refers to the degree to which the findings accurately reflect the actual participants (Shenton, 2004). Biases which the researchers may introduce hence decreases the confirmability. In qualitative research some degree of bias introduction is almost impossible to avoid, however it should be minimized (Shenton, 2004). One measure to decrease investigator bias is triangulation. Furthermore, the authors should admit their own predispositions to increase the degree of conformability. In order to increase the degree of conformability weaknesses in the method have been admitted.

3.4.5. Single source bias and common method variance

When data is collected from a single source, bias may arise (Campbell & Fiske, 1959). By using data from several sources, i.e. various cases, the likelihood of single source bias was reduced. Common method variance is defined by Podsakoff et al. (2003) as "variance that is attributable to the measurement method rather than to the constructs the measures are assumed to represent". As the main method used to collect data were interviews, there may be a risk of inflations or deflations in the data.

3.5 Critique of the research methodology

A main disadvantage of a comparative design is the focus it puts on contrasting the cases, as opposed to merely focusing on the context they are within (Bryman, 2008). This is valid for the study to some extent. Rather than exploring the very broad context each organization is within, the focus tended to be on the constructs in order to allow the study to compare the cases, with the purpose of answering the research questions. However, the fact that new constructs continually emerged throughout the process, demonstrates that attention was still directed to the organizations' specific contexts and experiences to some extent, and not merely the specified constructs.

Further, as earlier mentioned there exists a risk of common method variance as merely one method was used to collect data. However, this risk was decreased by allowing experts to comment upon the emerging theory and judge its validity. Further, even though no data was collected via other sources, an extensive literature review was conducted in order to strengthen the empirical findings.

In addition, there may exist issues concerning the conformability of the research. To increase the degree of conformability, the beliefs which underpin decisions taken in the process may be specified and motivated. This has not been the case, and there is a risk that the authors inflicted their own predispositions upon the interviewees. For example, biases may have been introduced via the interview questions asked. However, the authors focused on posing broad questions, rather than narrow and specific, in order to decrease the risk of poor conformability. Further, some degree of triangulation was used by comparing the empirical data with expert commentary and an extensive literature review.

Finally, critique may be directed to the unit of analysis used and the fact that it is varying across the organizations interviewed. In some interviews the general opinions and reflections of the interviewee are expressed – experiences, which they have gained and compiled through multiple cases, while in other interviews specific case examples and its context are elaborated upon. Thus, there exists a discrepancy in the unit of analysis, and it might have been beneficial to instead compare between several specific cases. However, as the focus of the research is to find general comparisons between organizations, the negative impact of this is deemed to be very small. It does not matter whether a specific construct can be found in a specific case context, or if the interviewee has experienced the same construct across several cases – it is still prevalent.

4. Literature Review

In the following chapter, an extensive literature review has been conducted. The topics presented and explored include various aspects of digitalization, preventive and predictive maintenance, servitization, data ownership and data sharing, business models, and lastly, platforms and ecosystems.

4.1 Digitalization

In order to explore the topic of IIoT, a broader understanding of digitalization and its impact upon organizations and industries is necessary. Gartner (2017) defines digitalization as "*the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business*". Companies which digitalize perform better than their peers, thus it is an important aspect for the society (Nagel-Martin, 2016). Further, it disrupts traditional industries as they are rendered obsolete and as boundaries between them are blurred. According to Markovitch & Willmott (2014) it is crucial for firms to offer a seamless digital experience in order to stay competitive, as this is what the customers demand. They further argue costs can be reduced by up to 90 percent and sales radically increased, by digitizing processes which are information-intensive. Digitalization brings the business closer to its customers as it enables interaction through technology (Nagel-Martin, 2016). Further, it enables an individual customer to get access to more information and superior solutions.

However, several challenges are associated with digitalization; ensuring an architecture which is capable of connecting all different technologies used, agreeing on standards, cyber security, data ownership and privacy, proof of value, acquiring human resources with the required skill sets, and understanding and anticipating the impact of the digital transformation (Boorsma, 2016). Daugherty et al. (2015) also emphasize the challenges of modifying the workforce when digitizing the business. As certain workflows will become redundant as they are computerized, new needs for workforce will emerge, such as for skills in data science, software development, hardware engineering, and operations among other (Daugherty et al., 2015).

4.1.1 Cloud computing

When implementing an IIoT initiative, the organization doing so is dependent upon the use of Cloud Computing. Cloud computing, also known as "the Cloud" (IBM, 2017) can be defined as "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction*" (Mell & Grance, 2011:2). Gartner (2017) further defines Cloud Computing as "*a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service using Internet technologies*". The concept can thus incorporate several capabilities including, but not limited to, storing data, with the common characteristics that it is offered from a remote location via the internet and that it is easily scalable as per demand.

The benefits of using the Cloud includes scalability, the option to pay fees on a per-use basis and self-service access (IBM, 2017). Further benefits include disaster recovery, automatic software updates by the provider, operational rather than capital expenditure, increased collaboration among employees, remote data access and security (Salesforce UK, 2015).

The main challenge associated with cloud computing is the security concern – when interconnecting operations online the business may be exposed to sabotage, data theft and cyber attacks (Daugherty et al., 2015). Further risks include operational disruptions and resisting employees. Other challenges associated with Cloud Computing are inherent from a lack of standards, such as the interoperability as data migrates in and out of the Cloud, data privacy, portability between providers, and issues concerning service usage and control, e.g. liability matters (LaManna, 2012).

4.1.2 Industrial Internet of Things

The World Economic Forum (2015) argues that the IIoT will bring new opportunities as well as risks to businesses worldwide. The competitive force related to IIoT is not created by the things themselves, but rather by the products' new capabilities, and by the data they generate (Porter & Heppelmann, 2014). IIoT devices generate data which can be analyzed and acted upon by firms in order to improve their offering, cut costs or increase their efficiency (Davies, 2015). Porter & Heppelmann (2014) argue IIoT constitute a third wave of IT-driven competition. The World Economic Forum (2015) agrees with this statement as they call IIoT transformative. They argue it will change industry boundaries and the basis of competitive advantage.

It is important to note that IIoT not only affects the products themselves, but rather all aspects of a manufacturing firm; the value chain, service, human resources, marketing, security and product design (Porter & Heppelmann, 2014). According to the World Economic Forum (2015), it still remains a question exactly how the IIoT will impact industries, business models and value chains, and how it should be managed, yet Porter & Heppelmann (2014) argue that some patterns may be distinguished.

The concept

The IIoT is one of the means that an organization can undertake in order to strive towards digitalization (Accenture, 2017). It is enabled by Cloud Computing as the Cloud serves as a pathway and remote storage of the massive amounts of data generated by the IIoT (Meola, 2016). The IIoT is the combination between IoT and Big Data analytics, which generates opportunities for various industries (Hinks, 2015). Moreover, IIoT is combining IT such as the company ERP system, with operations technology monitoring manufacturing, production processes, and equipment (Daugherty et al., 2015). In addition to IoT and Big Data analytics, IIoT may also incorporate Machine Learning and Machine-to-Machine Communication (Accenture, 2017). Each of these elements of IIoT will be elaborated on below.

IoT is a concept that permeates environments of objects and things that become part of the Internet (Coetzee & Eksteen, 2011). These objects and things are uniquely identifiable and interconnected wireless or with wires, and accessible to the Internet through installed sensors and actuators (Vermesan & Friess, 2013; Coetzee & Eksteen, 2011). The sensors and actuators have the capability to sense, compute, and act. Hence, the IoT enables continuous determining of location and status of these objects and things (Coetzee & Eksteen, 2011). Through the interconnections and cooperation between the objects and things, new applications and services are created in order to reach common goals (Vermesan & Friess, 2013). Hence, the Internet of Things combines the real, the virtual, and the digital into smart environments that make industry and other domains more intelligent. The ultimate goal of IoT is that anything can be connected to anything or anyone, everywhere and anytime, and with any network or service (Vermesan & Friess, 2013).

As IoT is developing rapidly, so does the possibilities of gathering Big Data (Root and Cronin Edwards, 2016). The vast volumes of the data exceed capacity of traditional data management technologies and hence require new ones. Although focus is largely on volume, Big Data can be defined using two more attributes: variety, and velocity. The variety refers to the data not being structured, emerging in various formats and from various sources, whereas the velocity refers to the speed of the generation and collection of the data that often happen in real-time (Mediratta, 2015).

Machine Learning is part of Artificial Intelligence, making machines intelligent in the way that they are able to learn and self-adapt, which is valuable in changing environments (Ethem, 2014). Machine Learning is accomplished through programming computers to optimize specific parameters based on past experience or example data (Ethem, 2014). The process regards utilizing algorithms to analyze large amounts of data, learn from it, and then to make a prediction or determine something. Hence, instead of coding instructions for the machine, the machine learns and trains itself using the algorithm and the data (Copeland, 2016).

Machine-to-Machine Communication most often regards information and communication technologies with the capability to measure, transmit, receive, and react on data autonomously. It is an essential part in the connected environment and minimizes the human element in deployment, configuration, operation, and maintenance activities (Antón-Haro & Dohler, 2015). Data management varies between Machine-to-Machine Communication and IoT because in Machine-to-Machine Communication the data resides within the boundaries and for the purpose that it was created for, whereas in IoT the data can be used and reused for various purposes beyond the original design (Höller, 2014).

In order for IIoT to generate maximum value, organizations need to master the following technology capabilities: sensor-driven computing, industrial analytics, and intelligent machine applications. Sensors collect data on equipment conditions such as motion, pressure, and temperature among others. Utilizing sensor-driven computing combined with industrial analytics, the perceptions from the sensors are transformed into valuable and actionable insights, enabling real-time decisions and actions. Intelligent machine application refers to the fact that machines are moving from solely providing mechanical functions towards including intelligence (Daugherty et al., 2015).

Furthermore, to get the most value out of IIoT and combine the sensor-driven computing, industrial analytics, and intelligent machine applications, firms must acquire a solid infrastructure and technical architecture, i.e. an IIoT platform that enables a combination of IT and OT. These platforms should advantageously enable APIs for data sharing, integration of third party applications, and even the control of channels for delivering services to customers. Further, they should enable equipment owners and operators to operate applications and the equipment, link and control processes, deliver and analyze data, and connect with other firms (Daugherty et al., 2015).

Benefits of IIoT

Hardware and software are now being embedded in the products themselves, which generates significant improvements in performance and functionality. These improvements relate both to the connectivity aspect, and the data being gathered and subsequently analyzed (Porter & Heppelmann, 2014). Porter & Heppelmann (2014) further argue IIoT is setting a new standard for operational effectiveness, which is the basis for competitive advantage. Thus IIoT is crucial for all product companies to act upon, in order to stay competitive. The World Economic Forum (2015) argue the key benefits and opportunities of IIoT include improved efficiency in operations, the enablement of machine-human collaboration and connected ecosystems blurring current boundaries between industries, and the emergence of an outcome economy, defined as the shift from selling the product itself to selling the end results produced by the product.

Service is affected by IIoT in mainly two aspects; an increase in productivity and the enablement and improvement of predictive maintenance (Porter & Heppelmann, 2014). Porter & Heppelmann (2014) argue that the current service may be improved efficient-wise by ensuring predictive service before a breakdown and avoiding unnecessary service, but the data generated concerning product usage may also be fed into the product design to improve future service efforts, e.g. by providing insights on faulty parts and insights on how repairs may be simplified by reducing complexity. Moreover, it can be used to control whether the service is related to a valid warranty claim or not.

Challenges of IIoT

Further, IIoT poses a challenge regarding human resources, namely the challenge of matching the employee base with the new skill sets required (Porter & Heppelmann, 2014). Considering security aspects, Porter and Heppelmann (2014) argue IIoT challenges organizations by setting new demands for security management. The data flowing from, to and between products, need to be protected from unauthorized access. As IIoT is implemented the virtual and physical worlds converge, raising the need for businesses to implement new security measures (World Economic Forum, 2015). This will be elaborated upon below in section 4.4: Data ownership and data sharing.

A further risk associated with IIoT, apart from those mentioned above, is the lack of interoperability between the current IT systems (World Economic Forum, 2015). To ensure a seamless integration of these, which is needed to fully utilize the benefits of IIoT, will incur high costs and complexity. Further risks which may be mentioned are the difficulty to assess the business case of the investment, a lack of rules concerning how to govern the data, and an undersupply of the required human resource skills.

Management of IIoT

Firms undergoing digital transformation fueled by IIoT need to consider several strategic aspects. One of these relate to what data a firm needs to capture in order to ensure value maximization (Porter & Heppelmann, 2014). The collection, analysis and storage of data incur direct as well as indirect costs related to security or privacy risks (Porter & Heppelmann, 2014). A firm needs to consider the tangible value a specific data set may generate, and ensure this value exceeds the costs associated with it. Another strategic aspect to consider is whether a firm should change its business model or not (Porter & Heppelmann, 2014). As IIoT improves efficiency in service, a firm may choose to expand its offering from merely just selling the product, to product-as-a-service where the firm takes control of the entire product cycle, including operation and service, for a fixed fee (Porter & Heppelmann, 2014). This will ensure the selling firm may reap the product performance benefits provided by IIoT, but requires a large shift in the business model. The World Economic Forum (2015) argues businesses should adapt their overall strategy in order to fully reap the benefits of the IIoT. Further, firms should map out the resulting ecosystem they are to act within, and identify stakeholders whom they should partner with.

4.1.3 Industry 4.0

The concept 'Industrie 4.0', or 'Industry 4.0', was coined by the German government as one part of its High-Tech Strategy 2020 Action Plan (MacDougall, 2014). The Industry 4.0 involves the introduction of a so-called 'smart factory' where cyber-physical systems enable automated decision-making by monitoring the factory's real-life processes (Marr, 2016). Thus it is a sub segment of IIoT, namely the application of IIoT in a factory environment. According to Marr (2016) a factory needs to entail four characteristics to be considered Industry 4.0; information transparency – information is contextualized to enable machines to make more intelligent decisions; interoperability – all parts of the system are integrated and communicate with each other; decentralized decision-making by autonomous systems; and technical assistance – systems supporting humans. Industry 4.0 is enabled by three key factors; IoT and cyber-physical systems, Big Data and analytics enabling data processing, analysis and action, and finally the development of a secure infrastructure ensuring reliability (Carreiro, 2015). In Industry 4.0, machines will be able to optimize and configure themselves, and use Artificial Intelligence, to perform complex operations (Hinks, 2015). This will ensure cost savings, but also superior products and services. Further benefits include the possibility to improve working conditions in environments dangerous to humans, the ability to monitor supply chains more extensively and in real-time, to achieve a greater reliability and consistency of the productivity level, to increase market share and revenues, and in extent, profits (Marr, 2016).

Some of the challenges associated with the shift to Industry 4.0 are loss of traditional human jobs, the challenge to cope with technical problems, finding the adequate human resources capable of working with the technology, a general resistance among stakeholders caused by a lack of trust in the new technology, issues concerning data security, and the need for very reliable and stable systems (Marr, 2016).

4.2 Preventive and Predictive maintenance

When implementing IIoT internally as well as when providing it externally, one of the major focus areas is often improvement of the maintenance operations. Effective maintenance is a significant part of product quality and competitiveness in markets (Mobley, 2002). Maintenance management can be divided into three segments: run-to-failure, preventive, and predictive. As technology is advancing and organizations are starting to realize the importance of effective maintenance, an increasing amount is moving from run-to failure and preventive towards predictive maintenance (Mobley, 2002).

4.2.1 Run-to-failure maintenance

Run-to-failure is a reactive maintenance management technique meaning maintenance is not conducted until the machine fails to operate. This is the most expensive kind of maintenance technique since it entails machine downtime, decreased production availability, high overtime labor costs, and because it requires the company to store vast amounts of spare parts in order to be prepared for all possible failures (Mobley, 2002). However, if a company has operated the run-to-failure maintenance strategy for a long time, it may be incorporated in their culture, which may inhibit a shift towards working more proactively with maintenance, aiming towards avoiding breakdowns. This is due to the organization having adapted to a flexible maintenance strategy where problems are being solved quickly, which are values that are not fully compatible with predictive maintenance (Campbell & Reyes-Picknell, 2016). In order to adapt a new maintenance strategy the managers need to understand what drives the behavior in the company and how changes in this behavior can be initiated and influenced. Succeeding with this requires a significant level of attention (Campbell & Reyes-Picknell, 2016).

4.2.2 Preventive maintenance

Preventive maintenance means scheduling maintenance tasks based on elapsed time or operation time. This means that maintenance is either conducted before it is required, or when the machine has already reached failure, hence rendering the maintenance either unnecessary or overdue, which requires run-to-failure techniques (Mobley, 2002). In the former alternative, certain components may be replaced although there is no functional failure and they may endure more production time

(Girdhar & Scheffer, 2004). Both of the alternatives generate unnecessary costs for the company, although the latter alternative induces substantially more costs (Mobley, 2002). Hence, a plant that is utilizing preventive maintenance undertakes a balancing act in trying to optimize the maintenance activities, so that they are not performed with a too high nor too low frequency. This is difficult due to various conditions being dynamic in the plant, thus the optimum level of preventive maintenance will vary (Kelly, 2006). However, preventive maintenance often decreases repair time, associated labor costs, machine downtime, and loss of production compared to utilizing the run-to-failure strategy (Mobley, 2002).

4.2.3 Predictive maintenance

Predictive maintenance entails monitoring of indicators such as the actual condition and efficiency of the machinery equipment, generating data such as vibrations that is used for analysis in order to optimize maintenance (Mobley, 2002). It is sometimes also called condition-based maintenance, online monitoring or risk-based maintenance (Hashemian & Bean, 2011). Using this maintenance technique, maintenance can be scheduled when actually needed, maximizing time intervals between maintenance sessions and minimizing costs (Mobley, 2002). The emergence of IIoT creates the opportunity to further enable and conduct predictive maintenance utilizing for example Machine-to-Machine Communication and IoT (Journal of Engineering, 2014). In addition to using these elements of IIoT, various computer applications are used in order to monitor, diagnose and predict faults in the machinery (Xu et al., 2012). Utilizing predictive maintenance instead of run-to-failure or preventive maintenance may not only decrease costs significantly, but also optimizes availability of equipment, increases productivity, profitability and quality of products (Mobley, 2002).

4.3 Servitization

When organizations provide products and services incorporating IIoT to their customers, a shift to a servitization business model is enabled (Björkdahl, 2011). Servitization provides a method for differentiation for manufacturing companies experiencing squeezed profit margins (Bourne, 2016; Björkdahl, 2011). The concept servitization includes, as earlier mentioned, a shift in firms' business models in order to provide extensive service in addition to the physical products, or even in some cases to offer a service replacing the original products (Bourne, 2016; Björkdahl, 2011). Bourne (2016) argues the two main benefits for servitization are an improved relationship with the customer, and the generation of long-term revenue streams. The manufacturing firm's evolutionary shift to a greater service focus is enabled by the joining of digitalization and servitization (Lerch & Gotsch, 2015). The capabilities that digitalization provides to firms enable them to co-create value with their customers in new, previously untapped, ways (Lenka et al., 2016). By combining products with services, and digitally integrate these, the value offering can be highly customized and accurate according to customer preferences (Lerch & Gotsch, 2015).

When asset owners and operators move towards servitization the equipment becomes a productivity enhancing hybrid if it generates data that is used for digital services within the supply chain (Daugherty et al., 2015). This requires the data being transmitted between various devices, complicating the matters of data access and ownership (Root and Cronin Edwards, 2016).

4.4 Data ownership and data sharing

When implementing IIoT initiatives the concepts of data ownership and data sharing are of great interest. This is due to the fact that in order to fully gain the benefits from IIoT, data will need to be shared between the various actors, and ownership needs to be secured.

Big Data is increasing all the time, since IIoT devices enable creation thereof with its massive amounts of sensors (Mediratta, 2015). The increased amount of data available and the fact that the data is often collected in real-time generate intellectual property issues regarding who owns the data. Furthermore, IIoT often implies transmitting data between various devices, creating new datasets and further transmitting the data, complicating the matter further (Root and Cronin Edwards, 2016).

4.4.1 Intellectual property rights

According to Cornell University (2017), it is not possible to apply copyrights to data, as it is facts. However, it is sometimes possible to apply copyrights on datasets in the form of databases, as creating databases entails selecting, organizing, and relating the various data in it (Cornell University, 2017). However, according to De Wachter (2013), as copyrights require the creation of data sets to contain elements of creative work it is difficult to apply copyrights to data sets generated by IIoT sensors. Factual data can instead be protected with contract law, trademarks, and other mechanisms (Cornell University, 2017). Moreover, it is also possible to utilize patents for protection, but it often refers to the methods of processing the data and is hence less relevant for protecting IIoT datasets (De Wachter, 2013).

There are regulations called *database rights* that protect storing and processing of data. However, these are specific for intellectual property in the EU (Rendie, 2014). In order for the data to be protected by the database rights, three criteria need to be fulfilled. Firstly, the data needs to belong to a database (Rendie, 2014). Gupta and Mitall (2009) defines a database as "a collection of interrelated data stored together with controlled redundancy to serve one or more applications in an optimal way. The data are stored in such a way that they are independent of the programs used by the people for accessing the data. The approach used in adding the new data, modifying and retrieving the existing data from the database is common and controlled one". According to Rendie (2014), it is not likely that it is a database per definition if the data is collected in real-time and not into a fixed base. Secondly, there has to be a substantial investment associated with the collection, verification, and presenting of the data (Rendie, 2014). The investments may either be financial, human, or technical resources (Pinsent Masons, 2017). Hence, this is common when utilizing IIoT, since it requires investment in sensors and other equipment (Rendie, 2014). Thirdly, the database makers need to have a substantial business and economic connection with a European Economic Area state (Rendie, 2014).

Should the three criteria of database rights be satisfied, the rights belong to the 'maker' of the database. The maker is considered to be the person who took the greatest initiative and invested the most in creating the database (Birstonas, 2009). However, according to Rendie (2014), in data chains it is difficult to determine the actual maker since there are many stakeholders involved that may want to exploit it. The maker is typically and most often in the top of the data chain. Moreover, several firms may be makers if the initiatives and risks have been taken jointly (Rendie, 2014). The critical activity in deciding who the maker is, is to assess who is ultimately economically and commercially responsible for making the database. This means that it might not be the firm that is actually collecting and presenting the data that is the maker, and that subcontractors can never be the makers. However, database rights may be allocated in contracts. (Rendie, 2014).

4.4.2 Contracts

Since data chains may be highly complex with many overlapping responsibilities, it is important that ownership commission is stated in contracts (Rendie, 2014). Since it is difficult to prove ownership solely using intellectual property law, contracts are essential in controlling Big Data (Tollen, 2017). Moreover, due to the high possible value in the Big Data that IIoT can generate, it is likely that there will be many disputes should contracts on data ownership not be in place (Rendie, 2014).

There are various forms of Big Data license agreements, stating legal access and treatment of Big Data that can be written in order to enhance the intellectual property rights. These licenses are commonly included in Cloud Computing contracts where the service provider utilizes the customers' data in order to create services for the customer (Tollen, 2017). In addition to creating services for the customer, the service provider may want to exploit the data commercially, by creating new services, utilizing the data to improve their own operations and offerings, or licensing the data to other firms. These interests often contrast those of the customers (Thomson Reuters, 2017). The customers typically prioritize confidentiality of their data, prohibition of usage of the data for other purposes than their benefit, and receiving access or ownership to new data sets derived from their data (Thomson Reuters, 2017). It is important to state the desired confidentiality for both parties in the contract (Tantleff, 2015), and that the contracts are aligned with the licensor's business model while also being broad enough for the licensee to generate the desired value from the data (Thomson Reuters, 2017). The licenses should specify delivery, maintenance, and control of the data, but most importantly security policies, practices, and protocols (Thomson Reuters, 2017).

4.4.3 Management Challenges

According to De Wachter (2013), the actual challenges related to data ownership when utilizing IIoT are neither legal nor technical, but are rather related to business models and interests. This can be derived from the fact that the value of the data increases with the usage of it, and not the restriction thereof (De Wachter, 2013). According to Daugherty et al. (2015), although it is important to be careful about who is given access to the data, firms tend to be overly cautious regarding sharing data and information. According to Jernigan et al. (2016), firms tend to be as willing to send data to customers, suppliers, and competitors as receiving data from said actors. Furthermore, they are more likely to share data with customers than with suppliers and competitors (Jernigan et al., 2016).

Data sharing within the supply chain enhances productivity and enables greater control over the supply chain and the processes (Daugherty et al., 2015). However, the access to the flow of the data is generally more valuable than having control over its sources, although in some cases it is necessary or valuable to have control over some aspects and forms of the data (De Wachter, 2013). Moreover, data sharing with other firms is critical in order to obtain business value from IIoT (Jernigan et al., 2016). Most data are being reused by someone else than the creator of the data. The essential part of the business value of utilizing Big Data is captured when combining data from various sources, and therefore an increasing amount of data flows is being combined and opened up. It is therefore more important for organizations to expand various means of utilizing the data than to acquire ownership thereof. Hence, it is not the data ownership that is of relevance, but rather who has access to the data and utilizes it, and for what purposes (De Wachter, 2013).

4.5 Business Models

Organizations starting to provide IIoT to their customers, are required to partly change their business model. Thus, the topic of business models, and how to design and redesign them, is of great interest.

4.5.1 Business Model Canvas

Osterwalder and Pigneur (2009) define a business model as something that "describes the rationale for how an organization creates, delivers, and captures value". It can further be defined as "the logic and the activities that create and appropriate economic value, and the link between them" (Björkdahl, 2009). A simple tool for visualizing business models is the Business Model Canvas. It facilitates a shared language and understanding among business developers. The business model canvas comprises of nine elements called building blocks: value proposition, customer segments, customer relationships, channels, key partners, key resources, and key activities, revenue streams, and cost structure. Furthermore, these building blocks cover the main areas of business: offer, customers, infrastructure, and financial viability (Osterwalder and Pigneur, 2009).

The value proposition constitutes the aggregated benefits that the customers receive when using the organization's products and services. It consists of a distinct set of elements suited to satisfy the needs of a specific customer segment whereby it creates value for this customer segment. The value can be measured both qualitatively and quantitatively. Some elements of a value proposition may for example be: newness, price, performance, customization, design, brand, cost and risk reduction, accessibility, and usability (Osterwalder and Pigneur, 2009).

The customer segments represent various groups of people and organizations that the company desires to reach and attain. Customers are grouped into segments based on common characteristics such as needs and behavior. Different segments represent customers that generate certain amounts of profits, are willing to pay for specific elements of the value proposition, require a specific offer, can be reached through specific channels or require a specific relationship (Osterwalder and Pigneur, 2009).

The organization decides what relationship to attain with each different customer segment. The relationships may vary on a scale from automated to personal. The motivations for obtaining specific relationships with customer segments are customer acquisition, retention, and increase of sales. Examples of different customer relationships are co-creation where customers and the organization design the offer together (Osterwalder and Pigneur, 2009).

The channels building block represents the interface between the organization and its customers. It refers to the communication channels, sales channels and distribution channels with which the organization delivers the value proposition to its customer segments. The impact of the choice of channels for different customer segments is significant; it is hence important to tailor the channels to the preferences of the customer segments. Channels can be direct or indirect, as well as owned by the organization itself or partner channels (Osterwalder and Pigneur, 2009).

Key partners and suppliers constitute a network that is essential to the organization in order for its business model to be viable. Some of the main reasons for organizations to form partnerships are to reduce risk and uncertainty, optimize operations and generate economies of scale, and acquire important resources and activities. Furthermore, there are different forms of partnerships; strategic alliances between non-competitors, strategic partnerships between competitors, joint ventures to form new companies, and cooperation between buyers and suppliers to secure reliable access to supplies (Osterwalder and Pigneur, 2009).

Key resources are assets that the organization need in order to operate a viable business model. These resources could be either physical, human, financial or intellectual, depending on what industry the organization is in (Osterwalder and Pigneur, 2009).

Key activities are the most critical activities that the organization undertakes to reach customer segments, maintain customer relationships, create and deliver the value proposition, and earn profits. These activities may for example be production or problem solving (Osterwalder and Pigneur, 2009).

The revenue streams constitute the funds that the organization receives when delivering the value proposition to each customer segment. A customer segment may have several different revenue streams and each of these may entail different pricing mechanisms. To create revenue streams the organization needs to understand which of the elements in their offer that each customer segment are willing to pay for. There are two forms of revenue streams; transactional and recurring. Transactional revenue streams constitute payments that occur one single time whereas recurring payments are continuous payments that are often received for supporting services. Revenue streams can be generated through a vast amount of means, as for example asset sales when selling ownership rights of a physical product, subscription fees when selling continuous access to a service, and usage fees when customers use a specific service (Osterwalder and Pigneur, 2009).

The cost structure entails the most significant costs associated with maintaining the business model. There are business models that evolve more around minimizing costs than others. These are mainly called cost-driven business models whereas the opposites are value-driven. Moreover, the costs incurred can be divided into variable and fixed costs (Osterwalder and Pigneur, 2009).

4.5.2 Designing and redesigning of business models

According to Chatterjee (2013), there are two phases that a firm undergoes when designing or redesigning a business model. In the first phase the firm needs to determine what business model category is best suited to the vision of the organization and in the second phase the firm must translate the generic value capture logic of the business model into core objectives, meaning deliverables that are measurable and specific for the firm (Chatterjee, 2013).

There are four generic business model categories that an organization may undertake: efficiency-based, perceived value-based, network value, and network efficiency. The value-based business models use the generic value capture logic to position the firm's offer as desirable and wanted, and hence enables the firm to charge a price premium. This can be translated into that the value-based business models are focused on increasing customer value by focusing on solving their problems *in lieu* of producing a commodity. The efficiency-based business models, on the other hand, use the generic value capture logic to produce their offer as efficiently as possible, which often means aiming for high asset utilization (Chatterjee, 2013).

When the firm has decided on what business model category to adopt, it moves on to the second phase of designing the business model. In the second phase, the generic value capture logic is translated to a logic specific to the firm, whereafter activity systems are designed based on the firm's core objectives. It is essential that the firm assesses the risks of execution of the business model chosen, however attractive it may be (Chatterjee, 2013).

When designing efficiency-based business models the focus is on asset utilization, but also on pricing advantages in relation to competitors. An efficiency-based model can be achieved through shifting demand in time and place, expanding the value proposition with complementary offerings, unlocking capacity, and decreasing prices (Chatterjee, 2013).

On the other hand, when designing value-based business models, the focus is shifted towards positioning the offer as a 'want' item. These business models are subject to risk and uncertainty, especially regarding that the offer will not be valued by the market. However, there are some actions that can be undertaken to minimize these risks when designing value-based business models (Chatterjee, 2013).

Moreover, when designing a value-based business model it is essential to identify the desired outcomes for customers in order to determine value drivers that are unknown to other firms. Preferably these value drivers may be achieved with already existing capabilities within the firm. Furthermore, it is beneficial for the firm to make numerous prototypes of the offer rapidly and present them to a small fraction of the customer base. This enables rapid feedback that can be used to iterate the design process, which in turn decreases time-to-market. Another benefit generated by targeting a narrow customer segment is that the customers may help and cooperate in the design process, lowering uncertainty about product success. (Chatterjee, 2013).

The emergence of IIoT, and the complexities that are associated with it, require firms to adapt their business models so that they are compatible with these changes (Björkdahl, 2009; Björkdahl, 2011). When doing so, the focus should be shifted from business models of the individual firms towards ecosystem business models (Westerlund et al., 2014). This means that value creation and capturing should not only be considered for the individual firm, but for the whole ecosystem. In order to do this, the value drivers of all participants in the ecosystems need to be understood, since it lays a necessary foundation for building long term relationships with the other participants (Westerlund et al., 2014). Hence, Westerlund et al. (2014) argue that the ecosystem business model should be designed to maximize the value for all parties involved.

4.6 Platforms and ecosystems

Finally, the topic of platforms and ecosystems will be elaborated upon. Most IIoT solutions are based on platforms, and exist in ecosystems of various actors who have an interest in the solution. Thus, understanding this topic is of importance in order to fully understand the benefits and challenges related to IIoT.

A platform can be defined as "a package of common parts from which a stream of derivatives can be efficiently created and launched with network effects" (Magnusson & Nilsson, 2014:51). A main purpose of a platform is to enable the organization to balance the achievements of economies of scale and scope (Magnusson & Nilsson, 2014). By allowing, and encouraging, co-creation on an enterprise system platform, disparate user needs may be fulfilled by the derivatives provided by various providers, yet which are building on the enterprise system's infrastructure. Which platform wins the competition between the various ones available will be determined by the level of co-creation, i.e. the capacity to innovate within the ecosystem (Magnusson & Nilsson, 2014). However, the outcome of these battles may be difficult to predict.

For an organization aiming at creating a successful platform, two phases are crucial – Coring and Tipping (Magnusson & Nilsson, 2014). The phase of Coring includes identifying and designing a technical component that is vital and important to the market. Further, the incentives of contributing value to each partner, must be clear. In the second phase, the firm should focus on carrying out various strategic initiatives, tipping the outcome to their favor, such as building the brand and ensuring control over the installed base. When successful, the number of users and providers will be self-reinforcing – a critical mass of providers generating content, will attract a critical mass of users, and vice versa (Magnusson & Nilsson, 2014). On the contrary, an ecosystem which does not reach the critical mass, will not add value to the parties and will thus lack a rationale.

5. Empirical findings

The empirical data collected throughout the study is presented below. Firstly, the case studies regarding the IIoT providers are presented, whereafter the case studies of the IIoT users will follow. Thereafter, the IIoT expert case studies are provided, and finally, a summary of the empirical findings is compiled.

5.1 Ericsson

In the following chapter, the case study of Ericsson, an IIoT provider, will be presented.

5.1.1 Company description

Ericsson is a Swedish company, founded in 1876, operating in the telecom industry. They are the world's largest manufacturer of equipment enabling mobile communication. Recently (March 2017) Ericsson restructured their organization, and thus slightly redefined their focus areas. Regarding IIoT, Ericsson generally has two main roles to play. Firstly, and naturally, they are an important actor concerning the connectivity factor – a superior network, which is their expertise, will be required to enable IIoT. Secondly, Ericsson has been acting as a partner, supporting companies in digital transformation, incorporating IIoT amongst other technologies. Here Ericsson has applied their knowledge within connectivity, enterprise systems, operations etcetera – a knowledge base which has developed during the many years they have helped network operators to build a strong customer relation and deliver real-time digital services. One example of a company they have acted as a partner with is Volvo Cars with the Connected Vehicle Cloud – Ericsson's automotive Cloud, available in all new Volvo Cars. Ericsson is the driver of this Cloud, enabling Volvo Cars to connect their ecosystem with dealers, repair shops, customers, insurance companies, application developers for Cloud based services etcetera. When Ericsson started to get involved in the automotive industry in 2010, the industry focused largely on hardware and embedded software, and Ericsson urged the industry to direct their focus to include the Cloud. Currently, in 2017, the industry is very much focused towards the Cloud and its opportunities, something that Ericsson was able to contribute with due to their outside-in perspective.

In this regard, Ericsson has slightly shifted focus from a consulting business to a platform business, where Ericsson provides IoT platforms as well as other platforms, to both industry actors and mobile operators. Apart from equipment for mobile communication, Ericsson does no longer manufacture any hardware or embedded software in devices. Instead they focus on providing the entire solution for the connection of these devices, including integration to the Cloud and access networks. Ericsson thereby ensures connection of the ecosystem between the actors to enable innovation and service creation on top of the platform. Ericsson further describes themselves as a 'trusted partner' helping customers transform industries by digitalization.

Regarding the decision of which industries to serve, Ericsson recently shifted focus in the reorganization. From initially focusing on the transport industry, including automotive and shipping, and the utilities and public safety industries, the focus was shifted towards building horizontal solutions applicable across all industries. However, Ericsson will continue to focus on automotive as a core industry as they have progressed far with their automotive offering and currently has established customers. The horizontal solutions will feature reusable functions and solutions, which may not solve all the specific problems of each industry. Instead partners will be used for these, allowing Ericsson to focus on their core competences. These include digital services, creating billing models, creating, enabling and connecting the ecosystem, analytics, software updates in devices etcetera, i.e. general functions that all industries need in order to undergo a digital transformation.

Ericsson's platform and IIoT focus have, according to themselves, been very successful so far, and are something they will continue working with in the near future. However, they believe it is still very early maturity-wise, and that the enormous potential of IIoT will be released later on. The experience so far has been positive, but Ericsson has continued high expectations of what the future of IIoT entails for them.

5.1.2 Innovation fueling

In the following section, the innovation fueling based on IIoT will be presented, including the initiative, implementation, and description of use cases of IIoT projects in which Ericsson has participated. Moreover, Ericsson's view of data ownership in the IIoT projects is elaborated upon.

Initiative

Ericsson believes that a majority of companies understands the value of utilizing IIoT. There is also is a curiosity regarding the subject – very few companies would question the need to undergo digital transformation in order to survive. IIoT initiatives often stem from individuals within a company, who have been given an innovation responsibility. These individuals explore IIoT and initiate discussions around what it can contribute with to the organization. One example of this is Volvo Cars' Connectivity Hub, which initiated their IIoT project concerning connected cars.

Implementation

Ericsson experiences that their customers often proceed with the IIoT implementation in smaller steps. It constitutes a large transformation, and it is often not possible to replace and develop the customer's core business in one single effort. The IIoT initiative often spans over a longer period of time, and comprises of smaller pilot projects where the customer explores and tests various areas, in order to form a strategy for the transformation.

Use cases

One of the use cases Ericsson has enabled is in the shipping industry. Ericsson supported the company Maersk in connecting their ships, enabling them to communicate with each other and with the onshore organization. Previously connectivity has been absent on the seas, with the exception for satellite communication. Ericsson installed small radio base stations on the ships, in order to enable a telecommunications network. These stations still communicate via satellite, but as the protocol is the same, it also allows for traditional IP communication from port to ship. This creates large opportunities for Maersk, as it allows them to monitor their statuses offshore. Three main benefits with the connection can be noted; fuel efficiency, crew welfare and the enablement of service-provision. Applying analytics on the concept of fuel efficiency, large savings can be made by choosing the most efficient route, when predicting wind and weather conditions. This is enabled by allowing real-time communication with the port. Regarding crew welfare, the network enables the crew to for example connect with a doctor remotely, and receive health-related advice. Thirdly, Maersk can sell IIoT services to their customers. One example is to sell a service to fruit companies who are shipping fruit in containers on Maersk ships. Maersk could provide a solution to these, where the temperature is not only measured in the containers, but is also alterable. Such a service could ensure that the fruit is always ripe and ready to be sold as it reaches its final destination, as the container temperature affects the ripening process.

Data ownership

The customers of Ericsson implementing IIoT, own the data generated by the connected products. For Ericsson it is crucial to never claim the data rights, but merely access the data, in order to ensure customer trust.

5.1.3 5G and IIoT

The concepts of 5G and IIoT are highly intertwined as 5G will be one of the most important enablers for IIoT. A powerful, flexible and scalable network will be necessary in order to connect devices, industries and people, and to transform organizations and industries. 5G is the mobile network standard currently growing, and Ericsson is working on developing it. Some of the fundamental problems with IIoT will be solved by 5G. The network connections will be faster, more reliable and require less battery power – the battery life of smaller devices will be up to ten years for example. Ericsson estimates they will have 550 million 5G subscriptions by 2022, two years after the technology is planned to be standardized and commercially available.

The 5G technology is created not only to be a better mobile broadband, but also to meet the requirements from transforming industries and societies. It is designed to support cases with a large number of connected sensors, such as in intelligent transport systems and infrastructure monitoring and control. Further, it enables critical machine type communication, allowing critical remote control of industry devices, cars, remote surgery etcetera. In numbers, 5G should be able to support 100 times the data rates that there are available in today's systems and up to 1000 times the data volumes with a five times shorter latency. It should be able to connect 100 times more devices per area unit than possible today, in a very cost efficient way – the cost of a modem should be around a tenth of the cost today.

Ericsson is currently engaging with customers and partners, and building testbeds and trial systems. The company is also running industry pilots in almost all industries, such as automotive and transport, manufacturing, process, safety, agriculture, energy and utilities. An example of these pilots is the cooperation between Ericsson, SKF and Chalmers University of Technology, building a world class manufacturing facility. All the machines in the facility will be connected, and a complete IIoT framework as well as a mission-critical Cloud platform will be introduced. Another example is the joint project between ABB, Boliden, Ericsson, Luleå University of Technology, PiiA, Vinnova, SICS Swedish ICT, Telia, Volvo and Wolfit rolling out 5G as industrial mobile communication in a mine. The purpose of the network is to enable both communication and autonomous mining vehicles for safety and security reasons. Further, it allows the system to be aware of the location of every person or machine in the mine. 5G will be especially important for companies operating in remote locations or have work environments dangerous to humans. Two examples which Ericsson demonstrated at the World Mobile Congresses 2016 and 2017 are the possibilities to remotely control an excavator and a car respectively, with great precision. Humans would thus not need to be present in the dangerous work environment, but could instead operate the vehicle from a safe distance. Another project together with ABB trials remote control of a critical industrial robot using a 5G network. The robot also provides haptic feedback, allowing the operator to feel when the robot is touching things, with a very short latency.

5.1.4 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT providers

Improved supply chain activities

In order to ensure a truly efficient supply chain in the manufacturing industry, continuously gathering quality real-time data is crucial. By doing so, the company is able to adapt and alter the production flows, and thus impact the lead times and increase the efficiency. One example from the automotive industry is to generate insights regarding when a car is predicted to break down, thus proactively ordering the correct spare part, which is then available in the repair shop when needed. By planning in advance, the costs can largely be decreased. When not reacting predictively, the spare part needs, in the worst case, to be manufactured with a short-time notice if not available in stock, upon breakdown of the car. This can cause great complexity in the supply chain as it may require upstream actions.

Another important benefit in the manufacturing industry would be to decrease recalls in case of faulty products. By having connected products, for example a car, it would be easier to investigate exactly which products are faulty, rather than having to recall an entire batch of the product.

Differentiation

Ericsson believes IIoT offers an opportunity of differentiation for their customers. As described above, IIoT will enable Maersk to provide a service to their customers where they may monitor and alter the container temperatures in order to ensure timely ripened fruit. Such a service would provide Maersk with a differentiation edge, over their competitors. Furthermore, an IoT platform can enable the company to differentiate themselves by creating a direct communication channel with their customers, in order to increase customer loyalty. One example is Volvo Cars who traditionally sell their cars via dealers and in the past has had no direct relationship with the end customers, including selling of service offers, for example. By creating their own Cloud solution, in cooperation with Ericsson, they are now able to communicate directly with their end customers, and deliver services to them. Service bookings, for example, can be offered through the Cloud predictively, due to the connected Cloud analyzing each car's statistics. This communication channel creates a differentiation and a strong customer relationship and loyalty.

New revenue streams

Both of the examples mentioned above, the Maersk fruit service and Volvo Cars' Connected Vehicle Cloud, not only allow for differentiation, but also ensure that the companies can benefit from the creation of new revenue streams.

IIoT customers

Standardized and centralized approach for processing data

Using the Cloud allows companies to have a centralized approach for the storing and processing of data. In contrast with having several local storage points, for example in each car, all data is stored in one database and analytics can be carried out across all of the available data, increasing the accuracy and thus the value of the insights. The data can also be more efficiently handled.

Better overview of operations activities

By connecting to the Cloud and transferring functionality and data to it, automotive companies ensure a better overview of operations activities. This will enable the company, in a much more efficient manner, to monitor and operate a large amount of cars, by allowing the Cloud to orchestrate and analyze the data. In contrast, a car limited to itself, cannot generate as smart insights, as it is not able to compare and analyze across the entire installed base of vehicles. Further, the software is easier to maintain as it may be updated via the Cloud as well, rather than having to install new software updates via a CD in each single car.

Decreased costs related to fuel efficiency

IIoT will ensure decreased costs for the users by increasing operational efficiency enabled by analytics. One example, as explained above, is Maersk Shipping's ability to increase their fuel efficiency with analytics calculating the most efficient route.

5.1.5 Costs, risks, and challenges

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

IIoT Providers

Lack of trust in provider

The customers of Ericsson may initially have a negative attitude towards Ericsson having access to their data. Thus, Ericsson is always careful to demonstrate that they never own the data nor have any right to it, but only have access to it. Claiming ownership of and selling customer data, as Google for example, may only be successful up until a certain point – eventually the customers will lose their trust in the company. Ericsson is instead following the strategy of positioning themselves to be seen as a trusted partner; trustworthy enough to receive access to even the most sensitive customer data. Ericsson plans to always act as a partner in the background, and they do not request their brand to be seen upon their solution. As an example, it is not commonly known they provide the Cloud solution to Volvo Cars' Vehicle Cloud.

Each new industry Ericsson wishes to enter with their solutions, constitutes a unique ecosystem with unique game rules, including different business models, dynamics, technology solutions, legal issues etcetera. Furthermore, there already are established and credible actors in each new domain. To enter as a new player is a challenge, which requires effort and time. It is necessary to spend resources on building trust in the firm, and prove the role it has to play.

IIoT Customers

Costs related to remote locations

Communication in remote locations is costly and thus poses a challenge for companies operating for example airplanes and oil rigs.

Organizational challenges - Resistance because of layoffs

Employees may resist IIoT implementations, fearing the digital transformation will result in technical changes overtaking their jobs. This is an understandable threat to some extent, as the combination of IIoT, Artificial Intelligence and robotics results in machines capable of performing many tasks which previously needed to be carried out by humans.

Organizational challenges - Resistance because of lack of trust and knowledge regarding technology

Furthermore, people may resist technological changes due to them not having trust in the technology or insufficient knowledge of it. People may fear the change if they do not understand how the technology will impact their work tasks or the organization. Ericsson experiences that almost all organizations initially resist new technology. Furthermore, IT in general has an ability to disrupt, i.e. drastically alter the game plans of the companies, generating suspiciousness and insecurity towards the technology, resulting in resistance.

Organizational challenges - Transformation of the whole organization

Successfully implementing an IIoT solution requires the entire organization to be transformed, which poses a great challenge due to the complexity of such a task. Above all, Ericsson argues it is challenging to ensure that the customers are mature enough as organizations, in order to successfully receive support and help. The customers need to obtain the proper mindset, and organize themselves around the implementation. One successful example is Volvo Cars and their Connectivity hub – the organization within the company driving their connectivity solution. They were focused on adapting, changing and preparing Volvo Cars in preparation of rolling out digital services, as opposed to only physical products as before. This requires much time and resources. Ericsson argues that the technology often is not the problem – there exists several mature and efficient solutions today, but it is instead the organizational challenges and how the organization uses the technology that pose the major challenges.

5.2 ABB

In the following chapter, the case study of ABB, an IIoT provider, will be presented.

5.2.1 Company description

ABB is a Swedish-Swiss engineering and manufacturing company founded in 1988 consisting of two major businesses; power and automation. Power mostly incorporates utilities such as electricity distribution, while automation largely focuses on the manufacturing- and process industry and the marine industry. Thus, the two businesses differ greatly in characteristics, not the least regarding the customer base.

The automation business can be divided in the following two divisions; *Process automation*, focusing on refineries, paper mills, mines, shipping ports and other continuous processes and *Robotics and motion*, focusing on industries such as automotive and electronics. This case study focuses on the robotics and motion division. Within the robotics and motion division ABB's product offering consists of robots, software, and accessories. ABB can further deliver the systems on a module base or as fully complete systems, and also offers their IoT integration named the IoT Services and People (IoTSP) integration. ABB only incorporates and connects their own robots to their systems and the IoTSP integration. The robotics and motion division employs 5 000 people and is thus a fairly small part of the entire organization employing around 140 000 people.

A large part of ABB’s revenue stems from service sales to customers. Due to a competitive landscape, ABB, as well their competitors, are often forced to sell their products below its production cost. Thus, it is crucial that ABB does not lose potential service sales to competitors.

5.2.2 Innovation fueling

In the following section, the innovation fueling based on IIoT will be presented, including the initiative, implementation, and description of use cases of ABB’s IIoT projects. Moreover, ABB’s view of the future of IIoT and data ownership in the IIoT projects is elaborated upon.

Initiative

ABB’s customers’ initiatives to implement IIoT projects often stem from a corporate decision initiated by the CEO, production manager, or equivalent individual at C-level. The IIoT initiative is often decided on with the rationale that one must implement a project incorporating IIoT in order to stay competitive. The IIoT projects do not often stem from a specific experienced need, but rather a willingness to move into IIoT, whereafter the business tries to find a useful use case for its implementation.

Implementation

Previously, IIoT was implemented at ABB’s customers’ sites by attaching a connected IIoT box to the existing robotic solutions. The purpose of the box was to enable transmittance of the data collected by the available sensors. ABB is currently producing the next generation robots where all required IIoT hardware is integrated in the robot itself, prior to delivering them to customers. The data collection by the integrated sensors will, to a larger extent than before, be planned based on the data required for the desired services. When these robots are integrated at the customers’ sites ABB will provide a few IIoT services free of charge, in order to demonstrate its potential to the customers. Additional services may be purchased via the service agreement, which will be elaborated upon below.

Use cases

At ABB’s customers’ sites, the robots are connected with a secure real-time connection to the Cloud. ABB is given access to the customer data, and in some cases the customer may also wish to have access to parts of the data sets.

A majority of the services provided by ABB concerns service and maintenance. ABB offers service agreements to their customers, meaning they commit to ensure functioning equipment for a fixed fee. There are also external service providers that may, alongside with application developers and content providers, take part in the ecosystem created by ABB. This way, ABB ensures other players have freedom to act, yet make sure they themselves are the drivers of the ecosystem and profit from it. Further, by having an open ecosystem, not only ABB is able to provide services to their customers and robots, which increases the value for their customers.

A new generation of connected services being developed by ABB, is the enhancement of service and maintenance using Augmented Reality (AR) and Virtual Reality. By using AR glasses, such as the HoloLens created by Microsoft, an employee in the customer’s factory can connect to a service center, ensuring the service center can see what the factory employee sees. The service center staff can draw holograms in the air, visible to the factory employee, and thus advice on the actions required.

IIoT in the future

In the future ABB believes all robots in the factory will be able to be remotely accessed and controlled. The humans controlling the robots are thus not necessarily on the same location as the robots, nor are they constrained to only operating one robot at a time. Further, the connection will not necessarily be handled through a specific device but should be controlled through any available device, such as a laptop, phone or tablet. Further, ABB imagines 5G might play a larger part in the future, enabling the data to simply be sent out via 5G, rather than to a specific network.

Data ownership

The customers of ABB own all the data generated in their factories by the ABB robots. A specific contract for this has not been written, as the customer provides ABB data access within the scope of the service agreement. It is not possible to purchase the service of connected products by themselves, but only as part of a service agreement contract.

5.2.3 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT providers

Facilitated access to information

As the robots are connected to the Cloud and ABB is collecting much data from them, ABB's R&D department gains access to interesting data concerning the functioning of their products, the quality, how the customers are using them, e.g. are they putting more or less strain on the robots than expected, etcetera. One example might be the discovery that no customer is using the maximal capacity of the most powerful robot, indicating that a smaller robot might be more valuable in the product offer. Without IIoT, it is difficult to obtain objective data for product development.

Further, the data collection from multiple customers enables ABB to compare data from the entire installed base of all similar robots. Applying Machine Learning, and to some extent external data, ensures the inference of correlations and predictions for any given robot in any given factory, which is not possible for smaller competing firms providing service, repair, and maintenance of the robots. These firms can never compete with ABB in offering this service, as they only have access to data from their local working points. This is ABB's main advantage and the reason they are the drivers of the IIoT ecosystem in their customers' factories.

Improved supply chain management

The service agreements and the connected robots allow ABB a better overview of their operations activities. When being connected to their customers' robots the efficiency of the service and maintenance operations can be greatly improved. Firstly, ABB can schedule maintenance in advance and thus plan their resources more efficiently. Secondly, once a robot has broken down, they may not even need to visit the customer site if they are able to remotely diagnose and correct the problem. Thirdly, should they need to be called out to a customer site due to a breakdown, they can diagnose the problem in advance and thus carry the proper spare part and expertise with them enabling them to correct the problem at once, rather than having to revisit the customer multiple times.

Decreased lifetime cost of products

The service agreements for predictive maintenance ensure a mutual objective for ABB and their customers. As described above, the service and maintenance activities can be carried out with a greater efficiency. It is no longer in ABB's best interest to increase revenues by increasing the amount of service, but rather to minimize the need for service by utilizing predictive maintenance. Prior to offering the service agreements, ABB could actually benefit from poorly maintained robots requiring repairs on a more frequent basis.

New revenue streams

As earlier mentioned, the implementation of IIoT is a prerequisite for successful service agreements. As ABB utilizes service agreements, a new revenue stream is created, which is, based on the relative importance of service revenues for ABB, a crucial one for their remained competitiveness.

IIoT customers

Removing the human element

As the robots are connected they can be controlled remotely, without the need for a human to stand closely. This is further fueled by an increased speed of communication increasing the precision for remote control. By enabling remote access and control, the risk of mistakes is decreased, and the safety in dangerous working environments is improved, as there is no need for humans to stand closely.

As earlier mentioned, ABB has the ability to conduct Machine Learning on the entire installed base of its robots. The firm is of the opinion that Machine Learning enables predictive maintenance, which requires less human interaction and enables greater precision.

Better overview of operations activities

Utilizing IIoT allows the company to monitor all robots and their statuses on a dashboard. This allows for a better overview as the user can clearly see all the current operations in the factory. Relevant external data may also be utilized to further increase the visibility. Further, it allows fleet assessment, i.e. the ability to monitor which robots require service when. Moving to predictive maintenance ensures a more efficient planning, avoiding downtime in production to an as great extent as possible.

Less workload for employees

As IIoT enables humans to control robots remotely as well as possibly control multiple robots simultaneously, the workload for employees will likely decrease and their productivity increase.

Data backup

When the robots and the data they generate are connected to the Cloud, rather than simply a local network, the data generated is backed up, which poses a further benefit.

5.3.4 Costs, risks and challenges

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

IIoT providers

Lack of trust in the provider

A challenge for ABB, is to ensure their customers trust them having access to their data - a prerequisite for the IIoT services. Customers can often initially oppose giving access to their data, even though they wish to have the IIoT service. Thus, ABB needs to successfully convince their customers that the value of IIoT exceeds the risk of sharing data. Due to the sensitive nature of much of the data generated, ABB relies on anonymization of the data. Information that is not required to be able to supply the service, such as the name of the customer and more specific details, are removed from the data sets. This is a crucial step in order to gain customer trust.

Changing the business model

ABB is moving towards servitization with their service agreement, however they have not yet fully adopted the servitization business model. ABB can imagine themselves charging a fee based on a certain number of output units, however they experience challenges that need to be overcome beforehand. The most prevalent one relate to the difficulty of forming contracts and determining liability. It is difficult for the provider and customer to agree upon how to measure various aspects and which party is liable for any malfunctioning. For example, if a robot is not functioning properly, it needs to be decided whether it is because the customer has operated it in a faulty manner, or if it is because the robot itself is malfunctioning. Deciding and planning for these situations pose a great challenge to servitization.

IIoT customers

Costs related to remote locations

In remote locations, such as mines, the communication of data poses a challenge. However, it is not unmanageable as fiber optics may be installed in mines that are operated during a longer period of time, for example.

Inadequate focus on generation of value

The industry in general has a tendency to collect large amounts of data, without necessarily having a valid use case for all of it. Data collection, as well as data storage, are costly and may not always be useful as companies are not sure of what services and analytics to use the data for. It is often believed that it will be useful in some application ahead, but oftentimes it will just be discarded. Thus, the gathering of irrelevant data poses a challenge to IIoT. This may partly stem from IIoT being a buzzword companies want to act upon, even though they do not have a valid use case yet. However, as companies gain a larger understanding of the technology and the concept, the degree of data relevance increases.

Cyber attacks

A major challenge experienced by the IIoT customers concern maintaining cyber security. Connecting the robots to the outside environment exposes the company to risks such as potential cyber attacks affecting operations in the factory. ABB believes that if the gains from an IIoT connection is valuable enough to the customer, their customers are willing to connect themselves despite the risk. However, if the value of the connection is marginal, they may choose not to implement it. The largest risk concerning cyber security is sabotage from the outside. The most common method to mitigate this risk is to only allow data to be sent out from the company, but not to allow for any data being received.

Further, these systems must not be susceptible to anyone overcoming this one-way communication barrier. A few of the solutions in operation today were created for a friendly network, and thus ABB has recently been reviewing some communication protocols and solutions in order to increase the cyber security. However, it is important to note that risks concerning cyber security are always prevalent for all industrial firms, whether the factory equipment is connected or not.

Lack of data privacy

A further risk associated with implementing IIoT in the factory is related to data privacy. Companies may be unwilling to let data out of their factory and trust others with it, risking competitors gaining access to it. Much of the data generated by the robots could be considered as sensitive; for example data concerning product mixes in manufacturing and ramp up speed of new products. There exist a contradiction and discussion between ABB, wanting to send customer data to the Cloud, and the customers, wanting the data to stay in their local data center.

ABB sometimes experiences that the IT department of the customer organization may resist an IIoT initiative, even though other departments wish to conduct it. When ABB initially started providing IIoT to their customers there were no issues, as they did not connect to the customer's network, but rather transmitted the data from the customer site to ABB via the mobile network. As ABB was not connected to the network, the IT department was often not aware of the IIoT project and could thus not resist to it. However, as soon as ABB wished to start to connect to their IIoT customers' networks, the IT department became involved, and resisted due to data security and privacy issues associated with the connection. The IT department often experiences risks associated with letting out, as well as letting in, data. Thus, even though several departments within the organization wish to initiate IIoT, the resistance from the IT department may impede it. However, as IIoT is becoming more and more frequently common, the customers are often finding loopholes in the company policies, allowing them to implement it anyways. This is not only a challenge for ABB, but for the entire industry. As it is so common ABB is having high hopes that it will be improved in the forthcoming time.

Integration of technology

In the new robots, the IIoT hardware is already integrated from the beginning. However, older equipment needs to be retrofitted with an IIoT-box in order to be compatible with the system. This integration poses a cost and a challenge.

5.3 Volvo Cars as an IIoT provider

In the following chapter, the case study of Volvo Cars as an IIoT provider, will be presented. The chapter will begin with a company description, which will serve as background context to this chapter, as well as the following chapter presenting Volvo Cars as an IIoT user.

5.3.1 Company description

Volvo Cars is a car manufacturing firm founded in 1927, in Sweden. The company operates plants in Sweden, Belgium, and China, with the headquarters located in Gothenburg, Sweden, and employs 31,000 people worldwide. Volvo Cars is since 2010 wholly owned by the Chinese automotive manufacturing group Geely.

Volvo Cars can be considered as both an IIoT provider, and an IIoT user. Firstly, they provide an IIoT service to their end users via the connected cars that they manufacture and sell. Secondly, they are aiming to utilize IIoT internally in their manufacturing processes of their cars. Both of these cases will be elaborated upon below, in two different case studies.

5.3.2 Volvo Cars as an IIoT Provider

Volvo Cars are currently providing IIoT services to their end users in each new car. The department Digital Connectivity and Consumer Services responsible for this, is a sub department of IT at Volvo Cars. It specializes in everything in IT that is related to the end customer, including webs, marketing, and the connected car and all of its infrastructure.

5.3.3 Innovation fueling

In the following section, the innovation fueling based on IIoT will be presented, including the initiative, implementation, and description of use cases of Volvo Cars as an IIoT provider's IIoT projects. Moreover, their view of the future of IIoT and data ownership in the IIoT projects is elaborated upon.

Initiative

Volvo Cars is of the opinion that they were in the forefront of connecting their car and that they predicted the necessity of offering additional services to their end customers early.

The first initiative to connect the car was taken in the beginning of the millennium, and the first feature was Volvo on Call, meaning that the car sent its position and a message for help in the case of collision. Ever since, the IIoT functions of the connected car have been developed further. The Volvo on Call was complemented with a smartphone application, enabling the customers to control some of the functions in the car remotely. One of the most popular features that can be remote controlled is to heat the car prior to using it. Moreover, when the cars were upgraded Volvo Cars also decided to connect the entertainment system, which was the real starting point of the connected car.

Implementation

The long cyclical processes of the car industry results in that the time from when a decision is made to when it is actually implemented can be very long. This is partly due to the manufacturing process of assembling numerous parts being very complicated, and many more advanced processes need to be executed before the product reaches the market. This long and complex process of developing the products also slows down the process of implementing more IIoT in the cars.

Use cases

The connectivity of the cars is supported by numerous inbuilt sensors that are integrated into the car in the production phase. Volvo Cars are currently developing all of the IIoT services themselves or together with partnering firms, but their platform is not open to third party developers. The company has seen that competitors that have open platforms have not succeeded in attracting enough developers yet. However, opening up their platform is part of a continuous discussion and should they discover an interest from developers, Volvo Cars are prepared to open up the platform.

The degree of connectivity and services offered in the cars vary based on geography. However, the connected entertainment systems are included in the cars globally. This does not mean that all cars have inbuilt modems in them, but rather that they are equipped with Internet functions that can be used if a mobile network is provided by the customers themselves, such as the network from their smartphones. When the customers connect their cars with their own mobile network, some data and information is sent to Volvo Cars as well.

The current data collection is conducted with the purpose of generating value for the customers. However, the company is researching the possible value and solutions that can be used for themselves as well. The data is currently primarily collected from when the cars are at service stations, approximately once a year. The data collected mostly regards the state of health and diagnostic information of the car. The diagnostic data that is collected is no raw data, but rather codes that are generated by raw data and logic in the cars. These codes are based on various parameters, such as RPM and vibrations. However, for customers that have Volvo on Call, data regarding warning signs, gasoline status, and distance driven is collected daily.

The IIoT functions that are currently offered regarding service and maintenance regards direct contact with service stations, thus facilitating the service booking of the customers. When the car requires service a message will appear asking the customer if the car should contact a dealer. Should the customer press the button for acceptance, he or she will receive suggested times for service at their preferred dealer. It can be noted that Volvo Cars works with many external dealers and service stations and own very few of them themselves.

Volvo on Call entails various convenience features such as fuel level, heater and engine starter, and as earlier mentioned it also offers automatic assistance in case of collisions. This means that the car automatically sends a message and the driver receives a call regarding the state of the car and the passengers. Depending on the needs of the passengers and the car, ambulances and tow trucks may be sent and insurance companies and hotels may be contacted immediately. This feature has been much appreciated by the customers as it can be seen as an additional, cheap safety insurance. Moreover, the EU has legislated that all cars will soon need to have a simpler version of this safety feature.

In some countries, Volvo on Call also includes a concierge service. In China, the cars have a call function that allows the driver to ask for address information and receive position data directly to its GPS. In the USA, the concierge service enables the car owner to order car washing or refueling by phone. With a digital key, Volvo Cars may unlock the car remotely, without using the mobile networks, and let someone wash or refuel the car, and then drive the car back to the customer, without the owner having to be present. In the future Volvo Cars hopes to be able to offer a concierge service enabling the customers to send the car to a service station remotely as well, for example when the customer is at work. Another service that is offered to customers is the so-called In-Car Delivery, which enables companies to deliver goods in the cars without the customers having to be present.

IIoT in the future

In the future IIoT will enable radically different business models regarding the ownership of cars. Volvo Cars wishes to invest more in optimizing their business model, as they regard it as key to the future. Their opinion is that IIoT enables new business models that will make transporting people easier, smoother, and more fun in the future.

Data ownership

The customers own the data generated by the cars and Volvo Cars believes that taking this view differentiates them from their competitors. They have a purpose for, and are transparent about the data collection, and they are trying not to write broad policies that will allow them to use the data for everything. The IIoT services in the cars do not work until the customers turn them on, so it is an active choice by the customers to use them, and they can decide whenever to not allow for further data collection.

Volvo Cars has specific contracts for collecting the data from the customers through services such as Volvo on Call. Moreover, third parties only receive access to the data if the customers give their permission, and it is only for the purpose of co-creating services that are valuable to the customers, such as the In-Car Delivery feature. Without sharing the data it would not be possible for the delivery companies to know the position of the car, for example. However, the delivery companies do not receive any raw data and the exposure of information about the car is minimized so that the delivery company only receives access at the time of delivery.

5.3.4 5G and IIoT

Volvo Cars believes they could gain several advantages from using 5G networks for their IIoT services in their cars. One is that when the car is turned off, it will use less electricity to monitor control messages. Another is that the latency of the 5G network for sending data is minimized, which will be advantageous for the autonomous driven cars, since they will be dependent on the networks in their decision making.

5.3.5 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT providers

Facilitated access to information

Volvo Cars has collected information about the cars for a long time. When computers were integrated in the cars and they became increasingly automated, the company created a software program called Vida, used by all of the company's service stations to troubleshoot the car. The information collected when the service stations use Vida is sent to Volvo Cars' data storage in Gothenburg. This enables the company an overview of history, diagnostics, error codes and more, on many of their cars. The disadvantage of this solution is that the data is gathered from each car with a maximum frequency of once a year. In the future Volvo Cars wants to collect the data more frequently and move towards collecting it in real-time, in order to be able to predict errors and thereby decrease their costs.

Differentiation

Volvo Cars offers their IIoT services to their customers in order to render the cars more attractive. With these features they are differentiating themselves by simplifying transportation for their customers. For example, the service and maintenance booking service in the car minimizes boredom of the customers since they generally do not like spending time handling service station bookings.

Decreased lifetime cost of products

As earlier mentioned, Volvo Cars wants to collect data more frequently from each car in the future. They have an ongoing project where they are trying to render predictive maintenance possible, meaning that they want to predict when a car needs to be repaired or when some parts of it need repairing.

New revenue streams

Some of the IIoT services are offered as standard offers in the cars, such as the connected entertainment system. However, some features are available for additional purchase in, such as Volvo on Call and its modem, and In-Car Delivery. Hence, by connecting the car the company is able to create new revenue streams generated by IIoT. Creating new IIoT services is currently one of Volvo

Cars' top priorities and they are investing much energy and resources in this, and receiving the new revenues is the driving force of it.

5.3.6 Costs, risks, and challenges

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

IIoT providers

Lack of trust in provider

A large amount of information that the company collects regards the car owners and hence personal information can be derived from this, making the data very sensitive. This is a risk that needs to be handled with caution. Therefore, Volvo Cars is currently investigating what data to collect and what data not to collect, for how long the data should be kept, why the data should be collected and how it should be encrypted. These factors have significant business impact for the company, since it is important for Volvo Cars to gain trust from their customers. However, since developing the IIoT services is essential to the company, they are trying to create contracts that enable innovating these services, while being careful about the data collection as well. This constitutes a difficult balancing act.

Changing the business model

The customers desire IIoT services, which is proved by the evident demand for them. However, increasing the amount of services or replacing the current way of selling cars, i.e. moving towards servitization, requires new business models, which poses a great challenge. Nevertheless, Volvo Cars believes that this will be the greatest trend in the future for the car industry.

The company is currently not selling the actual car as a service in the way that truck manufacturers, and other industrial companies, are doing. The reason is that there is a difference in the way vehicles are bought in the business-to-business and business-to-consumer markets. Volvo Trucks has no problem selling a guarantee that the drivers will have a working truck at 99.9% of the time, should the drivers follow their requirements. However, the customers of Volvo Cars are not buying a tool, as the customers of Volvo Trucks, but rather an experience with fun features. Selling a car to a private person entails selling a sensation and it is hence more emotional. Therefore it is more difficult to sell the car as a service in Volvo Cars' market. However, they are investigating how this could be packaged and how the business model could be changed, since the company believes that this is the future, even in their market.

Changing the business model is difficult due to the industry being conservative. The general business model of the industry has been the same since the creation of the industry, approximately 120 years ago. However, as earlier mentioned, the company believes that this is going to change and that there is no doubt about this. They think that their customers will change in the future and that their primary customers will be fleet operators such as Uber, while the private persons will constitute a smaller customer segment. IIoT and connectivity of the cars will be essential in order to succeed with servitization, in changing the business model, and selling uptime of the cars. Uptime is what the customers actually will prioritize, while design and sensation is secondary. However, design and sensation will stay important factors since people tend to value beautiful things, but the decisions will be more centered around business in the future.

IIoT customers

Costs related to remote locations

The main challenges regarding IIoT in the cars according to Volvo Cars, are the costs of data transmission and storing the data internally at the company. However, the data transmission is the largest cost, since they need to send their data using mobile networks and because the data storage can be restricted as data is not stored forever. Some cars have inbuilt modems that are included for the customers, and these modems roam all networks from all mobile carriers, making the data transmission very expensive. Due to the high costs of data transmission, the company is very selective in what data to gather from the cars. Moreover, this is the reason for the company only gathering diagnostic data from the car once a year when they are at the service stations, and not in real-time. Although the costs of data transmission are decreasing, the amount of data that the company sends is increasing, so Volvo Cars believes that the total effect will be zero. Further, they believe that this will always be a large cost for them.

Organizational challenges - Resistance because of lack of trust and knowledge regarding technology

The IIoT technology in the cars is not fully reliable, primarily because of the network connection. The cars contain batteries and should these begin to wear out, the modem is turned off as well. Moreover, the mobile networks that the cars are using are not fully reliable either. However, since this is a known problem the company is trying to build their solutions around it, requiring additional data in order to make the services work better. The largest problem with the networks not being fully reliable is that the customers do not always understand it. Some assume that the IIoT services should work all the time, even if the car is parked in an underground garage. Therefore it is important to educate the customers so that they gain understanding of these limitations. It is difficult for both the service provider and the customer to provide services regarding car washing or delivering of groceries remotely, if the car is parked in a locked garage, for example.

Inadequate focus on generation of value

A car generates terabytes of data each day when it is being driven. This amount of data is impossible to extract and collect from all cars, and it would not be possible to store the data either since the costs of this are too high. Therefore, it is very important to decide on what information should be collected.

Cyber attacks

There is always a threat of the cars being exposed to cyber attacks. Volvo Cars are working to protect the cars and their passengers as good as possible and want to be state of the art in this area. Volvo Cars is continuously monitoring the individuals, i.e. the cars. The cars are called individuals as they have their own personalities depending on how they are handled and other factors. Should a car act odd, Volvo Cars will know that something is wrong. Moreover, they are very careful of who is allowed to execute what in the cars, so that no one can destroy the driving experience of their customers. Currently, the rest of the car industry in general is not very good in this area, and therefore Volvo Cars is trying to be the very best.

5.4 Volvo Cars as an IIoT user

Volvo Cars is further aiming to use IIoT internally, in their manufacturing processes. The current setup of their manufacturing processes will be elaborated upon below, in order to provide and set the context of the following case.

When developing a new car, Volvo Cars specifies concepts for all of the stations needed in the factory. However, there is no in-house organization for building it, so they hire partners to build the actual stations and make the detailed construction thereof. Moreover, the partner firm integrates the equipment and implements it in the factory. Should IIoT be integrated in the factory, Volvo Cars needs to specify it to the partner firm since they have detailed PLC standards and online management, and hence they need to determine what systems to utilize.

All of the cars that are produced by Volvo Cars are ordered in advance, either from direct customers or from dealers. Moreover, Volvo Cars buys all of its manufacturing equipment from other companies and they perform a majority of the service and maintenance on the equipment themselves.

5.4.1 Innovation fueling

In the following section, the innovation fueling based on IIoT will be presented, including the initiative, implementation, and description of use cases of Volvo Cars as an IIoT customer's IIoT projects. Moreover, their view of the future of IIoT and data ownership in the IIoT projects is elaborated upon.

Initiative

Volvo Cars believes that an IIoT initiatives in their factories needs to be taken by top management. This is due to the fact that such as implementation is dependent on cultural values and the fact that IIoT initiatives tend to emerge as silos throughout the firm. Moreover, the IIoT projects need to have the same technical standards in the various factories in order for the projects to generate maximum value. In order for the plants to agree on a common standard, top management needs to pressure the factories, make a decision, and give orders.

In the plant in Gothenburg, Sweden, integrating IIoT is still in its idea phase, whereas the plant in Gent, Belgium, has implemented a number of quality projects related to IIoT. The Gothenburg factory is still working reactively regarding service and maintenance, for example. Volvo Cars believes that the reason for the Gothenburg plant not having come very far with IIoT is that they have implemented many other, more urgent, projects the last five years. During these last years they have built several new factories and developed new cars, which have demanded their focus.

As earlier mentioned, the factory in Gent has come much further regarding implementing IIoT than the factory in Gothenburg, and many of their solutions have been spread globally. The initiative in Gent was taken due to pressure from their service and maintenance manager who insisted that it was critical to maintain their existing equipment for several more years. During these years they would have a limited stock of spare parts for their equipment, which meant that they could not change engines every year, for example, since there were not enough engines to do this. Since this first IIoT initiative, the factory in Gent has continued to develop and implement more IIoT technology, most of it related to quality. There is a cultural difference between the factory in Gothenburg and the factory in Gent, where the factory in Gent has a culture that is more favorable of IIoT projects. Firstly, the level of academic achievements and education is generally higher in Gent than in Gothenburg. This generates a greater understanding for the necessity and value of the IIoT technology. Therefore the employees in the Gent factory have a greater interest in developing IIoT further. Moreover, there is a continuous concern for closure of the factory in Gent, because it is located far away from all other operations of the firm. This induces creativity and a desire to be the best, and for the factory to have a maximal uptime.

Implementation

When implementing IIoT projects in the Gent factory, Volvo Cars commenced with smaller projects. They implemented IIoT in one piece of equipment or station at a time, based on the frequency of failures, i.e. the piece of equipment with most failures or most frequent failures was handled first. Moreover, when choosing which parameters to measure in the equipment, parameters with known limit values were chosen.

Before the IIoT was implemented in Gent, the service and maintenance workers received error codes for failing equipment, but they did not receive information about the causes. The workers commenced to manage the available data in a more structured way and initiated an investigation of what specific parts of the equipment and what specific parameters caused the error codes. By deploying this it was possible to decide what errors were less critical, what errors were more critical, and what errors meant failure and needed service immediately. With this project much effort has been invested in actually understanding their equipment and their respective limit values of various parameters, in order to maintain the plant running with minimized downtime.

The existing IIoT projects in Gent are seen as silos, as they are not used globally in all of the company's factories yet. However, as factory building and car launches are moving towards completion and the efforts regarding these are decreasing, the product development department at Volvo Cars have begun to investigate a possible integration of IIoT in their other factories as well. The company believes that they are able to implement this eventually, when the other larger projects are fully completed. One of the driving factors of this is that they are now seeing the effects of being globally present. Having different standards in two plants have worked so far, but with five or six plants they will need a cohesive organization for developing their IIoT solution.

Use cases

There are numerous sensors generating data on the equipment in the factories. Every Volvo Cars factory has a control tower collecting signals from the equipment sensors, and all equipment is connected to a PLC that collects information and sends it to the other IT systems. The data collected regard tong opening times, engine effects, robot answering times, and waiting times for PLC signals, among others. However, the Gothenburg plant has not yet learned to process the information and apply intelligence to it in order to generate valuable insights. The Gent factory is currently doing this and conducting predictive maintenance, while the Gothenburg plant only utilizes preventive maintenance.

Moreover, the company sends almost all of their sheet metal used in Europe from Olofsström, Sweden. The sheet metal is transported by train to the plants and these distances are very long, requiring large investments. During the transports Volvo Cars utilizes expensive packaging and racks, of which they do not know the location most of the time. These are tracked with RFID tags, saving the company much money. However, this is currently only conducted in their own logistics chain and not with external logistics partners.

Volvo Cars is of the opinion that they have limited experience of IIoT. Even in their newly built factories the technology is not implemented, although they are investigating the possibilities for it. They still regard implementing IIoT in the new factories as a strong possibility as everything already contains the hardware and infrastructure for an IIoT connection.

IIoT in the future

In the future Volvo Cars believes that they will gain much learning from IIoT; both regarding their equipment and processes, but also between plants. They want their service and maintenance processes to be standardized and utilize predictive maintenance in all of their plants. Further, Volvo Cars wants to have the same IT infrastructure in all plants and standardize the processes for collecting and storing information in order to enable this.

Volvo Cars believes that they will build future IIoT features for their factories either internally or with a partnering firm that takes responsibility for all features, since they want all of their IIoT in the company to be standardized. The company is already working with Ericsson regarding the Cloud services in their cars.

Data ownership

As Volvo Cars owns all of their equipment, they also own all of the data generated by it. The information is only shared with equipment producers in the cases where Volvo Cars wants to know value limits for the equipment or other information which they can utilize in their systems. The company believes that if they would buy their equipment as a service, the service provider would own the data as they would then also own the equipment.

5.4.2 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT customers

Standardized and centralized approach for processing data

Volvo Cars is of the opinion that they do not currently have a standardized approach for comparing their plants and hence they do not take advantage of the learning that could be gained from utilizing IIoT in all of their plants. They believe that utilizing IIoT in the right way will generate a more standardized and centralized approach for processing and handling data among all plants globally.

Removing the human element

Currently, problems are not solved until a piece of equipment fails in the Gothenburg factory, and there is no knowledge about what happened prior to the failure or what caused the failure. As Volvo Cars initiates IIoT projects, they aim to compute the causes of failures, in order to conduct predictive maintenance. Predictive maintenance would decrease downtime in the plants, which is very expensive.

Better overview of operations activities

Previously manufacturing managers have had to travel between the Gothenburg and Gent plants in order to compare and learn from each other, which has worked well so far. However, as the company grows and becomes more differentiated, and more plants are built, the traveling is not sufficient and feasible in order to achieve maximum learning. IIoT will facilitate learning, measuring, and comparing between the plants with more precision and without managers having to travel all over the globe.

The company also believes that they may gain great value from IIoT by being able to plan their service and maintenance activities better. The production in the Gothenburg plant is only paused once a week and during this time various activities are undertaken, such as catching up on the production deficits of the week and rebuilding the plant to prepare it for production of new cars. Being able to schedule such activities and maintenance would be valuable to Volvo Cars as it is essential to them to have maximum uptime.

Due to the company having small buffers for car parts and aiming towards conducting Just-In-Time production, it is essential to have an overview of the logistics flows and processes. Cars that do not have all of its components in the plant in time should not be manufactured until everything has arrived. Moreover, the production plan could be revised dynamically in order to produce the cars for which the components are currently available, resulting in a more efficient production. Further, with IIoT and RFID tags Volvo Cars is able to track valuable goods during transportation, such as sheet metal racks, saving money on being able to locate the expensive equipment.

There are great possibilities for Volvo Cars to better satisfy the needs and wants of their customers. Currently, the delivery time of a car is much longer than for any other consumer good and it is difficult to alter order specifications. IIoT enables a more interactive relationship with the customers that could increase their satisfaction. The overview of the production and storage that IIoT can offer, could display surplus of products that could be offered at a lower price to the customers in order to compensate for the long delivery times. This would also enable greater revenues for Volvo Cars. The company could additionally utilize an overview of the available capacity of the subcontractors and tailor their offer accordingly. The overview of what is most efficient to produce or what generates the highest earnings, together with the interactivity, could enable the company to control the behaviors of their customers to earn more profits for Volvo Cars and at the same time increase the level of satisfaction of their customers.

5.4.3 Costs, risks and challenges

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

IIoT providers

Lack of trust in provider

Volvo Cars' equipment providers want to sell Cloud solutions and service and maintenance contracts, but only for their own equipment. This would imply releasing some of their control to the equipment providers. Rather, Volvo Cars would like to receive all of the information related to the equipment and conduct the service and maintenance themselves, as they already have a workforce dedicated to this area.

IIoT customers

Organizational challenges - Resistance because of lack of trust and knowledge regarding technology

Volvo Cars is very conservative regarding connecting to the Cloud, but realizes that this is due to lack of knowledge about it rather than the resistance being part of their strategy. There is uncertainty regarding what and how much is possible to control from a Cloud. Hence, Volvo Cars is extremely cautious about Cloud services and they do not want to give access to external firms to control anything in their plant through the Cloud. However, they may consider allowing external firms to read the data and analyze it, in order to receive help with troubleshooting their equipment.

There is a resistance towards IIoT in the Gothenburg factory due to cultural issues regarding perceptions of the purpose of the service and maintenance department. Historically, the person who solves a problem becomes a hero, and this view has permeated and affected the attitudes towards service and maintenance practices. The service and maintenance workers have difficulties in adopting predictive maintenance as its purpose is to minimize problems and failures, hence rendering it difficult to solve problems. Managing to maintain the factory running smoothly is not seen as a hero mission. Moreover, practicing predictive maintenance requires the workers to achieve greater understanding of the plant and the equipment, and to analyze the possible problems prior to them occurring, instead of being skilled and fast at using tools. Hence, this will require a fundamentally new mindset of the workers.

There is also a resistance to high-tech solutions in the Gothenburg factory. Even though Volvo Cars does not regard IIoT as complex technology, many of their employees think that this is the case and are frightened of it. The factory workers are generally resistant towards automation and new IT systems as they think that it only generates problems and causes equipment failure. The general opinion is that it is better to use people for every purpose, since people do not break down, they are replaceable, and more can be added should they need to. The value in automation is acknowledged in some cases, with heavy duties and tedious processes that are better handled by machines. However, the workers need to be convinced about the purpose of the technology; to be able to monitor the equipment and provide maintenance prior to failures. The more automated and computerized processes become, the more hidden it is, and hence it is difficult for the workers to realize the benefits thereof. The company needs to learn and teach their employees about this subject in order to gain understanding about the benefits and what the real purpose and values are. Volvo Cars believes that it is a long process of education until all employees have gained understanding regarding this and also that they will need to recruit new employees with different knowledge and higher levels of education.

Organizational challenges - Transformation of the whole organization

There have been ongoing discussions regarding implementation of IIoT at Volvo Cars, but it has been difficult to come to a conclusion of what it would mean to everyone and every department at the company. The discussions often regard small initiatives, but it is difficult to make it a strategic plan of the whole company, as all departments have different needs and different views on the issue. It is a fact that IIoT could and should affect the whole firm. The digitalization of the cars affects the industrial, procurement, sales, and logistics departments as well. However, this is not discussed at Volvo Cars yet, although some employees are aware that it is possible to gain much more value should they broaden their perspective. They currently only have a narrow focus on predictive maintenance and making logistics more efficient, since these departments may save a lot of money on it. The company needs a transformation in order to maximize their value from IIoT.

Inadequate focus on generation of value

Volvo Cars has numerous sensors gathering data, both in their factories and in their cars. Hence, the amount of data available is vast and they realize that it is crucial to handle it and process it in a manner that generates value for the company.

Cyber attacks

Volvo Cars is skeptical towards connecting their equipment to the Cloud, buying Cloud services and service and maintenance from external firms, such as their equipment providers. The service providers will need not only access to data, but also to be able to control the equipment remotely, which would result in a great risk of cyber attacks. The plant is extremely sensitive to sabotage and only a little knowledge about the processes is required in order to shut the factory down. The saboteurs will only need to access their network in order to execute an attack.

In order to prevent cyber attacks and sabotage Volvo Cars separates the network controlling the equipment from the network of surveillance systems. If they were to connect to an external network it would need to be separated from the network controlling the equipment as well. However, they think that it is difficult to create a business case for adding an external connection, since the risk of doing so outweighs the benefits.

Lack of data privacy

As earlier mentioned, Volvo Cars is hesitant regarding connecting their equipment to the Cloud and buying services related to this from external providers. This is because they are concerned about cyber attacks, but also because they are hesitant towards giving away access to data and control of their equipment. However, the company is more hesitant regarding giving away some data than other, as some is more sensitive.

Integration of technology

The age of the equipment in the Gothenburg factory varies, and some of the oldest robots have been used for approximately 30 years, rendering it difficult or impossible to integrate IIoT in them. Some of the equipment needs to be replaced in order to integrate IIoT, but some will be able to be modified.

Further, in the manufacturing industry there is a great lack in standardization, even of new equipment and associated services. Currently, all equipment and service providers have their own Cloud solution for their respective equipment, and they want to sell this to their customers. However, Volvo Cars does not think that their business model is compatible with buying these services, as they want a standardized approach for all of their equipment. Hence, Volvo Cars does not want to buy various service contracts from several equipment providers, as they have approximately a total of 10.000 robots in their plants. Volvo Cars realizes that they need an IoT platform to handle their data in a standardized and centralized manner. They want this platform to be able to build further upon over time to integrate all of its plants. The company does not think that it is necessary to build new factories in order to integrate IIoT, as long as they have an appropriate platform.

5.5. Hecla Mining

In the following chapter, the case study of Hecla Mining, an IIoT user, will be presented.

5.5.1 Company description

Hecla Mining is an American mining company founded in 1891. The company mines for gold, silver, lead, and zinc in four different mines located in Idaho, Quebec, Mexico, and Alaska. All of the mines are underground except for the one in Mexico, which is an open pit mine. The mines are about three kilometers deep and hence constitute dangerous working environments as heat and seismic activity are present.

Hecla Mining procures its equipment from several manufacturers such as Atlas Copco. Most equipment that is acquired is standard equipment, but there are some cases where Hecla Mining requests some customization, such as the equipment being electric instead of diesel driven.

Moreover, sometimes they participate in the design with the equipment manufacturer, but this rarely occurs.

The service and maintenance operations of the equipment at Hecla Mining are mostly conducted by their own employees. During major rebuilds, components are shipped to the mines, which is often a difficult activity due to the depth of the mines. Large pieces of equipment need to be cut to pieces in order to be transported down in the mine, and then they are reassembled underground. Hence, service and maintenance activities are complex and much of the equipment never returns to the surface again.

The customers of Hecla Mining are not traditional business to business customers. The product is transported to smelters and sold to a few amount of metal brokers. Hence, the customers do not take much interest in the operations and quality of Hecla Mining. The company has little possibility to determine their prices, since metals prices are set by the world market. Therefore, the survival of the company depends on low cost operations.

5.5.2 Innovation fueling

In the following section, the innovation fueling based on IIoT will be presented, including the initiative, implementation, and description of use cases of Hecla Mining's IIoT projects. Moreover, Hecla Mining's view of the future of IIoT and data ownership in the IIoT projects is elaborated upon.

Initiative

The IIoT initiative at Hecla Mining in the mine in Idaho was initiated by several employees. Initially the IT director was approached by IFS and was convinced that the project should be conducted. The general managers of operations have also been involved in taking the initiative, but primarily the executive management is responsible for the project being conducted. Moreover, Hecla Mining has employed a person specialized in technology and innovation. This employee has previously worked globally helping organizations with IIoT projects and has hence been a helpful agent for change, according to Hecla Mining. Further, Hecla Mining takes the view that the supportive mindset regarding the technology of the CTO and the CEO is helpful in initiating the project as well. Still, the project is only in its infancy where Hecla Mining is working together with IFS and the equipment manufacturer Atlas Copco in order to enable the equipment to send data to Atlas Copco and IFS for analysis.

Implementation

Regarding Hecla Mining's new equipment, the sensors are integrated in the manufacturing at Atlas Copco, as the acquired equipment most often is standard. Regarding the old equipment, not all of it is possible to retrofit and integrate sensors in. An engineer at Hecla Mining is responsible for integrating sensors in the equipment when possible. The equipment manufacturer helps Hecla Mining in configuring the sensors and sending the data to their ERP system.

Use cases

Currently Hecla Mining uses IIoT for proximity monitoring of their equipment and employees. The proximity monitoring of the equipment is used for tracking the location of the equipment, and also its working status. In the mine located in Alaska, the company has enhanced its IIoT proximity monitoring practices considerably and uses this for collision avoidance. There are many sharp corners in the mine and therefore it is difficult for the operators to see equipment approaching them. The IIoT technology enables Hecla Mining to automatically shut down a piece of equipment when it is about to collide with another piece of equipment. Hence, IIoT enables more beneficial deployment of the equipment, enabling reduction of idle time and increasing of productive time. The monitoring of the workers is used because of safety concerns due to the hazardous environment in the mines. The workers are tracked by RFID tags in order to determine their location at all times. Should there be a safety incident, Hecla Mining will know how to get the workers out of the mine quickly. Moreover, it is sometimes used to track whether they are working or not.

The company aims to utilize IIoT for maintenance practices as well, but so far they have only implemented the proximity monitoring. With this technology, Hecla Mining wants to ensure that the operators take care of the equipment and wants to be able to schedule maintenance before the equipment is worn down. They are not currently doing any real-time monitoring of parameters related to maintenance such as vibration, RPM, oil temperature, equipment availability, and utilization, but this is a desired goal with the IIoT project. These are the initial parameters that Hecla Mining wants to monitor, but it will get more refined in the future.

The data gathering is one of the greatest challenges in the IIoT project. Fiber optics are gradually being installed throughout the mine in order to enable Wi-Fi, with the intention that the equipment should continuously be connected with IFS. Future impermissible conditions of the equipment will generate real-time notifications for IFS, who will in turn create a work order for Hecla Mining. The maintenance work ordered will be performed manually, and Hecla Mining believes that they are a long way from machines repairing machines.

IIoT in the future

In the future, Hecla Mining wants to have underground mines that are connected and technologically capable to such a high degree that they would need few people in the hazardous environments underground. They want to have equipment learning itself based on programmed algorithms and well educated engineers and operators on the surface, monitoring the equipment. Furthermore, the company eventually wants pieces of equipment to be able to detect where the high grade silver, gold, lead, and zinc are, based on X-ray fluorescence and other technologies. Currently Hecla Mining has geologists searching underground, interpreting where the ore body is located and guiding the drilling.

Data ownership

Hecla Mining owns all of the data generated by the sensors in the mine. However, sometimes they give the equipment manufacturer Atlas Copco access to the data in order to receive help with analytics. In these situations confidentiality agreements are signed.

5.5.3 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT customers

Removing the human element

Hecla Mining believes that computers steer the equipment more efficiently than people do. They do not want to remove the human element completely, but their opinion is that the IIoT will facilitate movement towards remote controlled equipment, which increases safety both for the equipment and the workers.

Proximity monitoring and predictive maintenance require less human interaction and will reduce idle time and increase productive time, which decreases costs associated with downtime, repairs, and replacement of equipment. As the equipment can be up to a million US dollars per piece, decreasing the risk of the equipment colliding and downtime is likely to save much money.

Better overview of operations activities

The proximity monitoring that Hecla Mining conducts gives them a better overview of the activities in the mine. The overview decreases costs since it saves expensive equipment from collision, and further it increases safety for the workers who are tracked in the cave.

Decreased costs related to layoffs

Hecla Mining believes that the jobs at their company will change in the future. As their maintenance practices are becoming more proactive and move towards predictive maintenance, there is a possibility that fewer employees will be needed for service and maintenance. As the mining practices are increasingly moved to the surface of the mine, people will be operating equipment remotely, and hence more capabilities in programming and data will be needed.

5.5.4 Costs, risks, and challenges

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

IIoT customers

Costs related to remote locations

Wi-Fi in the mines is essential in order to maintain continuous connection and to send real-time data between the equipment and IFS. There are a lot of challenges for Hecla Mining due to the fact that most of its operations are underground. Firstly, GPS does not function in the mines and this poses a risk when driving expensive equipment. Secondly, the current infrastructure underground is not modern and it is very challenging to install the fiber optics needed for the Wi-Fi. The Wi-Fi in the mines is enabled by fiber optics with certain access points. These access points need to be lined at sight, at frequent intervals. Due to the mines containing many sharp corners, doing so is difficult. Thirdly, the infrastructure underground easily corrodes as the mine constitutes a hot and humid environment, and the corrosion is disproportional in this environment. Since the access points needed to enable the Wi-Fi are required to be exceptionally durable, they are very expensive. Regular Wi-Fi that is used in homes does not last for long in this environment. However, when installed correctly, the Wi-Fi works very well in the mines and the connection is strong. The access points are installed in a circular arrangement with redundancy, and hence if one access point fails, the network continues to operate. The failed access point is replaced immediately with a spare one by an electrician.

Organizational challenges - Resistance because of layoffs

Hecla Mining realizes that there are ethical concerns regarding automation reducing the workforce. The mine in Idaho has experienced a strike due to the company facilitating automation, which would reduce the jobs. The workers in the mine want to retain their historical work rules and are troubled by the reduction of jobs. However, Hecla Mining is of the opinion that the survival of the mine depends on this automation, as they are depending on low cost operations.

Organizational challenges - Resistance in business unit due to insufficient business case

Philosophically, there has been no resistance to the IIoT initiative at Hecla Mining being approved, but there is competition for funding between various projects. The company has a strong treasury and good cash balance, but still there is competition whether to spend it on automation, exploration, company acquisition or something else.

Organizational challenges - Resistance because of lack of trust and knowledge regarding technology

The culture in the mine in Idaho poses a great challenge for the IIoT project. Hecla Mining has experienced a great resistance to change in this mine compared to the other mines that they operate.

Hecla Mining realizes that many of their employees do not know what IIoT is since the project is in its infancy, and they need to be educated about it. Moreover, Hecla Mining has for many years adopted the ownership paradigm and Cloud phobia. However, during the last two years much of their content and data, such as their emails, many files, and their ERP system, have been moved into a hosting Cloud. Despite this, local data still resides at the company as well. They are of the opinion that technologies and analytics related to Big Data lie far in the future.

Integration of technology

Some of the existing equipment cannot be retrofitted with sensors and smart diagnostics, posing a challenge since it is highly expensive to buy new equipment.

5.6 Songa Offshore

In the following chapter, the case study of Songa Offshore, an IIoT user, will be presented.

5.6.1 Company description

Songa Offshore is a Norwegian-Cypriot offshore drilling contractor founded in 2005 providing drilling services in the North Atlantic basin. The firm has roughly 1000 employees and is operated from the corporate head office in Cyprus and regional offices in Norway. The IT department consists of four people. Currently (2017), the offshore market is suffering due to decreasing oil prices. This results in projects being ceased, affecting all companies operating in the offshore oil and gas sector.

Songa Offshore has one customer, the oil company Statoil, and operates a fleet of seven rigs; about half of these are older rigs, and half are new and modern rigs, which were delivered in the beginning of 2016. These modern rigs were specifically ordered and built for Statoil as a customer, thus Statoil have long-term contracts for them. The modern rigs are complex in their design, resulting in large maintenance expenses. Further, they offer a larger opportunity for automation of operations activities than the older rigs, and large parts of the rigs already have integrated sensors. Thus, the modern rigs are of particular interest for Songa Offshore's current IIoT project. The rigs were built by another company and are owned by Songa Offshore. Statoil, who designed the rigs, had high expectations on the digitalization of the rigs, thus the rigs already had many digital components upon manufacturing.

In the drilling industry, the largest costs regarding operation of the offshore assets, are related to maintenance. Further, periodical certification of the equipment is important. Due to the high cost of maintenance and the need for certification, Songa Offshore would benefit greatly from a switch from calendar-based maintenance to condition-based maintenance. Regarding maintenance today, a large part of the more specific work is carried out by the employees on the rigs. However, some maintenance operations need to be planned far in advance. These may be carried out by internal staff as well as external people.

5.6.2 Innovation fueling

In the following section, the innovation fueling based on IIoT will be presented, including the initiative, implementation, and description of use cases of Songa Offshore's IIoT projects. Moreover, Songa Offshore's view of the future of IIoT and data ownership in the IIoT projects are elaborated upon.

Initiative

The IIoT project was initiated by a senior IT technician, who has worked much himself to ensure a successful implementation of the idea. Songa Offshore believes that IIoT is no longer simply a buzzword, but something all industries need to acknowledge. IIoT is also progressing now more than ever, as the understanding of the concept increases. Further, the benefits of implementing IIoT are becoming more visible.

Implementation

Songa Offshore believes the implementation process benefits from having the end user understand the benefit of the IIoT. Some of their employees have been in the oil and gas industry for several decades and are initially not very interested in the concept of IIoT. However, as soon as the IT department actually explains to them how it functions and how it can impact operations, it is something they relate to quite easily. By laying down the concept to the end users and ensuring they have accepted the idea, Songa Offshore ensures a smooth implementation process.

Use Cases

Songa Offshore is currently implementing two scenarios of IIoT. A majority of the equipment on the rigs is already equipped with sensors collecting data. The first scenario incorporates extracting and collecting existing sensor data, by cooperating with equipment providers. The second scenario instead entails creating an end-to-end architecture for IIoT, together with IFS. In this scenario, Songa Offshore builds and installs their own sensors, resulting in more work, but also a greater control of the data collection as it will allow Songa Offshore to extract data from any sensor and use it as desired, and require them to manage the information flow from the technical sensor to the end point. Songa Offshore can then process the data with the frequency and aggregation level they see fit. The two scenarios will not be executed simultaneously as the available bandwidth is not sufficient for this. Instead, the first scenario will be focused upon first. The self-implemented sensors are however running and collecting data, but it is not possible to see its potential in a maintenance context until after the first scenario is finished. The first scenario is currently (April, 2017) live in operations.

Currently, Songa Offshore is cooperating with the equipment manufacturer Kongsberg for the first scenario. Their equipment has sensors extracting data from the rigs to Kongsberg's' IoT platform for data collection and analysis. The first step is for Kongsberg's IoT platform to communicate with Songa Offshore's IIoT server, resulting in the data triggering actions, and increasing the level of automation. It is estimated to be around 600 sensors on each rig. The potential of data collection is large, but in order to prove a business case smaller projects are being run first. The first project entails how to access more data from the current equipment, and bring the onshore and offshore organizations closer together.

In order for Machine Learning and IoT platforms to realize their full potential, the access to Big Data is important. The precision in the predictive analytics is dependent on a sufficient amount and frequency of the data. The algorithms and frameworks discovering trends expect and require vast amounts of data.

The IT department believes in the potential of IIoT, but it is up to top management to decide whether they want to invest resources in it or not. Currently, the trials are documented and presented, and hopefully further funding will be allocated to the project.

IIoT in the future

Songa Offshore believes they will be moving towards fully automated rigs in the future. This will be enabled by limiting human intervention, increasing the degree of remote controlled operations, and analyzing and triggering the data they have access to. In a shorter time-frame, Songa Offshore focuses on enabling automated actions based on the data. This will be possible in non-critical systems, such as an indication of high humidity triggering the humidifier. However, in critical systems automated actions are not likely in a short time-frame; here the system should rather focus on providing advice to the human operators, thus not fully removing the human element.

Another aspect likely in the future will be to allow the onshore organization, to remotely access simplified data, preferably visually, regarding the status of offshore operations. Anyone wanting to know the current health status of the rig, should simply be able to glance at a dashboard providing visual insights of live operational data. This would require the distillation of thousands of sensors to a simple 'good' or 'not good' display.

Songa Offshore's primary goal is to ensure safety of their staff, and derived from this costs can also be minimized. Many of their current activities are carried out to ensure a safe environment, i.e. no environmental spills, no potential human health damages etcetera. These will hopefully be automated to a higher degree in the future.

Data Ownership

Songa Offshore is the sole owner of all the data generated on the rigs. Some of the data is shared with external parties, such as the equipment manufacturers and their customer Statoil. When this is the case, written contracts are agreed upon.

5.6.3 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT Customers

Standardized and centralized approach for processing data

A current issue for Songa Offshore is that all the various equipment manufacturers operate in their own information silos, and it has previously been impossible to compile all of the data in one single system. Songa Offshore's second scenario of IIoT benefits the firm by allowing them to have a standardized and centralized approach for collecting sensor data and dispatching required actions. In this aspect, IFS IoT platform and Microsoft Azure play important parts. This enables them to not compete with their equipment manufacturers for data access and creates independence for Songa Offshore and their IIoT solution.

Removing the human element

An important benefit of IIoT is to reduce the involvement of humans where possible and feasible, in order to improve data quality and increase the process execution speed. As soon as humans are involved in feeding data into the systems, the quality of the data will vary – sometimes it will be perfect, other times poor. In order to generate insights from the data, the quality needs to be known and sufficient. By building an end-to-end automated process Songa Offshore can always expect to have consistent data quality and data structure. Further, Songa Offshore believes the technology is generally much more reliable than human intervention, as humans tend to make more mistakes than machines.

IIoT will allow Songa Offshore to decrease their costs by relying more on condition-based, rather than calendar-based maintenance, of the equipment. This is a great benefit, as maintenance is a relatively high cost for the company. When needed, the equipment will dispatch a maintenance order by itself, removing human intervention in the process and thus increasing the efficiency. Further, machines may, in contrast to humans, by Machine Learning recognize a potential breakdown before it occurs. This will reduce rig downtime, which is very expensive.

Better overview of operations activities

Another benefit of IIoT will be to allow the onshore organization to access the offshore equipment's live statuses, enabling more accurate and quicker decision making. Preferably, the onshore organization will access aggregated data where the current status is visualized using traffic lights. Aggregating all the sensor data is a challenging task, although it will be much appreciated by the onshore organization. Currently, the status of the rig is orally communicated by phone, relying on the human element, which does not always result in correct information.

IIoT will also allow a better overview of operations activities for the staff on the rigs. Any faults in the technical systems will generate work orders for the responsible staff, in order for them to act upon it.

IIoT will ensure Songa Offshore has access to greater processing power for data analysis to predict unwanted events prior to these appearing, thus allowing the implementation of actions to prevent these events. The maintenance planning can then be executed accordingly to this predictive analytics. This will be benefited by not only analyzing the data from their own sensors in Songa Offshore's IIoT framework, but also applying data provided by the equipment manufacturers. The data from the equipment manufacturers, such as Kongsberg, may be fed it into Songa Offshore's IoT platform and applied to their own data. This may improve the accuracy of the predictive analytics, as the equipment providers have access to their entire installed base. One example would be applying equipment provider data regarding temperature intervals to be careful about, upon temperature data from the rig, in order for actions to be dispatched.

Less workload for employees

The implementation of IIoT and the enablement of condition-based maintenance will ensure a decreased workload for the employees regarding maintenance activities, as it enables automatic collection and analysis of data - tasks that were previously carried out manually. Instead employees can focus on other tasks needing to be executed on the rig, rather than merely monitoring and repairing equipment. This may result in happier employees as data collection is generally considered a tedious task, and also a healthier rig as an employee with a less heavy workload can discover other improvement areas, and spend time improving them. Due to this, the internal benefits for Songa Offshore are clear.

Decreased costs related to layoffs

The implementation of IIoT will allow a greater degree of automation and remote controlled operations on the rigs, bringing work that previously needed to be carried out offshore, onshore. Offshore staff is very expensive – one position usually requires four employees, as working days on the rig need to be followed by a greater number of days free from work.

5.6.4 Costs, challenges, risks

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

IIoT Customers

Costs related to remote locations

Offshore communication, via satellite or other means, is very expensive. Thus Songa Offshore's IIoT architecture involves accumulating and aggregating the data, sending it in a lower frequency, before dispatching it from the rig. For example, rather than dispatching temperature data every second to the IoT platform, data concerning the maximum and minimum temperature, weighted average, and the last registered temperature, could be dispatched every ten minutes.

Due to the communication challenges, there are further issues concerning relocating operations from offshore to onshore. The available communication is often unstable, and remote operations require larger data bandwidth and lower latency than available. In the near future, Songa Offshore is trialing 4G offshore, and it is currently not functioning well. Nevertheless, they have one of the best communication systems on rigs worldwide – when the rig is stationary it can be operated as if it were onshore, but this is not the case when the rig is moving and relocating.

Furthermore, the fact that the environment is a high-risk one, increases both the complexity and cost of the IIoT project. One example is sensor availability – regular sensors are often relatively cheap and standardized, while sensors designed for an offshore environment often are very expensive. To conclude, there are many challenges related to Songa Offshore being an offshore drilling company.

Organizational challenges - Resistance because of layoffs

When introducing new technology, employees may feel threatened because they may lose their jobs due to the technological advancement. Therefore, the matter needs to be laid down properly in the organization. Employees need to understand that it is not a matter of if, but rather a matter of when, IIoT needs to be introduced. Another stakeholder working against IIoT and automation, are the employee unions. The unions want people to continue working on the rigs, rather than relocating the tasks to the onshore environment, which would be enabled by increased automation. This is, as earlier mentioned, because the equivalent task offshore, would require a fourth of the employees onshore, resulting in layoffs. It is in the union's best interest to have many employees connected to them, while it is in Songa Offshore's best interest to reduce labor costs, resulting in an inherent antagonism.

Organizational challenges - Resistance in business units due to insufficient business case

Generally, there are people who resist the IIoT project due to the difficulty of proving a viable business case for it. Currently, Songa Offshore finds it difficult to prove a viable business case. The IT department has pushed for the IIoT project several times, on board level and top management meetings, and they do not understand it. Creating a business case for an audience who does not understand it, nor is interested in technology in general, is very difficult. Thus, the IT department currently has almost no internal funding for the IIoT project. The IT department is currently documenting all their progress, in order to present it to the business side later on. It will then be up to them to decide whether the project should continue, or not.

Organizational challenges - Resistance because of lack of trust and knowledge regarding technology

As mentioned before, the understanding of technology is generally poor within the board and top management. This results in resistance, and a lack of funding. The benefits of IIoT are clear to the IT department, but it is difficult to communicate them to the rest of the business, due to the lack of understanding. Songa Offshore believes this lack of understanding of IIoT is general across their industry, which is relatively slow to develop. Other companies are also trying to develop innovative solutions, but it will take some time, especially when adding on the safety aspect. The IT department is currently managing this challenge, by preparing a simple information sheet regarding the first and second scenario of IIoT, which will be distributed within the organization. They believe this has previously been lacking, and will benefit the implementation onwards.

Regarding the safety aspect on the rig, there is a lack of trust in the technology. There are some areas on the rig which will not be connected in the near future, even though it would be technically possible to do so. This may be because of regulations or because the equipment provider deem it to be unsafe. Further, the equipment providers are generally wary and protective concerning opening up their technical systems to enable IIoT. Songa Offshore manages their lack of trust in technology by not removing the existing technical system, but instead allowing the IIoT system to complement it. For example, a blinking light showing when the temperature in a critical system is too high, will still be there – but the system will also dispatch an advice on action via the IoT platform. Further, the calendar-based maintenance will not be fully removed as the organization moves to condition-based maintenance; however it may be conducted less frequently. Instead, these should work together and complement each other. It can also be noted, that in the most critical systems the processes are likely not to be fully automated. Here, the IIoT system will rather advise the operator than perform actual actions, thus not fully removing the human element.

Organizational challenges - Transformation of the whole organization

An IIoT implementation is not merely an IT project, as it entails a transformation of the entire organization. Departments such as IT, maintenance and the technical department, as well as external parties such as the equipment manufacturers, need to cooperate and align themselves in order for an implementation to be successful. Thus, it poses a challenge as a complex transformation will need to be managed. Songa Offshore experiences a different acceptance for the IIoT project between the departments. The IT department often tends to be willing to initiate similar projects. Their opinion is often that the projects are exciting and that it is important to try and keep up with technology. However, there must be clear business benefits, which the business side of the company needs to acknowledge. Thus, the project needs to be laid out correctly within the organization, to avoid resistance from other departments.

Technical requirements and complexity

Naturally, there are complexities and costs associated with buying or building sensors and installing them, processing the data and generating insights, and communicating with the onshore unit via means such as satellite communication. In order to initiate an IIoT project, funding needs to be secured. This may be complicated as, which was elaborated upon above, it can be a challenge to prove a viable business case for it. Furthermore, disregarding costs, it may be impossible to even find technology suited for the offshore environment. The environment is highly critical, and often sensors need to have a certified low energy output, in order to be allowed for use. Many of these sensors which are needed, may not be available for purchase. In that case, the initiative may fall flat, as it would not be economically viable to build and certify every sensor required.

Inadequate focus on generation of value

Gathering relevant data poses a challenge. Often there is a tendency to collect much data without having a proper plan for how to analyze and generate insights from it. In that case, the data collection constitutes an unnecessary cost.

Lack of data privacy

Lack of data privacy may pose a challenge, thus Songa Offshore is careful about fully securing their data with contracts. However, they are not overly afraid of sharing data as they are used to accessing services by, and providing data to, external parties and do not regard this very differently compared to the data in the IIoT project. Moreover, Songa Offshore believes that it is impossible for one company to operate all aspects of business by themselves and that cooperation with external firms is necessary and should be based on a trust relationship. Due to this, Songa Offshore's strategy is to use the Cloud and Software-as-a-Service. Further, they claim that they have a greater trust in Microsoft storing their data than doing it internally, and argue that one of the largest data security risks in the world is in fact internal people.

Cyber attacks

Cyber security is an important aspect when operating on a rig. It is crucial not to compromise rig integrity when installing software, as this can be very dangerous. Songa Offshore realizes that it is necessary to open up systems in order to extract data when initiating an IIoT project However, it exposes the company to the risk of cyber attacks. If someone would be able to take control of that equipment, it might result in a severe accident. This is one of the reasons Songa Offshore is implementing IIoT at a relatively slow pace – some of the areas need to be secured in order to avoid and prevent large accidents from happening.

Integration of technology

A majority of the equipment on the rigs contains a large amount of sensors. Although the equipment is part of the technical setup, Songa Offshore does not own the architecture for the end-to-end solution inside. It would be very beneficial to be able to integrate all this data with the IIoT system. However, the integration of these sensors located on various equipment is a complex and challenging task, as they operate with different standards. The equipment providers are unwilling to agree on standards, and each provider uses their own proprietary solution. The equipment providers greatly benefit from having access to the data themselves, so deciding to allow only one equipment provider to collect data from all rig equipment, would not be possible. The attitude within the industry, is to ensure that the customers, such as Songa Offshore, are required to pay for their solution if they desire to access the data. However, there are a few equipment providers who do provide a standardized approach to interface the data.

Further, extracting data from existing sensors require a cooperation between the IT department, the technical department and the equipment provider. The technical department generally has a protective mindset regarding opening up systems due to the potential safety risk, and the equipment manufacturer will also likely be protective regarding their equipment.

5.7 IFS

In the following chapter, the case study of IFS, an IoT platform provider, will be presented. The case study will serve as a general expert case compiling experiences across several organizations, rather than a description of a specific example.

5.7.1 Company description

IFS is a Swedish enterprise software company founded in 1983. They are headquartered in Linköping, Sweden, and employ 2700 people worldwide. The main product offered is the so-called IFS Applications, which focuses on managing four core processes; Manufacturing, Projects, Service & Asset Management, and Supply Chain Management.

The IFS IoT Business Connector is an IIoT software program that brings together operational data, executes analytics and generates insights which can be acted upon. Approximately half of the costs related to current IIoT projects are stemming from the challenge of technology integration. The purpose of the IoT Business connector is to minimize this cost. By providing an efficient tool for integration IFS is able to decrease the risks of IIoT investments for their customers. However, IFS will not ensure the actual data collection as that is not their expertise – the configuration setup is a task of IFS partners, or the customers themselves. Once the data is in the Cloud, the IFS IoT Business Connector will analyze the data, and when and if certain conditions are met, issue relevant actions as a result of it.

5.7.2 Management of IIoT

In the following section, the interviewee's general advice on how to manage IIoT in organizations to ensure a successful implementation, is presented.

Servitization is a basis for differentiation

Manufacturing companies should focus on the problem they are trying to solve for their customers, rather than the actual product they are selling. This requires a very different mindset, in which the company focuses on the capability they deliver to each customer. By focusing on what each customer wants to achieve, e.g. improve the quality of their products, the company may start to remove the product itself from the actual sale. This will ensure a differentiation strategy where the actual product sale is wrapped into a service contract in which the company commits to ensuring that the customer may produce a certain amount of units in a certain period of time. By selling the capability rather than merely the specific product, the company, to some extent, protects themselves from price competition from competitors. This shift to a servitization model requires the capability to receive field data from customers' sites. Thus the concept of servitization is highly dependent on the concept of IIoT.

IIoT initiatives should be implemented top-down in the organization

IIoT initiatives should be driven by individuals in the organization with C-level positions, i.e. by operations directors rather than maintenance managers, for example. These individuals need to realize and communicate that the initiative is required in order to remain competitive in the market place. The initiative should then be executed throughout the organization in conjunction with HR and the rest of the board, in order to ensure an efficient and effective implementation.

Firms should initiate small and successful IIoT projects in order to build trust

IIoT projects should be initiated by executing a project of small scope in a chosen business area – a project that can be implemented in weeks. This project may then demonstrate the benefits and return on investment of IIoT to all project stakeholders, such as the board and the employees, in order to gain trust and ensure an internal understanding of the technology.

A further method to ensure trust of the IIoT technology within the organization is to implement it in a stepwise manner. One of IFS's early adopters of the IFS Business Connector was unfamiliar with the Cloud technology prior to implementing IIoT. Rather than automating all processes in the initial phase, manual steps were included in the processes at first. An operator needed to manually review the data, approve it and then allow the data to move on to the next process stage. Any data discrepancies could thus be highlighted and corrected. Gradually, these manual steps were removed once trust concerning the data quality had been gained in the organization. The described method was successful in building technology trust within the organization.

Data ownership

From a servitization point of view, the company providing the services owns the data generated by the sensors in the product. This is due to the fact that the service provider is not selling a product to their customers, but rather providing a capability. The servitization customer is generally only interested in ensuring that the service provider follows through on the contract, rather than precisely how the service is executed.

5.7.3 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT providers

Facilitated access to information

As earlier mentioned, IIoT enables the providing firm to operate a business model based on servitization as it ensures that the firm more efficiently can collect information about operations. The manufacturing industry has generally had the capability to collect information, such as running hours, from machines in the factory for many years, e.g. by the use of PLCs. However, the technology changes, and more specifically the use of the Cloud, which enables collection of such information from machines that are no longer on the firm's premises.

By using IIoT, the providing firm may receive accurate information about, and monitor, the usage of their contracted products at the customers' sites. If the product is not used as intended, i.e. per configuration, the firm may approach the customer and argue breach of contract, and that the contract will have to be altered in accordance with the actual usage. Hence, IIoT can prove if the service and maintenance is required due to a faulty configured machine, or due to faulty usage by the customer, and in extension who should bear the cost. Thus IIoT may be used for legal purposes, to prove who is responsible for a faulty product.

Differentiation

By offering an improved service, firms may differentiate themselves in the market, thus increasing revenues and profitability. One example is the condition-based maintenance; rather than dispatching a service engineer to the customer's site in fixed time intervals, it can be based on the condition of the equipment. An IIoT device on the customer's machine can send information via the Cloud into the IFS

IoT Business Connector, whereby it can be analyzed. Likewise, information may be pushed in the opposition direction, from the firm to the customer, e.g. in order to update the software remotely, thus decreasing travel costs and general expenses while likely also increasing the customer's satisfaction.

Decreased lifetime cost of products

When a firm shifts their business model towards servitization, the lifetime cost of the product is of greater importance. The manufacturer is then likely to focus on building a product of greater quality, which will require less service, even though the initial manufacturing cost may be higher. This will ensure increasingly satisfied customers and lower lifetime costs, thus resulting in good Key Performance Indicators. However, it will likely dissatisfy the service engineers, as it will require less callouts for repairs.

IIoT customers

Outsourcing of IT operations and servers

By storing data in the Cloud, the firm may access as much storage as desired and when needed, rather than having to order a new server and educate the internal IT-staff as required with local on-site storage. By using the Cloud these operations are outsourced, which also de-risks the IT operations, as the firm's IT setup is less dependent upon a single individual – the IT manager.

5.7.4 Costs, risks, and challenges

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

IIoT customers

Organizational challenges - Resistance because of layoffs

IIoT needs to be managed carefully as it can create disruption among the workforce. One example is for the service engineers in manufacturing companies. Rather than visiting each customer on a regular basis and conduct service on their machines, the service engineer will only be dispatched to customers to perform a specific job when required. Thus, the service engineers may feel that their jobs are at risk, due to machines being monitored automatically, rather than manually by themselves.

Further, the operations directors, who decide upon the investment, as well as the employees themselves, may fear potential layoffs stemming from the implementation of IIoT, resulting in further disruptions among the workforce.

Organizational challenges - Resistance in business units due to an insufficient business case

Directors, managers, and employees alike may not all see the full potential value, as opposed to the costs, risks and challenges, of the IIoT investment, and thus resist it. Directors may for example feel that they are delivering good Key Performance Indicators at the moment and may not wish to disrupt the situation by introducing new technologies. One of the most difficult questions for companies concerning IIoT technology is understanding and deciding where it may be implemented in their business and what the technology should benefit. There is a general sentiment that technologies often tend to be overhyped, and companies need to make sure they understand where the real value lies, and to what extent the technology may benefit their business.

Organizational challenges - Resistance because of lack of trust and knowledge regarding technology

Resistance among people in the organization may occur due to employees not trusting the technology. Further, it may be prevalent due to individuals not having sufficient knowledge and understanding of it, as well as being unwilling to expose themselves from a knowledge point of view. The latter is especially prevalent among older individuals. People often understand the internal aspect of IIoT, i.e. the sensors collecting information, which may be interpreted manually. However, the external aspect, i.e. information dispatched into the Cloud and thereafter analyzed in a system, is more difficult to understand technology-wise. Should a company not be familiar with Cloud technology, this may pose as a risk.

The lack of understanding is further often greater among the employees on the shop floor than among directors. This is due to that the latter group more frequently participates in various conferences, communicates with analysts such as Gartner, and is exposed to technology news via marketing and magazines, hence gaining a larger technology understanding. The employees that will actually operate the technology in daily operations are however not exposed to IIoT on an as regular basis.

Organizational challenges - Transformation of the whole organization

A further risk associated with IIoT, is the fact that implementing it efficiently requires a transformation of the whole organization. In general, individuals tend not to like change, and one faulty link may have a large negative impact. The human nature of these topics is therefore of great importance. Thus, building trust in the company for IIoT is crucial and will have a big impact.

Lack of data privacy

Organizations often fear the fact that IFS has access to their data, via the Cloud. However, companies often do not realize that many of their systems already are in the Cloud, such as their company email systems. The data stored in the Cloud is generally more secure than data stored internally, as large amounts of resources are invested in keeping the large data centers for the Cloud secure. It is not reasonable for a company to invest as heavily in keeping the internal servers up to the same security level and heavily rely upon the IT manager – it is wiser to store it in the Cloud.

Integration of technology

As earlier mentioned, approximately half of the direct costs associated with current IIoT projects are related to technology integration. Thus, efforts need to be directed towards decreasing this cost category.

5.8 Accenture

In the following chapter, the case study of Accenture, a consulting organization, will be presented. The case study will serve as a general expert case compiling experiences across several organizations, rather than a description of a specific example.

5.7.1 Company description

Accenture is a global IT and management consultancy firm providing services in the areas of strategy, consulting, digitalization, technology, and operations. The company was founded in 2001 by Andersen Consulting and operates in 120 countries.

Together with General Electrics, Accenture has formed the joint venture Taleris, which is an IIoT product that enables predictive maintenance and aircraft fleet optimization for airlines. It performs analytics in order to minimize disruptions from mechanical failures and weather. Taleris has over 30 customers and was founded in 2012.

5.7.2 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT providers

New revenue streams

Accenture has been working with Michelin, which traditionally sells tires, but recently has revised their business model with IIoT. They now sell tires as a service, receiving revenues from their customers based on the utilization of the tires, instead of their traditional product sales. IIoT enables Michelin to receive information about the utilization, and hence the data can generate new revenue streams.

IIoT customers

Better overview of operations activities

Schneider Electrics and Accenture have developed an IoT platform based on Microsoft Azure, which constitutes a tablet application with a dashboard that displays how the customers' equipment is operating. This dashboard facilitates the work of the customers' operations managers as they receive access to an overview of predictive maintenance activities in their factories.

5.7.3 Costs, risks, and challenges

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

IIoT customers

Costs related to remote locations

According to Accenture, there are challenges in the airline industry related to sending data real-time from the engines when the plane is in flight. The data is therefore aggregated and sent to the IoT platforms once the plane is at the hangar.

Organizational challenges - Resistance in business unit due to insufficient business case

One of the key points that has been slowing down the takeoff of IIoT is the lack of being able to generate valuable insights instantly. Due to combinations of old and new data, and lack of possibilities to experiment, it is hard to prove that IIoT will generate value. IIoT has been a hyped concept for a while, but according to Accenture there are only a few concrete examples and cases of organizations that have managed to create new and better businesses based on data so far.

Technical requirements and complexity

Accenture is of the opinion that the technical complexity and technology landscape pose challenges for organizations implementing IIoT. There are 300-400 different IoT platforms and the various vendors are arguing which platform is the best one. Hence, understanding the alternatives offered and choosing the best suited platform is a complex matter for organizations.

Inadequate focus on generation of value

Initially IIoT initiatives in organizations usually were taken by engineers that were overly excited about the technology, according to Accenture. The hype regarded connectivity and the technical side of IIoT, acquiring fancy gadgets that could be instrumented to different locations and measure various arrays of data. This resulted in organizations installing basic IIoT solely enabling data collection, which did not generate much value as data collection is not sufficient in order to render insights. Many enterprises do not investigate the possible value adding applications of it. It is important to keep the business need in mind when implementing IIoT. One of the key considerations should be ensuring that there is not only data collection, but that there is data analytics capability in place as well.

5.9 Cybercom Group

In the following chapter, the case study of Cybercom Group, a consulting organization, will be presented. The case study will serve as a general expert case compiling experiences across several organizations, rather than a description of a specific example.

5.9.1 Company description

The Cybercom Group is a Nordic IT consulting company founded in 1995 that conducts strategic projects for business-to-business customers. Hence, most projects are centered on the customers and their business models. The organization employs 1300 people across seven countries.

Many of Cybercom Group's projects regard connecting existing, old equipment and investigating the possible value that it may generate. In these projects Cybercom Group's consultants interview with their customers and their customers' customers, research the industry, and analyze trends. To find the possible value for the customers, their pain points are identified, as well as what can be digitized and what cannot be digitized. This is done through workshop series.

Cybercom Group has for example worked with a Swedish robotics firm, focusing on enabling servitization. Moreover, Cybercom Group has investigated the possible value for the government and society in connecting outdoor lighting in public places and indoor lighting in offices. The organization has also worked with a Swedish grocery store chain to investigate the value in connecting their surveillance equipment.

5.9.2 Management of IIoT

In the following section, the interviewee's general advice on how to manage IIoT in organizations to ensure a successful implementation, is presented.

Let the prospective users of the technology see and try for themselves

In some organizations many employees that are practically oriented tend to be skeptical towards the new IIoT technology and the benefits that it may imply for their work. However, when given the possibility to try the applications, a more positive attitude is usually formed since the employees may see for themselves that many of their tedious tasks have been replaced with something better.

Research and plan thoroughly before implementing the project

Many organizations commence the implementation phase of IIoT projects without doing a sufficient study in advance, because they are excited to deploy a new and interesting technology. However, Cybercom Group assesses that the demand for strategic planning consulting services regarding IIoT projects is increasing.

The organization needs to work together and cross-functionally

The need for cross-functional ways of working, preferably in workshops, is increasing with the emergence of IIoT. It is no longer sufficient that the management team makes all the decisions themselves as the other departments, such as IT, marketing, and sales need to be included as well. Working cross-functionally may provide the various departments with a common language, which otherwise tend to be absent in organizations.

Start small with people who have an apparent interest in the project

When commencing the IIoT project it is advisable not to focus on convincing those who are not interested in implementing IIoT. It is preferable to instead approach a few people that show some level of interest in the technology and conduct a small project together with them in order to fully convince them of the benefits of IIoT. This benefit realization will then hopefully spread to the other employees.

5.9.3 Benefits

In the following section, the constructs depicting the benefits found in the case, are presented.

IIoT providers

Improved supply chain management

IIoT provides an opportunity to plan service and maintenance activities better. In some organizations that have not yet implemented IIoT there is often no overview of what equipment needs service, which sometimes leads to unnecessary downtime. The robotics firm that Cybercom Group has been working with experiences difficulties planning when service and maintenance activities of their customers' equipment should be undertaken. The machines arrive to the robotics firm's service centers as they break down, while the firm has various other activities to perform at the same time. Cybercom Group is of the opinion that a service contract from the robotics firm, based on IIoT, could help themself in their planning process as it would enable an overview of their service and maintenance activities. This could save the robotics firm much time and money.

IIoT customers

Removing the human element

When using manual checklists in a plant it is difficult for the supervisor to tell whether or not the routines have actually been followed or misconducted due to the human element. According to Cybercom Group, the rationality of the human element often implies that tedious tasks are avoided if possible. IIoT will give the exact data and facts, and remove the human element and its responsibilities.

Better overview of operations activities

Cybercom Group has customer experience in the hole punching and construction industry, where equipment is often used until it breaks down. As downtime is expensive, the organization will desperately try to repair the equipment. In this industry and many others, there are various lead times to take into consideration, which makes downtime even more difficult to manage. Due to this, an overview of the service and maintenance activities would be desirable. IIoT enables the predictive analytics to provide this, which in turn enables better planning of the service and maintenance activities.

5.9.4 Costs, risks, and challenges

In the following section, the constructs depicting the costs, risks and challenges found in the case, are presented.

Organizational challenges - Resistance in business unit due to insufficient business case

Many IIoT projects stem from tech savvy employees in the technical departments of the organization, who are excited about their own ideas and want to commence the IIoT initiative immediately. However, it is likely that the management or the business unit will question whether or not implementing IIoT is the right action to undertake. This is due to the fact that the technical departments are not generally focused on the viability of the business case.

Organizational challenges - Resistance because of lack of trust and knowledge regarding technology

In the industry there are a lot of proud conservative professionals that consider themselves to know their job better than anyone or any technology. Therefore, it is important to be cautious when deciding what messages the employees should receive from the IIoT technology when operating the equipment. There is a difference in communicating "I need service" versus "You are doing it wrong". This can be a very sensitive matter that should be taken into consideration.

Organizational challenges - Transformation of the whole organization

Digitalization and implementing IIoT is not an isolated event. It is not the same as having six product categories and initiating the development of a seventh category; it requires an organizational transformation. As digitalization is a transformation of everything in the whole organization there is a demand for new management techniques and new forms of organizations. Many firms operate traditional silos and waterfall models, which need to be switched for working together in new ways. This is often perceived as difficult in firms and it may be one of the reasons why the IT department is often assigned responsibility for IIoT projects, enabling the rest of the organization to avoid it for a little more time.

Inadequate focus on generation of value

There are many firms that are excited about becoming digitized and decide to implement the technology immediately. However, it is important to research and plan in advance in order to decide what value the technology is supposed to generate.

Nowadays everyone wants connectivity and access to data and it is often conducted in-house as mobile applications and tools. A lot of equipment is connected for the sake of being connected, without knowledge of what value it can, or cannot, generate. Firms want everything to be connected and massive amounts of various data are hence being collected. However, there is no value in raw data and gathering vast amounts of data that cannot be used for anything. Therefore, it is important to choose what information is desirable, whether generated advice is valuable, and whether various data sources should be combined, analyzed, and delivered. Only then it is utilized in the best way possible.

5.10 Summary of empirical findings

In the following section, a summary of the empirical findings is provided as two tables.

Table 3. A summary of the benefits identified in the empirical findings, with associated examples and corresponding cases.

Perspective	**Category**	**Cases**	**Exmples**
IIoT Providers	Facilitated access to information	ABB, IFS, Volvo Cars as a provider	R&D input, insights by comparing the installed based, enables servitiziation, identify breaches of contracts
	Improved supply chain management	ABB, Ericsson, Cybercom Group	Efficient planning and scheduling, possibility to adapt production flows, decrease number of recalls
	Differentiation	IFS, Ericsson, Volvo Cars as a provider	Improved service and software updates, increase product or service appeal
	Decreased lifetime cost of products	IFS, ABB, Volvo Cars as a provider	Minimize need for service by predictive maintenance and servitization
	New revenue streams	Accenture, ABB, Ericsson, Volvo Cars as a provider	Service agreements, servitization, features available for purchase

Continued table 3. A summary of the benefits identified in the empirical findings, with associated examples and corresponding cases.

Perspective	Category	Cases	Exmples
IIoT Customers	Standardized and centralized approach for processing data	Songa Offshore, Ericsson, Volvo Cars as a user	Comparing data between plants, one single database – analytics across all the available data, moving away from information silos
	Removing the human element	Songa Offshore, Cybercom Group, Hecla Mining, ABB, Volvo Cars as a user	Remote controlled equipment, increeased precision, avoidance of down time by predicitve maintenance, improved data quality and process execution speed
	Better overview of operations activities	Songa Offshore, Accenture, ABB, Ericsson, Volvo Cars as a user, Hecla Mining, Cybercom Group	Status dashboards, fleet assessment, avoiding down time, efficient planning and scheduling, overview of activities by proximity monitoring, overview of factories, overview of logistics flow, predictive analytics in order to predict unwanted events prior to them appearing
	Less workload for employees	Songa Offshore, ABB	Remote controlled robots, predicitive maintenance – decreased workload regarding maintenance
	Decreased costs related to layoffs	Hecla Mining, Songa Offshore	Nature of tasks will change, automation, fewer employees needed for service and maintenance due to predictive maintenance
	Decreased costs related to fuel efficiency	Ericsson	Calculating most efficient route
	Outsourcing of IT operations and servers	IFS	Cloud storage
	Data backup	ABB	Cloud storage

Table 4. A summary of the costs, risks, and challenges identified in the empirical findings, with associated examples and corresponding cases.

Perspective	Category	Cases	Exmples
IIoT Providers	Lack of trust in provider	ABB, Ericsson, Volvo Cars as a provider and as a user	Unwillingness to share data, wanting to create a own solution rather than use the providers'
	Changing the business model	Volvo Cars as a provider, ABB	Forming contracts and determining liability, conservative industry
IIoT Customers	Costs related to remote locations	Songa Offshore, Accenture, Hecla Mining, ABB, Ericsson, Volvo Cars as a provider	Expensive, absence of communication methods, corrosion of communications infrastructure, high-risk environments raising complexity of technical solutions
	Organizational challenges - Resistance because of layoffs	Songa Offshore, IFS, Hecla Mining, Ericsson	Predictive maintenance decreasing need for service engineers, digital transformation and automation removing traditional jobs, unions oppose it
	Organizational challenges - Resistance in business unit due to insufficient business case	Songa Offshore, Cybercom Group, IFS, Accenture, Hecla Mining	Few concrete cases as examples, understanding the value, the challenge of building a business case for an audience not understanding the technology, competition between projects concerning funding
	Organizational challenges - Resistance because of lack of trust and knowledge regarding technology	Songa Offshore, IFS, Hecla Mining, Ericsson, Cybercom Group, Volvo Cars as a provider and as a user	Varying level of technical knowledge within the company and between customers, fear of Cloud technologies, fear of high-tech solutions as unreliable and susceptible to failure, a belief that IT systems are complex and generate problems, fear of technologies disrupting industries, lack of trust in technology deployed in high-risk environments, the sentiment of "I know my job", corporate culture

Continued table 4. A summary of the costs, risks, and challenges identified in the empirical findings, with associated examples and corresponding cases.

Perspective	Category	Cases	Exmples
IIoT Customers	Organizational challenges - Transformation of the whole organization	Songa Offshore, Cybercom Group, IFS, Ericsson, Volvo Cars as a user	Organizational change is challenging and highly complex, digitalization is not an isolated event, many firms work with traditional silos – these need to be switched to working together, no unified or standardized IIoT solution but instead small and disconnected projects, resistance because of different interests between departments
	Technical requirements and complexity	Songa Offshore, Accenture	Various IoT platforms to choose between, technology complex to implement
	Inadequate focus on generation of value	Cybercom Group, Songa Offshore, Accenture, ABB, Volco Cars as a provider and as a user	Unneccessary data collection, unneccessary technical solutions, not sufficient planning and researching in advance
	Cyber attacks	Songa Offshore, ABB, Volvo Cars as a provider and as a user	Cyber attacks; sabotage, affecting operations
	Lack of data privacy	ABB, Songa Offshore, Volvo Cars as a user, IFS	Sensitive data
	Integration of technology	Songa Offshore, IFS, Hecla Mining, ABB, Volvo Cars as a user	Retrofitting old equipment, technology integration is costly, lack of standardization, not owning the architecture for the end-to-end solution, cooperation between departments and equipment providers needed

6. Analysis

The analysis chapter is based on the literature review, the empirical findings, opinions from Tobias Persson, Innovation Lead IoT at IFS, and ideas of the authors.

6.1 Benefits for IIoT providers

There are several benefits for IIoT providers that can be achieved by utilizing IIoT. These benefits will be elaborated upon below.

6.1.1 Improved supply chain management

When asset owners and operators move toward servitization the equipment becomes a productivity enhancing hybrid if it generates data used for digital services within the supply chain (Daugherty et al., 2015). According to Marr (2016), IIoT generates benefits, including the ability to monitor supply chains more extensively and in real-time, and to achieve a greater reliability and consistency of the productivity level. This holds true for ABB, Ericsson, and Cybercom Group. Ericsson argues that continuously gathering quality real-time data is crucial in order to ensure a truly efficient supply chain in the manufacturing industry. By doing so, the company is able to adapt and alter the production flows, and thus impact the lead times and increase the efficiency. ABB experiences that the service agreements and the connected robots allow them the benefit of having a better overview of their operation activities. They believe that when being connected to their customers' robots the efficiency of the service and maintenance operation can be greatly improved. Marr (2016) argues that this enhanced productivity level that stem from utilizing IIoT in the supply chain may increase profits. This seems likely as ABB, Ericsson, and Cybercom Group gain the possibility to enhance their planning process of operations activities, increasing efficiency and decreasing costs, which in turn affects the profit margins positively.

6.1.2 Differentiation

The capabilities that digitalization provides to firms enable them to co-create value with their customers in new, previously untapped, ways (Lenka et al., 2016). This is done by Volvo Cars, who is delivering services and communicating directly with their end customers, utilizing a Cloud solution in cooperation with Ericsson. This communication channel creates a differentiation advantage, strong customer relationships, and loyalty.

By combining products with services, and digitally integrating these, the value offer can be highly customized to customer preferences (Lerch & Gotsch, 2015). The case where Ericsson enables Maersk to provide their customers with a service of delivering perfectly ripe fruit is an example of a service that is customized based on IIoT. It seems highly likely that the customization may increase customer satisfaction, hence providing an enhanced base for differentiation.

As the product markets are steadily maturing, making it more difficult to differentiate the firm from competitors, it seems likely that moving towards servitization may provide new possibilities for differentiation. The increased customization that servitization based on IIoT provides, creates value for customers and increases their loyalty, which may be a superior basis for competitive advantage than that of price, as competing with price could decrease the profit margins. This is also emphasized by Bourne (2016), who argues that servitization provides a method for differentiation for manufacturing companies experiencing squeezed profit margins.

6.1.3 Decreased lifetime cost of products & facilitated access to information

IIoT may provide firms with the benefit of more efficiently receiving access to information. This enables said firms to produce products of greater quality, which together with predictive maintenance may enable firms to decrease the lifetime costs of their products. Thus these two benefits; decreased lifetime cost of products and facilitated access to information, will be elaborated upon jointly below.

Porter & Heppelmann (2014) argue that the current service may be improved efficient-wise by ensuring predictive service prior to breakdowns and thus avoiding unnecessary service. According to IFS, due to the emergence of IIoT, information can be collected from machines that are no longer on the firm's premises. ABB is utilizing this and is thus able to compare data from their entire installed base of all similar robots, enabling them to interpret correlations and predictions, hence enabling predictive maintenance. According to Mobley (2002), predictive maintenance entails monitoring of indicators such as the actual condition and efficiency of the machinery equipment, generating data such as vibrations that is used for analysis in order to optimize maintenance. ABB is currently shifting its focus from increasing revenues by increasing the amount of service to minimizing the need for service by utilizing predictive maintenance. Moreover, Volvo Cars wants to collect data more frequently from each car in the future in order to predict errors and decrease costs.

In addition to that the current service may be improved by ensuring predictive maintenance, Porter & Heppelmann (2014) argue that the data generated concerning product usage may also be fed into the product design to improve future service efforts, e.g. by providing insights on faulty parts and insight on how repairs may be simplified by reducing complexity. This is something that ABB is ensuring, as the firm is utilizing the data collected from their customers as input to their R&D processes. The R&D department thereby gains access to insights concerning the functioning of their products, the quality, and how the customers are using them. For instance, if they were to discover that no customer is using the maximal capacity of the most powerful robot, it indicates that a smaller robot might be more valuable in the product offer.

As mentioned above, the facilitated access to information increasing quality, in combination with predictive maintenance, enable firms to decrease the lifetime costs of their products. IFS argues that the lifetime cost of the product is of greater importance when a firm shifts its business model toward servitization. Hence, it seems that IIoT shifts the focus from earning profits by conducting service and maintenance activities for customers into producing products of higher quality and thereby decreasing the overall need for service and maintenance. As companies are commencing to sell service agreements for a fixed fee based on IIoT, it is in the best interest of the provider to ensure that the costs of service and maintenance are minimized, even though it might entail higher production costs. This holds true as the goal is to minimize the overall lifetime cost of a product, which may be achieved if the additional production costs are exceeded by the savings in service and maintenance.

6.1.4 New revenue streams

The World Economic Forum (2015) argues that one of the key benefits of IIoT includes the emergence of an outcome economy, i.e. moving towards servitization. Moreover, Bourne (2016) argues that the two main benefits for servitization are an improved relationship with the customer and the generation of long-term revenue streams. All of Accenture, ABB, Ericsson, and Volvo Cars as a provider mention the additional revenue streams as a benefit stemming from IIoT. Accenture mentions Michelin providing tires as a service and ABB experiences additional revenue streams from selling service agreements based on their IIoT data. Further, Ericsson has enabled both Maersk and Volvo Cars to create new services that they sell to their customers, such as providing ripe fruit at the right time, and services such as Volvo on Call and In-Car Delivery. Hence, IIoT does not only enable differentiation, but it also generates the possibility to create additional services that could be sold to customers.

According to Osterwalder & Pigneur (2009), there are two forms of revenue streams; transactional and recurring. Transactional revenue streams constitute payments that occur one single time whereas recurring payments are continuous payments often received for supporting services (Osterwalder & Pigneur, 2009). Many of the services in the examples described above enables the firm to generate recurring revenue streams, as they entail contracts extended over a time period. It could be argued that recurring payments may increase customer loyalty and strengthen the relationship to the customer, as the focus is shifted from one-time transactions to more steady revenue streams, requiring the provider and customer to interact with each other.

6.2 Benefits for IIoT customers

There are several benefits for IIoT customers that can be achieved by utilizing the technology. The benefits will be elaborated upon below.

6.2.1 Standardized and centralized approach for processing data

Daugherty et al. (2015) argue that to get the most value out of IIoT and combine the sensor-driven computing, industrial analytics, and intelligent machine applications, firms must acquire a solid infrastructure and technical architecture, i.e. an IoT platform that enables a combination of IT and OT. These platforms should enable equipment owners and operators to operate applications and the equipment, link and control processes, deliver and analyze data, and connect with other firms (Daugherty et al., 2015). Songa Offshore is utilizing IFS IoT Business Connector in combination with Microsoft Azure IoT as IoT platforms, enabling a centralized and standardized approach for handling their data and dispatching required actions on the rigs. This contrasts their equipment manufacturers' information silos, which render compilation of their data in one single system difficult. Ericsson similarly argues that operating the IoT platform in the Cloud enables centralization of data storage, enabling firms to apply analytics across all the available data, increasing the accuracy and thus the value of the insights. Moreover, Volvo Cars believes that utilizing IIoT in their plants correctly will generate a more standardized and centralized approach for processing and handling data among all plants globally. Hence, it seems that IIoT may not only enable connection and interaction with other firms, but may also enhance collaboration between a firm's internal operations, enabling a more uniform and standardized way of working throughout the firm.

6.2.2 Removing the human element

According to Antón-Haro & Dohler (2015), Machine-to-Machine Communication is an essential part in the connected environment and minimizes the human element in deployment, configuration, operation, and maintenance activities. One reason for aiming to remove the human element, according to the empirical findings, is that machines operate more efficiently and with greater precision than humans. Hecla Mining and ABB are of the opinion that computers steer their equipment more efficiently than humans do. ABB argues that the development of remote controlled robots is fueled by an increased speed of communication, increasing the precision for remote control.

By enabling remote access and control, the risk of mistakes is decreased, as robots can be controlled to a larger extent by other parties. Songa Offshore believes the technology is generally much more reliable than humans, as humans tend to make more mistakes than machines. Moreover, they argue that decreasing the human element may increase data quality and process execution speed, as involving humans in the collection of data will cause the quality to vary. Further, according to Songa Offshore, data quality needs to be known and sufficient in order to generate valuable insights. They believe that by building an end-to-end automated IIoT system, they will have consistent data quality and data structure. Moreover, according to Cybercom Group, the rationality of the human element often implies that tedious tasks are avoided if possible.

ABB, Songa Offshore, and Volvo Cars are all of the opinion that Machine Learning enables computing superior to the skills of humans. According to Ethem (2014), Machine Learning renders machines intelligent as they are able to learn and self-adapt, which is valuable in changing environments. ABB argues that their customers would not be able to implement as effective predictive maintenance on their own, without ABB, as ABB has the ability to conduct Machine Learning on the entire installed base of its robots. They are of the opinion that Machine Learning requires less human interaction and enables greater precision. Moreover, Songa Offshore and Volvo Cars mention that with Machine Learning, potential breakdowns may be recognized before they occur, with greater accuracy than would be possible by human interaction. It may thus be argued that together with Machine-to-Machine Communication, Machine Learning may increase the efficiency of predictive maintenance and other operations activities.

Another reason for aiming to remove the human element, according to the empirical findings, is to increase the safety for employees who work in hazardous environments. This is also emphasized in the literature review as Marr (2016) argues that one benefit of IIoT is the possibility to improve working conditions in environments dangerous to humans. Both ABB and Hecla Mining mention that IIoT will facilitate movement towards remote controlled equipment, which increases safety for the workers.

Hence, it seems that the two most common reasons for wanting to remove the human element with IIoT is to enable more efficiency and precision, and to increase safety for employees. Thus, removing the human element is not only desired for the possibility of layoffs, efficiency and increased profits, but for the benefit of the employees as well.

6.2.3 Better overview of operations activities, less workload for employees & decreased costs related to layoffs

The experienced benefits better overview of operations activities, less workload for employees and decreased costs related to layoffs all have a cause in common; predictive maintenance.

The emergence of IIoT creates the opportunity to further enable and conduct predictive maintenance utilizing for example Machine-to-Machine Communication and IIoT (Journal of Engineering, 2014). Predictive maintenance enables many of the interviewed firms a better overview of their operations activities. As predictive maintenance allows for scheduling of service of the equipment prior to it breaking down, it could hence be argued that planning thereof is facilitated. Songa Offshore utilizes analytics to predict unwanted events prior to these occurring, by allowing the implementation of actions and execute the maintenance planning accordingly. Volvo Cars believes that they may gain great value from IIoT in being able to plan their service and maintenance activities better, as their scheduled downtime for service and maintenance is very limited. Moreover, with better insights and capability to plan, the investments regarding service and maintenance activities could be optimized.

The maintenance activities can be visualized by dash boards, which are used by Songa Offshore, Accenture, ABB, Ericsson, Volvo Cars, and Hecla Mining.

According to Mobley (2002), using predictive maintenance, maintenance can be scheduled when actually needed, maximizing time intervals between maintenance sessions and minimizing costs (Mobley, 2002). It can hence be argued that predictive maintenance may decrease the need for service and maintenance work. Further, this may result in either that the existing service and maintenance workforce can work on other tasks than repairing equipment, or that the service and maintenance workforce could be decreased. Should the management delegate additional responsibilities to the workforce, it could be argued that this may increase the efficiency, since the same amount of employees is able to perform more work than before. Further, should the management decide to decrease the workforce, it may result in decreased costs. ABB and Songa Offshore both aim to utilize this possibility to increase their efficiency. ABB believes that IIoT enables humans to possibly control multiple robots simultaneously, decreasing the workload for employees and increasing their productivity. Songa Offshore mentions that the implementation of IIoT and the enablement of predictive maintenance might ensure a decreased workload for the employees regarding maintenance operations, enabling them to focus on other tasks. They believe that this will result in happier employees, and also a healthier rig as an employee with a less heavy workload can discover other improvement areas, and spend time improving them. On the other hand, Songa Offshore also realizes that remote controlling of the offshore equipment enabled by IIoT will relocate work that previously needed to be carried out offshore, onshore. As one position offshore usually requires four employees, it is likely that the relocation of staff onshore will result in fewer employees. Hecla Mining believes that the character of the work at their company will change in the future. As their maintenance practices are becoming more proactive and move toward predictive maintenance, there is a possibility that fewer employees will be needed for service and maintenance.

6.2.4 Decreased costs related to fuel efficiency

Porter & Heppelmann (2014) argue IIoT is setting a new standard for operational effectiveness, which is the basis for competitive advantage. A great example of this is Maersk Shipping increasing their fuel efficiency with analytics calculating the most efficient route. There seems to be various means that a firm can undertake in order to obtain operational efficiency with IIoT, but fuel efficiency benefits both the firm and the environment, rendering it highly relevant.

6.2.5 Outsourcing of IT operations and servers & data backup

The benefits of being able to outsource IT operations and servers, and provide data backup both relate to utilizing the Cloud for data processing. According to IBM (2017), Cloud computing incorporates storing data from a remote location via the Internet. The benefits of using the Cloud includes scalability, the option to pay fees on a per-use basis and self-service access (IBM, 2017). The fact that the Cloud enables processing data in a remote location via the Internet, and that it is easily scalable per demand, facilitates the outsourcing of IT operations. IFS mentions that when storing data in the Cloud, the firm may access the desired amount of storage when needed, rather than having to order a new server and educate the internal IT-staff. According to Salesforce UK (2015), further benefits of utilizing the Cloud include disaster recovery, automatic software updates by the provider, remote data access and security (Salesforce UK, 2015). This is a benefit that ABB experiences as their robots generate vast amounts of data that is being backed up the Cloud, decreasing the risk of losing it should a server crash.

6.3 Costs, risks and challenges for IIoT providers

There are several costs, challenges, and risks for IIoT providers that can impede utilizing the IIoT projects. These will be elaborated upon below.

6.3.1 Lack of trust in provider

All of ABB, Ericsson, and Volvo Cars as a provider and as a user mention that lack of trust in the service provider from the customer point of view constitutes a challenge when integrating IIoT into their products in order to move towards servitization. ABB and Ericsson both experience that their customers have negative attitudes regarding them receiving access to their data, even though they desire the resulting services thereof. This appears to be due to them not trusting the service providers fully. Moreover, Volvo Cars mentions that they are most skeptical towards releasing control to their equipment providers as they want to create one standardized solution of their own.

According to Thomson Reuters (2017), there are often conflicting interests of the service providers and customers. As mentioned in the literature review, the service providers are generally eager to exploit the customer data commercially by creating new services, utilizing the data to improve their own operations and offerings, or licensing the data to other firms (Thomson Reuters, 2017). This is emphasized in the empirical findings of ABB, Ericsson, and Volvo Cars. All three companies aim to create services based on the data, such as ABB's service agreements regarding service and maintenance, Ericsson's IIoT services provided to Maersk and Volvo Cars, and Volvo Cars' Volvo on Call and In-Car Delivery features in their connected car. Furthermore, ABB is utilizing customer data in order to improve both their operations and their products, as the data enables them to predict and plan service and maintenance at their customers' premises and as the R&D department is utilizing the data in order to improve the robots. Regarding licensing the data further, Volvo Cars is doing this to partnering firms such as grocery companies delivering food for their In-Car Delivery service.

On the other hand, customers tend to value confidentiality of their data, prohibition of usage of the data for other purposes than their benefit, and to receive access or ownership to new data sets derived from their data (Thomson Reuters, 2017), which is also strengthened by the empirical findings. ABB experiences the challenge with customers prioritizing confidentiality and thus the data is anonymized. Since many of Volvo Cars' customers are private persons, the data may be sensitive as well, and hence the company ensures that the customers may refuse data retrieval. Moreover, Volvo Cars realizes the importance of only utilizing the data for the benefit of the customer, and hence this has been their sole purpose for gathering data so far, as most of their data is utilized for creating services and features that are valuable to the customers. Further, ABB is experiencing that some of their customers desire access to data sets or parts of the data sets that are derived from their raw data.

The service providers desire access to as much data as possible in order to have the best prerequisites for innovating services, which in fact is desirable by the customers. However, it seems that the more data the service provider requires, the less trust the customers obtain for the service provider. Hence, the amount of data that should be collected constitutes a difficult balancing act for the IIoT providers.

Thus, the challenge of lack of trust in the service provider could be argued to be based on these conflicting interests. However, it is not evident that these need to conflict, as is proved by ABB and Volvo Cars that are utilizing the customer data while still taking the interests of their customers into account. By doing this, it is hence possible to gain the trust of the customers. The trust is essential, because without the trust the service providers will not be able to satisfy their own interests either.

According to Daugherty et al. (2015), firms tend to be overly cautious about sharing data, indicating that there is room for more trust regarding data sharing in the supply chain. Moreover, De Wachter (2013) argues that the value of data increases with the usage of it and that most of the business value utilizing Big Data is captured when combining data from various sources, and Daugherty et al. (2015) argue that data sharing within the supply chain increases productivity. Hence, there is much incitement for customers to share their data with IIoT providers.

Weight

Persson rates the probability of the challenge of having to overcome lack of trust from customers regarding data sharing as low, as he is of the opinion that customers are in a transitional phase where they are becoming increasingly comfortable with the new technology and sharing their data. Moreover, he thinks that if the customers realize the benefits of the services that are created with the data, their willingness to share it will increase. Further, Persson rates the impact as high, because if the customers do not trust the provider, it is impossible to sell the services.

Mitigation

As earlier mentioned, maximizing benefits for the customers and confidentiality of the data are important values of the customers (Thomson Reuters, 2017). In order to gain the trust of the customers it could hence be argued that explaining the advantages associated with data sharing is essential. ABB is currently mitigating this risk as they are trying to convince their customers that the benefits of sharing data outweigh the risks. Further, they are working on minimizing the risks regarding sensitive data by anonymizing and removing details not crucial for the creation of services. Volvo Cars is also working to maximize perceived benefits and minimize risks as they only utilize the data relevant for creating customer value and are very cautious about not collecting any unnecessary data.

It may also facilitate customer trust to demonstrate that the customers are the owners of the data, as this is desired by customers, according to Thomson Reuters (2017). Ericsson is careful about this and believes that this is crucial for all actors to realize. They emphasize the importance of being seen as a trusted partner by the customers. Hence, it can be argued that shifting customer relationships towards closer partnerships may facilitate trust in the IIoT providers.

6.3.2. Changing the business model

As IIoT improves efficiency of service, a firm may choose to expand its offering from merely just selling the product, to product-as-a-service where the firm takes control of the entire product cycle, including operations and service, for a fixed fee (Porter & Heppelmann, 2014; Björkdahl, 2011). This will ensure that the selling firm may reap the product performance benefits provided by IIoT, but requires a large shift in the business model (Björkdahl, 2011). Both ABB and Volvo Cars as a provider believe that the process of changing one's business model constitutes an important challenge to move towards servitization. ABB primarily argues that the challenge regards forming contracts and determining liability, in order to agree upon which party is liable for any malfunctioning and how to measure various aspects. Volvo Cars, on the other hand, believes the greatest challenges lie in the customers' perceptions – the customers do not wish to buy a tool with a certain specified uptime, but rather a sensation and an experience with fun features. Thus, Volvo Cars needs to be wise in their packaging, in order to appeal to these customers with a servitization business model.

Several aspects of an organization's business model need to undergo change as the business shifts to servitization and incorporates IIoT (Björkdahl, 2011; Björkdahl, 2009). The value proposition constitutes the aggregated benefits that the customers receive when using the organization's products and services (Osterwalder and Pigneur, 2009). When providing a capability rather than a one-time product sale, the quality of the product is of greater importance, as the concept of lifetime cost of products is then of focus. This is due to the company then selling uptime – it is thus desirable to decrease the future need for service, rather than minimizing the product costs at the point of sale. A further aspect organizations need to consider is a change in the customer segments they serve. The customer segments represent various groups of people and organizations that the company desires to reach and attain (Osterwalder and Pigneur, 2009). As industries are transforming, so are the customer segments that the industries serve. For instance, Volvo Cars believes their primary customers in the future will be fleet operators such as Uber, while private persons will constitute a smaller customer segment. When shifting customer segments, uptime will be of increasing focus, in extension impacting their value proposition and increasing the importance of IIoT and connectivity of the cars.

The relationships between an organization and its customers may vary on a scale from automated to personal (Osterwalder and Pigneur, 2009). Shifting to a business model based on selling a capability, rather than a single one-time product, and thus requiring access to customer data, may require closer cooperation where the actors are moving towards partnerships in order to build trust. Key resources are assets that the organization needs in order to operate a viable business model (Osterwalder and Pigneur, 2009). The nature of these will likely change from tangible resources such as equipment and physical labor, to entailing a larger degree of intangible competences, such as well-educated human capital and skills in technology and IT. The change will further impact the revenue streams, i.e. the funds that the organization receives when delivering value proposition to each customer segment (Osterwalder and Pigneur, 2009). As earlier mentioned, there are two forms of revenue streams; transactional and recurring. When shifting from selling a product to selling a service, the revenue streams will shift from transactional to recurring. Likewise, it is likely that the cost structure will be altered. The cost structure entails the most significant costs associated with maintaining the business model (Osterwalder and Pigneur, 2009). By renting out equipment rather than selling, the costs inflicted by maintaining each customer relationship will likely be larger, as the providing organization is responsible for the entire capability, rather than merely the costs associated with the actual product sale. However, as mentioned above, the revenue streams are also likely to shift accordingly. Further, using service agreements, for example, it will likely be in the organization's best interest to minimize the need for service, rather than earning revenues from service sales. The final aspect affected by a shift to servitization is the key activities. Key activities are the most critical activities that the organization undertakes to reach customer segments, maintain customer relationships, create and deliver the value proposition, and earn profits (Osterwalder and Pigneur, 2009). When providing a service instead of a product the key activities are likely to be altered. For example, the organization will probably need to be involved in their customers' organizations to a larger extent building relationships and trust.

To conclude, a majority of the aspects of an organization's business model will likely need to undergo transformation, when shifting to servitization. Thus, it can be understood why it poses such a complex and challenging task. There exist few examples of organizations which have undergone a complete shift to servitization, however many companies exist on a scale where they are slowly shifting in that direction.

Weight

Persson deems the probability of encountering the challenge of changing the business model as high, since it is not questionable that organizations undergoing a shift toward servitization will be required to manage this. Concerning the impact, it is also regarded to be high by Persson. Redesigning one's business model is a very complex and challenging task. It will affect all aspects of the organization, including activities, positioning, value proposition and culture. However, all organizations moving toward servitization need to undergo this transition, and those starting earlier will likely have an advantage. It can further be noted that this challenge mainly is prevalent for well-established companies which are required to undergo a transition - it is probably less challenging for start-ups which can align their business models to servitization from the start. Thus, it is mainly the transformation itself which is problematic, not the actual final business model.

Mitigation

When redesigning one's business model, numerous aspects ought to be taken into consideration (Björkdahl, 2011). Firstly, the organization should decide which major type of business model category is best suited (Chatterjee, 2013). It can be argued that when moving towards servitization the organization is most likely to operate a value-based business model, as this business model focuses on increasing customer value by solving their problems *in lieu* of producing a commodity. Secondly, the firm must translate the generic value capture logic of the business model into core objectives, meaning deliverables that are measurable and specific for the firm (Chatterjee, 2013). In order to identify what the customers value, it might be beneficial to make numerous prototypes of the offer and present these to a small fraction of the customer base in order to enable rapid feedback and an iterative design process (Chatterjee, 2013). In analogy, it might be useful to only change the value proposition from a product to a service offer, for a small customer segment. The new product offering could be co-designed with this specific segment, and numerous prototypes could be directed to it. Targeting a small segment may facilitate the co-creation as it can be argued to be easier to work closely together with a smaller amount of customers than a larger amount. One example of this might be the possibility of Volvo Cars providing a servitization offer, selling the capability of driving to Uber drivers, who might be focused on car uptime to a larger extent than private persons.

When operating IIoT, firms should map out the resulting ecosystem they are to act within, and identify stakeholders whom they should partner with (World Economic Forum, 2015). The emergence of IIoT requires firms to focus on ecosystem business models (Westerlund et al., 2014). This means that value creation and capturing should not only be considered for the individual firm, but for the whole ecosystem. It can be argued that the ecosystem business model should be designed to maximize the value for all parties involved. Focusing on ecosystem business models may hence be beneficial for all, and will likely increase the total value of the ecosystem. Thus, when altering business model within the technology area of IIoT, one should consider how the organization's various activities and actions alter the ecosystem and affect its, and others', positions within it. This will be elaborated upon below in 6.4.10 *Integration of technology*.

6.4 Costs, risks and challenges for IIoT customers

There are several costs, risks, and challenges for IIoT customers that can impede utilizing the IIoT projects. These will be elaborated upon below.

6.4.1 Costs related to remote locations

Songa Offshore, Accenture, Hecla Mining, ABB, Ericsson, and Volvo Cars as a provider all mention that costs related to remote locations can be a great challenge. Songa Offshore, Hecla Mining, and ABB mention similar problems with complex environments requiring them to utilize specially manufactured, expensive sensors. Moreover, Accenture talks about the challenges in the airline industry as the costs of transmitting the data when the plane is in flight are high. Ericsson had similar thoughts as they specifically mentioned the airline industry and oil rigs experiencing this challenge when implementing IIoT. Further, Volvo Cars experiences high costs of transmitting data from their connected cars, as they roam mobile networks.

Weight

Persson rates the probability of encountering high costs related to remote locations as high, commenting that this naturally only applies to firms operating in remote locations. Firms that do not operate in remote locations should ignore this risk. Persson further rates the impact as high, as it is very expensive and difficult to implement IIoT for firms that experience this challenge. If the firms operating in remote locations cannot justify the costs, they will not be able to reap the benefits either.

Mitigation

As proved by Songa Offshore, costs of operating IIoT equipment in remote locations can be lowered by accumulating and aggregating data, hence sending it in a lower frequency than real-time. Moreover, as is stated by Volvo Cars, it is important to be careful when selecting what data to send. If the costs of transmitting it are high, the company should be certain that the data sent actually generates valuable insights exceeding the cost.

Another enabler of decreased costs related to IIoT in remote locations could be the emergence of 5G. As Ericsson states, 5G will be especially beneficial for firms that operate in remote locations or have work environments dangerous to humans. Hence, this could be applicable for all of the interviewed firms which mention this challenge, but most importantly for Hecla Mining that emphasizes several times that the working environment in their mines is highly dangerous. Ericsson is currently working with the mining firm Boliden in order to enable communication and autonomous mining vehicles for safety and security. Hence, it seems that 5G will be a strong enabler of IIoT in the mining industry.

Further, as earlier mentioned, 5G will enable faster and more reliable network connections with less latency, and require less battery power. This might be beneficial in both the mining industry and with robots, as remote controlling equipment in mines as well as the precision of movements of robots require minimal latency. Moreover, Volvo Cars mentions that 5G requiring less battery power will be beneficial when monitoring control messages when the car is turned off.

6.4.2 Organizational challenges - Resistance because of layoffs

Songa Offshore, IFS, Hecla Mining, and Ericsson mention that implementing IIoT can induce resistance in the organization due to possible layoffs. According to Daugherty et al. (2015), certain workflows will become redundant as they are computerized. This causes feelings of being threatened among the workers, and this argument is enforced by the firms acknowledging this challenge. Songa Offshore experiences that its workforce on their rigs is threatened by the IIoT, as it will enable the work tasks being relocated onshore, requiring less employees. IIoT is therefore also opposed by the unions. Both Hecla Mining and IFS believe that the automation may affect primarily the service and maintenance workforce in firms, as the equipment is monitored automatically and hence will not need a technician to monitor it manually as often. Further, according to Porter & Heppelmann (2014), IIoT poses a challenge of matching the employee base with the new skill sets required. This argument is supported by IFS who believes that the operations directors themselves, who decide upon the investment, may fear potential layoffs stemming from the implementation of IIoT, because of the unknown. Ericsson realizes that this challenge exists due to that IIoT and robotics may be able to perform the same tasks as humans. Thus, it seems that the resistance stems from various actors in the organization and society, such as managers, workers, and the unions, and the inherent challenge regards matching the workforce with the prerequisites of IIoT.

Weight

Persson rates the probability of experiencing resistance to IIoT in the organization due to possible layoffs as low, since he regards this as a general fear of technology rather than a true challenge. Regarding the impact, he rates it as medium. Persson believes that all new technology induces this challenge, but that it does not constitute a main argument for not implementing IIoT. Often the employees are not laid off as the firms are instead utilizing the technology merely for increasing productivity.

Mitigation

IFS emphasizes that IIoT needs to be managed carefully as it can create disruption among the workforce. Moreover, Songa Offshore realizes that the matter needs to be laid down properly in the organization. They emphasize that the employees need to understand that it is not a matter of if, but when, IIoT will be introduced, as it is a prerequisite for maintaining competitiveness in the market.

According to The World Economic Forum (2015), the key benefits and opportunities of IIoT include an improved efficiency in operations and the enablement of machine-human collaboration. For instance, the same workforce could produce more output in collaboration with the IIoT. Hence, as mentioned above, it might not even be necessary to decrease the workforce as IIoT can be utilized for increasing efficiency and revenues instead of decreasing costs. Furthermore, according to Daugherty et al. (2015), digitalization will create new needs regarding the workforce, such as for skills in data science, software development, hardware engineering, and operations among other. Hence, it can be argued additionally that the workforce might not need to be decreased, but rather that different positions and work tasks will be created. This is also acknowledged by Hecla Mining who wants to move their workforce above the surface of the mine. They hope to enable remote controlling of the equipment, increasing safety for workers, requiring more capabilities in programming and data.

6.4.3 Organizational challenges - Resistance in business unit due to insufficient business case

According to Markovitch & Willmott (2014), digitizing information-intensive processes can increase sales radically and reduce costs by up to 90 percent. However, according to Porter & Heppelmann (2014) the collection, analysis and storage of data incur direct as well as indirect costs related to security or privacy risks. Moreover, according to the interviewed firms, there are many more costs associated with implementing IIoT than those of security. Porter and Heppelmann (2014) argue that a firm hence needs to consider the tangible value the data generated by IIoT may generate, and ensure this value exceeds the costs associated with it.

Both Songa Offshore and Cybercom Group mention that IIoT projects often stem from the IT department or other tech savvy employees in the firms, who are not always focused on the possible profits that may be generated from the project, but are rather fascinated by the new technology.

Hence, it can be argued that this may decrease the credibility of the estimated benefits of the business case, making it even more difficult to persuade the management. Moreover, according to IFS, decision makers in firms that already are delivering good results may not want to jeopardize it by introducing new technologies.

Songa Offshore experiences that there are people within their firm who resist their IIoT project due to the difficulty of demonstrating a viable business case for it. It is difficult for the IT department to provide an attractive business case as management is resistant due to a lack of understanding and interest in the technology. Hence, there is little funding for the IIoT project, rendering it even more difficult to prove and quantify the benefits. Accenture mentions the same problem as they believe that IIoT projects are often slowed down due to a lack of proof of instant value delivery. Due to a lack of possibilities to experiment, it is difficult to prove that IIoT will generate value. Thus, it seems like a vicious cycle; in order to receive funding for an IIoT project the benefits need to be proved and quantified, but in order to prove and quantify the benefits the project needs to be initiated which in turn requires funding.

Weight

Persson rates the probability of encountering resistance to IIoT from the management due to an insufficient business case as high, since this is a frequent obstacle in organizations. It is a common phenomenon that IIoT projects are not embedded well enough in the management's mindset, and are often not seen as a part of the firm's strategy. Further, Persson rates the impact as high as well. If the business case is not approved, the project may not be conducted at all.

Mitigation

In order to create a favorable business case, it may be beneficial to research and plan thoroughly regarding the value and insights that the IIoT project may generate. This advice is also emphasized by Cybercom Group as they argue that many firms are not conducting sufficient studies prior to implementing IIoT projects.

According to Cybercom Group and IFS, implementing IIoT may be facilitated by targeting few employees that are evidently interested in the project and implementing a project of small scope together with them. A success of this project may convince more employees of the benefits and return of investment of IIoT, increasing trust and understanding in the technology. Songa Offshore is currently conducting smaller IIoT projects that are documented in order to prove the benefits thereof, in order to raise funding for their IIoT projects of larger scope. However, conducting smaller projects requires some degree of funding as well, even though it may be considerable less than for larger projects. Hence, it could be argued that it is likely less challenging to receive funding for smaller projects, but it should be noted that someone still has to be convinced of approving the smaller funding as well.

6.4.4 Organizational challenges - Resistance because of lack of trust and knowledge regarding technology

A majority of the organizations; Songa Offshore, IFS, Hecla Mining, Cybercom Group, Ericsson and Volvo Cars both as a provider and as a user mention the challenge of employees resisting IIoT due to a lack of trust and knowledge regarding the IIoT technology. Generally, there is a great uncertainty towards new technology. Ericsson argues that IT in general has an ability to disrupt, i.e. drastically alter the game plans of companies, generating suspiciousness and insecurity towards the technology, resulting in resistance. In accordance, Marr (2016) writes that one of the challenges of Industry 4.0 is a general resistance among stakeholders caused by a lack of trust in the new technology. As can be categorized from the empirical findings, these sources of uncertainty appear to stem from three major sources; a lack of understanding, a lack of trust, and cultural issues. These will be elaborated upon below.

Many employees often resist the technology as they do not understand it and thus do not realize the benefits of it. Songa Offshore mentions that the understanding of technology is generally poor within the board and top management, which results in skepticism and a lack of funding. IFS experiences that the insufficient knowledge among individuals does not only generate a lack of trust, but also an unwillingness to expose oneself from a knowledge point of view. The latter is especially prevalent among older individuals, and among employees on the shop floor. In contrast with Songa Offshore, IFS believes that most directors generally have a greater technology understanding due to that the latter group more frequently participates in various conferences, communicates with expert analysts, and is exposed to technology news via marketing and magazines. Hecla Mining realizes that many of their employees do not know what IIoT is since the project is in its infancy, and they need to be educated about it. Ericsson also argues that people may resist technological changes due to them having insufficient knowledge of it – people may fear the change, if they do not understand how the technology will impact their job and organization. Volvo Cars realizes that their conservative attitude regarding the Cloud stems from a lack of knowledge. Volvo Cars does not want to give access to external firms to control anything in their plant through the Cloud. In accordance, Daugherty et al. (2015) mention that one risk with implementing Cloud computing is resisting employees. The challenge concerning a lack of understanding is not only prevalent among internal staff, but also among customers of those providing IIoT. Volvo Cars as a provider argues that the largest problem with the networks not being fully reliable is that the customers do not always understand it. Some assume that the IIoT services should function consistently, even when the car is parked in an underground garage.

The second major category entails a lack of trust in the technology. Songa Offshore argues, with regard to safety aspects, that there are some areas on the rig which will not be connected in the near future due to regulations or it being deemed unsafe. Both IFS and Ericsson also experience that resistance among people in the organization may occur due to employees not trusting the technology. Volvo Cars as a user further demonstrates a lack of trust in IIoT among their employees. The factory workers do not want to automate anything at all as they think that it only generates problems and makes the equipment fail. The general opinion is that humans are more reliable.

The final category generating resistance regards the cultural aspects within the organization. Cybercom Group experiences that in an industrial setting there are many proud and conservative professionals that believe they know their job better than anyone or any technology. Hecla Mining further mentions that the culture in the Idaho mine poses a great challenge for the IIoT project. The cultural setting can also result in resistance from certain departments in the organization. Volvo Cars mentions that there is a resistance towards IIoT in the Gothenburg factory due to cultural issues regarding perceptions of the purpose of the service and maintenance department. Historically, the person who solves a problem becomes a hero, and if there exist no problems due to predictive maintenance, their status may decrease. It will further require a new mindset for the employees, focused on preventing problems by understanding the plant.

Weight

Persson rates the probability of resistance occurring due to a lack of technological trust and knowledge as medium, as it is rather prevalent in organizations. Regarding the impact of the challenge, he rates it as high. If an organization does not trust the technology, inducing unwillingness to dispatch data to the Cloud, this poses a great obstacle. In that case, the organization will not be able to implement IIoT at all.

Mitigation

In order to mitigate the organizational challenge caused by a lack of trust and knowledge in the technology, several mitigation efforts can be directed.

In order to provide knowledge and generate an understanding of the technology, the organization should ensure the employees are educated in IIoT and its implications for the organization and themselves. Songa Offshore mentions that their IT department is currently managing the lack of understanding in the organization by preparing information material. They believe this has been lacking, and will benefit the implementation onwards. Volvo Cars as a user agrees with the importance of educating employees. The workers need to be convinced about the reliability of the technology, but the more automated and computerized processes become, the more hidden it is, and hence it is difficult for the workers to realize the benefits. Thus, the company needs to undergo a long process of education in order for the employees to gain an understanding of the possible value. Further, as the employees, as mentioned before, are skeptical toward IIoT it should be pressed that gathering information and monitoring the equipment is not the same thing as implementing complicated technology in the factory.

By ensuring that the entire organization understands the technology, including top management as well as workers, the organization doing so will hopefully secure funding and direct and encourage employee efforts, while avoiding resistance from any individual. Further, it can be noted that which group of individuals lack understanding and knowledge, might differ from company to company. For example, Songa Offshore believes a majority of the lack of understanding lies with the top management and the board, while IFS argues it is mostly prevalent among the factory employees. Thus, it might be beneficial for each organization to map out their situation, in order to direct the education efforts accordingly.

Further, in this regard as well as concerning the challenge of proving the business case, it might be beneficial to commence the project by initiating small and successful projects in order to build trust. IFS argues that IIoT projects should be initiated by executing a project of small scope in a chosen business area – a project which can be implemented in weeks. This project may then demonstrate the benefits and return on investment of IIoT to all project stakeholders in order to gain trust and ensure understanding in the technology. As mentioned above, Cybercom Group adds that it might be beneficial to commence the IIoT initiative with people who have an apparent interest in the project, instead of focusing on convincing those who have not. The firm could approach a few people that show interest and conduct a small project together with them in order to fully convince them of the benefits of IIoT, which will then spread to more employees. IFS further mentions that another method to ensure trust in the technology may be to implement it in a stepwise manner. Rather than automating all processes in the initial step, manual steps can be included in the processes. Gradually, these manual steps may be removed once trust concerning the technology and its functioning is gained. A further method to tackle the lack of trust might be to not remove the previous set-up at first, but allow it to operate alongside the IIoT solution. Songa Offshore, for example, manages their lack of trust in technology by not removing the existing technical system, but instead allowing the IIoT system to complement it. To conclude, it might be beneficial to commence an IIoT initiative with smaller projects carried out by those who have an interest in it. Moreover, manual steps can be included in the project at first instead of automating all at once and the previous technical system may not need to be removed initially.

Another initiative in order to increase the level of trust and knowledge within the organization might be to let the prospective users of the technology see and try for themselves. Cybercom Group mentions that some of their customers' employees that are practically oriented tend to be skeptical towards new IIoT technology. However, when trialing the technology and seeing the benefits for themselves, Cybercom Group usually experiences the formation of a more positive attitude.

6.4.5 Organizational challenges - Transformation of the whole organization

A majority of the organizations; Songa Offshore, Ericsson, Volvo Cars as a user, IFS and Cybercom Group mention the organizational challenge of transforming the whole organization in order to implement IIoT. To digitalize the organization and implement IIoT are not isolated events or merely an IT project - it is a company-wide one which requires an organizational transformation. This poses a great challenge due to the complexity of such a task. According to Boorsma (2016), one of the challenges associated with digitization is understanding and anticipating the impact of the digital transformation. According to the World Economic Forum (2015), it still remains a question exactly how the IIoT will impact industries, business models, and value chains.

IIoT not only affects the products themselves, but rather all aspects of a manufacturing firm; the value chain, service, human resources, marketing, security and product design (Porter & Heppelmann, 2014). This is strengthened by the empirical findings. Songa Offshore mentions that various departments, as well as external parties, need to cooperate and align themselves in order for an implementation to be successful. Volvo Cars also realizes that the digitalization of the cars affects the industrial, procurement, sales, and logistics departments as well, for example. Their perspective concerning IIoT is currently rather narrow, focusing on predictive maintenance and logistics, although some employees are aware that it is possible to gain much more value should they broaden their perspectives. Thus, Volvo Cars needs a more extensive transformation in order to maximize their value from IIoT. So far, it has been difficult for Volvo Cars to come to a conclusion of what IIoT would mean to everyone and every department at the company. Rather than making a major strategic plan, smaller initiatives not cohesive for the whole organization have been implemented by various departments. These smaller projects exist in silos and are thus not scalable, and all departments have different views on the issue. Another organization experiencing different opinions regarding this matter between departments is Songa Offshore. They experience a different acceptance for the IIoT project in between the departments; often the IT department is willing to initiate a project, while the business unit is skeptic. Cybercom Group further believes that organizations currently working with traditional silos and waterfall models need to switch to working together in new ways. This is often perceived as difficult.

In general, the organization, as well as the individuals in it, need to be prepared and willing to change. It is important to acknowledge the human nature of change. IFS argues that people in general tend not to like change, and one faulty link may have a large negative impact. Further, Ericsson argues that the organizations need to be mature enough and up for the challenge, in order to successfully receive support and help.

Considering IIoT, it is important to note that a majority of the challenges are related to humans and the nature of organizations, rather than technology. Humans have a large impact on IIoT projects, in some regard larger than technology, and thus the concept of Internet of Things may be considered as too narrow. Instead, a wider concept entailing more aspects, including humans and industries, such as the Internet of Everything, may be more accurate. This would emphasize the need for organizations to transform themselves completely, in order to implement the technology. The technology does not merely incorporate devices, hence the focus on things inherent in the concept may be too limiting.

Weight

The probability of the challenge of transforming the whole organization occurring is rated as high by Persson. It is very common for organizations to work in their own silos and to not regard the digitalization as the organizational transformation that it is. IIoT is a strategic matter for the top management to provide direction in, but many organizations do not regard it as such. Concerning the impact of the challenge, Persson regards it as high as well. To not take the transformation aspect into consideration, will likely have a large negative impact on the IIoT initiative as well as on the organization.

Mitigation

In order to successfully transform the organization digitally, thoughtful planning and consideration of the change process need to be in place. IFS mentions that the IIoT initiatives need to be driven top-down in the organization, in conjunction with HR and the rest of the board, in order to ensure an efficient and effective implementation. Cybercom Group on the other hand argues that organizations need to work cross-functionally with the IIoT initiative. It is no longer sufficient that the management team makes all the decisions themselves – the other departments need to be included as well. This will ensure that the various departments are aligned, and work toward common goals. To synthesize, it may be beneficial to utilize a combination of these perspectives. On the one hand, direction through an overall strategy and, not at least, funding, need to stem from top management. On the other hand, the entire organization needs to be aligned and work together. In order to implement this, cross-functional workshops might be a good idea, allowing the participants to change focus to a common one centered on their customers. By laying out the project correctly within the organization, resistance from other departments may be avoided. Further, Cybercom Group mentions that there is a demand for new management techniques and new forms of organizations. As mentioned above, many firms are organized in traditional silos and work with waterfall models, which will not be compatible with IIoT.

Ericsson further argues that organizations need to obtain the proper mindset, and organize themselves around the implementation. Having a certain group or organization within the company responsible for driving IIoT might be beneficial. This can be demonstrated by the success story of Volvo Cars' connectivity hub. The individuals in the connectivity hub were focused on adapting, changing and preparing Volvo Cars in preparation of rolling out digital services. Further, IFS mentions that building trust in the company for IIoT is crucial and will have a big impact.

6.4.6 Technical requirements and complexity

Both Songa Offshore and Accenture mention the challenge of technical requirements and complexity. Accenture mainly believes that this stems from navigating across the technological landscape, e.g. choosing a certain IoT platform among the numerous ones available. Understanding the alternatives and choosing the one best suited poses a complex task. This is amplified by the fact that it is difficult to predict which platforms will be the winners of any prevalent battles (Magnusson & Nilsson, 2014). Prior to technologies becoming mature, several actors offer various products, and all of these will likely not be successful.

Songa Offshore instead points out all aspects of ensuring a functioning IIoT solution, including the buying or building of sensors, installation, processing and analyzing of data, and communication, as challenging and complex matters. The literature review strengthens these empirical findings. According to Marr (2016), two of the challenges associated with the shift to Industry 4.0 are to cope with technical problems and the need for very reliable and stable systems. Companies need to find the adequate human resources capable of working with the technology. Further, Songa Offshore stresses that these matters are even more complex in the critical offshore environment, including using satellite communication and finding sensors with a certified low energy output.

Weight

Persson deems the probability of IIoT projects being impeded by technical requirements and complexity as high. Many of the organizations entering the IIoT field have not been involved with similar technology before. They may have earlier provided a product without software, and now they are required to control the IIoT system, including software and sensors. This poses a large challenge for those not used to it, and requires the organizations to work hard. Regarding the impact, Persson also rates it as high. This may pose such a large challenge that the organization chooses not to carry through the project, or that the project may fail entirely.

Mitigation

Firstly, companies, especially those new to this technology area, need to ensure they have adequate human resources and competence. The company needs to master various capabilities, such as sensor-driven computing, industrial analytics, and intelligent machine applications (Daugherty et al., 2015).

Secondly, firms must acquire a solid infrastructure and technical architecture, i.e. an IoT platform that enables a combination of IT and OT (Daugherty et al., 2015). The success of a platform is determined by the level of co-creation, i.e. the capacity to innovate within the ecosystem (Magnusson & Nilsson, 2014). Thus, this should be considered when choosing the most suitable one. It might be beneficial to thoroughly investigate the various alternatives by talking to the various actors in the ecosystem, as well as third-party external experts. To consider the actors' willingness to contribute to the platform, may provide an indication of the level of co-creation. Another aspect to consider is the number of users of the IoT platform. Successful platforms which have reached a critical mass of users and providers, tend to be self-reinforcing (Magnusson & Nilsson, 2014).

6.4.7 Inadequate focus on generation of value

In order for IIoT to generate maximum value, organizations need to master the following technological capabilities: sensor-driven computing, industrial analytics, and intelligent machine applications (Daugherty et al., 2015). Thus merely collecting data is not sufficient. Utilizing sensor-driven computing combined with industrial analytics, the perceptions from the sensors are transformed into valuable and actionable insights, enabling real-time decisions and actions (Daugherty et al., 2015). Songa Offshore, Accenture, Cybercom Group, ABB and Volvo Cars both as a user and as a provider all mention the challenge of having an inadequate focus on value generation when undertaking innovation fueled by IIoT. Firms undergoing digital transformation fueled by IIoT need to consider several strategic aspects. One of these relate to what data a firm needs to capture in order to ensure value maximization (Porter & Heppelmann, 2014). All of the organizations mentioned above experience that there is a tendency to collect data without having a proper plan of how it will deliver value. It is often believed that it will be useful in some application ahead, but many times it will just be discarded. Accenture further mentions that previously IIoT initiatives in organizations often were taken by engineers who were overly excited about getting connected, acquiring fancy gadgets that could be instrumented to different locations and measure various arrays of data. This resulted in many organizations solving the exact same problems over and over again, and did not generate value as it is not sufficient to only collect the data. The application of sensors and data collection is not enough – analytics must be instrumented on it and the data collection should focus on what might potentially generate valuable insights. Volvo Cars also argues the importance of deciding what information should be collected from the cars, as a car generates more data than what would be possible to extract and collect.

Weight

Persson rates the probability of having an inadequate focus on value generation as high. Especially prevalent amongst organizations undertaking IIoT transformations is a lack of sufficient planning and research before embarking upon it. Due to this, it is very common for organizations to collect large amounts of data, which they do not have an actual use case for. Regarding the impact, Persson rates it as medium. The project will likely not fail because of it, but it might result in the organization working in parallel and spending unnecessary resources, which will require a correction later in the IIoT project.

Mitigation

The collection, analysis and storage of data incur direct as well as indirect costs related to security or privacy risks (Porter & Heppelmann, 2014). A firm needs to consider the tangible value a specific data set may generate, and ensure that this value exceeds the costs associated with it. Accenture argues that it is important to keep the business need in mind when implementing IIoT. One of the key considerations should to ensure that there is not only data collection, but that there is data analytics capabilities in place as well.

Cybercom Group mentions that many firms are excited about becoming digitalized and decide to implement the technology immediately. However, it is important to research and plan in advance in order to decide what value the technology is supposed to generate. It is important to choose what information is desirable, whether generated advice is desirable, and whether various data sources should be combined, analyzed, and delivered. Only then IIoT is utilized in the best way possible.

6.4.8 Cyber attacks

Songa Offshore, ABB, and Volvo Cars as a provider and user all regard being exposed to cyber attacks as one of the great risks of implementing IIoT. When interconnecting operations online the business may be exposed to sabotage, data theft and cyber attacks (Daugherty et al., 2015). Porter and Heppelmann (2014) also regard this as a challenge as they argue IIoT challenges organizations by setting new demands for security management. According to Songa Offshore, IIoT requires them to open up their systems in order to collect data, exposing the company to great risks as they operate in a critical environment. If someone would be able to take control of the equipment, it might result in a severe accident. Further, ABB realizes that their customers are exposed to cyber attacks when connecting their robots to the external environment, which may affect operations in their factories. Moreover, Volvo Cars is hesitant towards connecting the equipment in their factory to the Cloud and buying Cloud services, as this requires them to enable remote controlling of the equipment. The factory would be extremely sensitive to sabotage, as saboteurs will only need to access their network in order to shut the plant down. Moreover, they realize that the connected cars are exposed to cyber attacks as well. Thus, different types of firms are more sensitive to this risk than others, as the stakes are higher for some firms should a cyber attack occur.

The World Economic Forum (2015) argues that as IIoT is implemented the virtual and physical worlds converge, raising the need for businesses to implement new security measures. The data flowing from, to, and between products needs to be protected from unauthorized access (World Economic Forum, 2015). Hence, it is a fact that IIoT exposes companies to the risk of cyber attacks, and thus these firms need to determine whether or not the risk is worth taking. However, there are measures that can be taken in order to increase security.

Weight

Persson rates the probability of cyber attacks occurring to be low, as it is not common to hear firms talk about this being a fear. Regarding the impact, he rates it as high, as a cyber attack could be devastating to a firm.

Mitigation

In order to decrease the risk of cyber attacks, firms can separate their networks. Volvo Cars is utilizing this method in their factories, as they separate the network controlling the equipment from the network of surveillance systems. Should they add a connection to an external network, they would separate it from the network controlling the equipment as well.

According to ABB, the most common method to mitigate this risk is to only allow data to be sent out from the company, and not in. Further, it requires the systems not to be susceptible to anyone aiming to overcome this one-way communication barrier.

As earlier mentioned, a firm needs to consider the tangible value a specific data set may generate, and ensure this value exceeds the costs associated with it (Porter & Heppelmann, 2014). It is hence important that the benefits of implementing IIoT outweighs the disadvantages related to the risk of cyber attacks. ABB supports this argument as they believe that if the gains from an IIoT connection is valuable enough to the customer, their customers are willing to connect themselves despite the risk. However, if the value of the connection is marginal, they may choose not to implement it.

6.4.9 Lack of data privacy

ABB, Songa Offshore, Volvo Cars as a user, and IFS regard the lack of data privacy as a challenge when utilizing IIoT services in operations provided by another firm. ABB mentions that many of their customers are hesitant towards releasing their data to ABB, as they are afraid of their competitors gaining access to sensitive data regarding their product mixes and ramp up speed of new products, for example. This contrasts the view of Songa Offshore, who believes that it is impossible for one company to operate isolated and trusts their partner Microsoft well. However, they realize that the lack of data privacy may pose a challenge and are hence careful with what data they share and with whom they share it. Volvo Cars is hesitant towards giving away access to data and control of their equipment in their factories, but realizes that they are more cautious with some data than other, depending on the degree of sensitivity. IFS experiences similar attitudes from their customers as they are fearful both of IFS having access to the data and that the data is stored in the Cloud. However, according to IFS, much of their customers' data, such as their emails, are already stored in the Cloud without them worrying about the privacy risks of it.

Weight

Persson deems the probability of a lack of data privacy to occur as overall medium. He emphasizes that the data needs to be regarded as an own entity, which needs to be treated in each contract. Firms carefully considering these contracts will be exposed to a low probability, while those disregarding the importance of the contracts will be exposed to a high probability. Further, Persson rates the impact to be medium as he generally regards the impact of this risk to be lower than that of cyber attacks.

Mitigation

Songa Offshore secures their shared data with contracts with their service providers. According to Tollen (2017), data ownership can be determined by intellectual property rights, but contracts are more efficient since it is difficult to prove ownership solely using intellectual property rights. Rendie (2014) argues that many disputes are likely to emerge should contracts not be in place, since there is such great potential value in Big Data. Hence, it can be argued that contracts may increase the data safety and privacy for IIoT customers.

Since contracts may increase the degree of safety and privacy of IIoT customers, it can be regarded as an efficient mean of enabling collaboration and data sharing between IIoT providers and customers. As earlier mentioned, according to Tollen (2017), Big Data license agreements that state legal access and treatment of Big Data can be used in Cloud computing services where a service provider needs access to the customers' data. Moreover, according to Thomson Reuters (2017) the licenses should include security policies, practices, protocols, and delivery, maintenance, and control of the data. Hence, it may be beneficial to write these contracts in a clear manner, ensuring to include all the important aspects regarding release of data access.

Thomson Reuters (2017) emphasizes that the contracts or licenses should be aligned with the licensor's business model and that the license should be broad enough to enable the licensee to generate the desired value from the data. This is supported by Volvo Cars. They argue that it is more difficult for service providers to enhance their services to their customers if their data access is highly restricted. Volvo Cars further mentions that this constitutes a difficult balancing act; maintaining the customer's privacy, while also being dependent on the data access to develop services. The company compromises regarding this with their In-Car Delivery feature, where access to the car's location data is restricted to a brief time slot. Thus, it can be concluded that the contracts should benefit both the provider and the customer and that being overly cautious about sharing data will affect both IIoT providers and customers negatively, since neither will gain benefits from this.

Naturally, it is also important to follow up on compliance of the said data privacy contract. According to Osterwalder & Pigneur (2009), customer relationships can be changed for a certain segment if it is deemed advantageous. It could be argued that it is beneficial for the IIoT provider and customer to work closely together, moving towards more personal relationships, such as partnerships. This is supported by Songa Offshore who believes that cooperation with an external firm should be based on a trust relationship. It seems that an IIoT provider that has few deep customer relationships will treat the customer data with greater care, since the relationship is built on trust and the customer is possibly more important to the provider than in a shallow transactional relationship. Hence, this may create a situation that is favorable for both parties. If the provider is more careful with the data and the customer, the customer will gain more trust in the provider and thus increase their willingness to share data with the provider.

6.4.10 Integration of technology

A majority of the companies, including Songa Offshore, IFS, Volvo Cars as a user, ABB and Hecla Mining mention the challenge of technology integration. According to IFS approximately half of the direct costs associated with current IIoT projects are related to technology integration. Thus, efforts need to be directed to decreasing this cost category. There are two major challenges related to the integration of technology; the integration of old equipment in need of retrofitting, and the creation of a single end-to-end IIoT solution, rather than operating several disparate systems.

ABB, Hecla Mining and Volvo Cars all mention the issue of integrating old technology. Hecla Mining argues that some of the existing equipment cannot be retrofitted into being IIoT compatible, posing a challenge as it is very expensive to buy new equipment. ABB mentions the challenge of integrating their older robots with an IIoT-box in order for them to be compatible. Likewise, Volvo Cars argues that the variation of age of the equipment in the Gothenburg factory results in that some equipment is possible to modify, while some needs to be replaced.

Regarding the challenge of creating a complete and single IIoT system architecture, both Songa Offshore and Volvo Cars argue its prevalence. It would be beneficial to integrate all potential data in a single system, but the lack of standards create complexities, as it is thus not possible to integrate the various providers' systems. Songa Offshore is further to some extent dependent upon these providers in order to access the data at all, increasing the severity of the challenge. Neither Songa Offshore nor Volvo Cars own the architecture for the end-to-end IIoT solution, however both would like to do so. Volvo Cars argues that their business model is not compatible with buying the various services offered by all of their equipment providers, as they desire a standardized approach for all of their equipment. They have approximately a total of 10.000 robots in their plants, and acquiring various service contracts would not allow them to manage their data in a standardized and centralized manner, which is needed in order for them to build further upon the IoT platform over time and ensure complete integration. The empirical evidence of this challenge is in line with the literature review. Boorsma (2016) argues that two of the challenges associated with digitalization are to ensure an architecture that is capable of connecting all different technologies used and to agree on standards. It is further mentioned that a risk associated with IIoT is the lack of interoperability between the current IT systems (World Economic Forum, 2015). To ensure a seamless integration of these, which is needed to fully utilize the benefits of IIoT, will incur high costs and complexity.

In the empirical findings, there appears to be an inherent challenge in determining which actor should be the owner of the IoT platform and solution. ABB would like to host the IIoT solution of their robots, earning revenues selling the service to their customers, and generating insights applying analytics across the installed base. Volvo Cars on the other hand, one of ABB's customers, also wants to own the architecture of the IIoT solution, ensuring a standardized and centralized approach for all of the equipment from various providers and across factories. Likewise, Songa Offshore also wishes to own an end-to-end IIoT solution. They would like to combine various data from the equipment providers with their self-collected data. However, the equipment providers, such as Kongsberg, also aim to sell this data as a service to Songa Offshore, rather than merely providing the raw data.

The equipment providers, such as ABB and Kongsberg, have the competitive advantage that they can generate insights by comparing customer data across the installed base, however this relies on the customers actually providing them access to the data in the first place. As mentioned earlier, a customer needs to weigh the tradeoff of the risks of providing access to their data, with the potential benefits it may give them. As explained in the literature review, which platform wins the competition may be determined by the level of co-creation, i.e. the capacity to innovate within the ecosystem (Magnusson & Nilsson, 2014). This in turn may be related to the point where the equipment provider attains a critical mass of customers. At this point, the number of users and providers will be self-reinforcing – a critical mass of providers generating content will attract a critical mass of users, and vice versa (Magnusson & Nilsson, 2014). A clarifying example of this may be a situation where an equipment provider has such a large installed base of users, that it can generate great insights by applying Machine Learning across it. In that case, a customer to this equipment provider would be at a competitive disadvantage if they were to choose not to gain access to these insights via the provider's IoT platform, and rather use their own. In that case, the equipment provider may have gained a critical amount of users. Hence it may be debated which party, the equipment provider or the customer, wins the battle of owning the IoT platform and ecosystem. It may be the case that both the IIoT providers and their customers are interested in utilizing the platform and architecture for innovating, and would thus benefit from owning it. It then remains a question when the customers are choosing to release the data and pay for a service, rather than hosting the system in-house. It may be the case that the equipment providers will not be the winners of this battle, until they can successfully coordinate across organizational boundaries, being able to provide their customers' with a centralized IIoT solution for all the equipment in their factories. It might further be noted, that third-party enterprise system vendors may play a large role here, in order to enable cooperation concerning solutions across organizations. Here, standards may be a significant enabler.

Weight

Persson rates the probability of the challenge of integrating technology to occur as overall high. More specifically, he does not regard the challenge of retrofitting old equipment as the most pressing issue, but rather the challenge of creating a complete and integrated solution. The initial phase of an IIoT process does not usually pose a problem, but rolling out a complete solution does. When doing so, the probability of technology integration being an issue is high. This requires the organization to have skills in working cross-functionally, which is often not the case. Various parties in the organization need to take part in the process, and play a role in the IIoT value chain. Regarding the impact, Persson rates it as high. In order for an IIoT solution to generate value for the firm, the technology integration part must be in place – otherwise it may have a large negative impact on the organization. When using various IIoT providers, it will constitute a problem if no one bears responsibility for the end-to-end solution. Larger organizations more often have their own solution, but smaller ones are often in need of using a variety of providers. In that situation, the integration of the architecture becomes a problem, and in the case of a problem occurring no party bears responsibility for ensuring its proper functioning. When an organization is not in charge of their solution, it will constitute a competitive disadvantage against the companies who are.

Mitigation

To ensure the greatest value of the IIoT solution and combine the sensor-driven computing, industrial analytics, and intelligent machine applications, firms should acquire a solid infrastructure and technical architecture, i.e. an IIoT platform that enables a combination of IT and OT (Daugherty et al., 2015). These platforms should advantageously enable APIs for data sharing, integration of third party applications, and even the control of channels for delivering services to customers. Organizations need to ensure that ownership of the solution and architecture is assigned, either to themselves or to another party. This requires organizations to map out and control the solution and the associated partners they need to cooperate with.

Further, as mentioned in the literature review, an organization aiming to win a platform battle could carry out various strategic initiatives, with the purpose of tipping the outcome to their favor, such as building their brand and ensuring control over the installed base (Magnusson & Nilsson, 2014).

6.5 Summary of analysis

In the following section, a summary of the analysis is provided as two tables.

Table 5. A summary of the costs, risks and challenges identified in the empirical findings, with associated probability, impact, and weight as well as possible mitigation strategies.

Perspective	Category	Cases	Exmples	Probability	Impact	Weight	Mitigation
IIoT Providers	Lack of trust in provider	ABB, Ericsson, Volvo Cars as a provider and as a user	Unwillingness to share data, wanting to create a own solution rather than use the providers'	1	3	**3**	Demonstrate benefits' superiority to risks. Work closer with customers and move towards partnerships.
	Changing the business model	Volvo Cars as a provider, ABB	Forming contracts and determining liability, conservative industry	3	3	**9**	Prototype and co-design service offerings to certain customer segments. Focus on and consider the ecosystem and its actors.
IIoT Customers	Costs related to remote locations	Songa Offshore, Accenture, Hecla Mining, ABB, Ericsson, Volvo Cars as a provider	Expensive, absence of communication methods, corrosion of communications infrastructure, high-risk environments raising complexity of technical solutions	3*	3	**9** (only relevant for firms operating in remote locations)	Aggregate data and send in a lower frequency. Prioritize what data to send. Utilize 5G.
	Organizational challenges - Resistance because of layoffs	Songa Offshore, IFS, Hecla Mining, Ericsson	Predictive maintenance decreasing need for service engineers, digital transformation and automation removing traditional jobs, unions oppose it	1	2	**2**	Manage carefully. Lay down the matter properly in the organization. Focus on increasing efficiency and revenues rather than cutting costs. Adapt the workforce to new work tasks.
	Organizational challenges - Resistance in business unit due to insufficient business case	Songa Offshore, Cybercom Group, IFS, Accenture, Hecla Mining	Few concrete cases as examples, understanding the value, the challenge of building a business case for an audience not understanding the technology, competition between projects concerning funding	3	3	**9**	Research and plan throughly regarding the possible value and insights that IIoT may generate. Find employees who are interested in IIoT and initiate small projects proving the benefits.
	Organizational challenges - Resistance because of lack of trust and knowledge regarding technology	Songa Offshore, IFS, Hecla Mining, Ericsson, Cybercom Group, Volvo Cars as a provider and as a user	Varying level of technical knowledge within the company and between customers, fear of Cloud technologies, fear of high-tech solutions as unreliable and susceptible to failure, a belief that IT systems are complex and generate problems, fear of technologies disrupting industries, lack of trust in technology deployed in high-risk environments, the sentiment of "I know my job", corporate culture	2	3	**6**	Map out which groups have a lack of knowledge and educate the organization. Commence the initiative with small projects carried out by individuals with an interest in IoT. Introduce manual steps in the process at first, rather than automating all at once. Keep the existing technical system alongside the IIoT solution until trust has been reached. Let the prospective users try the technology for themselves.

Continued table 5. A summary of the costs, risks and challenges identified in the empirical findings, with associated probability, impact, and weight as well as possible mitigation strategies.

Perspective	Category	Cases	Exmples	Probability	Impact	Weight	Mitigation
IIoT Customers	Organizational challenges - Transformation of the whole organization	Songa Offshore, Cybercom Group, IFS, Ericsson, Volvo Cars as a user	Organizational change is challenging and highly complex, digitalization is not an isolated event, many firms work with traditional silos – these need to be switched to working together, no unified or standardized IIoT solution but instead small and disconnected projects, resistance because of different interests between departments	3	3	**9**	Top management provides direction, support and funding. Cross-functional workshops and alignment of departments. A dedicated IoT group can be assigned to drive the transformation. Let the prospective users try the technology for themselves.
	Technical requirements and complexity	Songa Offshore, Accenture	Various IoT platforms to choose between, technology complex to implement	3	3	**9**	Acquire adequate technological competences. Choose a solid IoT platform by investigating level of co-creation and number of users and providers.
	Inadequate focus on generation of value	Cybercom Group, Songa Offshore, Accenture, ABB, Volco Cars as a provider and as a user	Unneccessary data collection, unneccessary technical solutions, not sufficient planning and researching in advance	3	2	**6**	Keep the business need in mind and only collect data generating value. Research and plan ahead.
	Cyber attacks	Songa Offshore, ABB, Volvo Cars as a provider and as a user	Cyber attacks; sabotage, affecting operations	1	3	**3**	Separate vulnerable networks from other networks. Allow for sending, but not receiving, data. Ensure the benefits of implementing IIoT outweigh the risks of cyber attacks.
	Lack of data privacy	ABB, Songa Offshore, Volvo Cars as a user, IFS	Sensitive data	2	2	**4**	Write clear contracts benefitting both provider and customer. Work closer with customers and move towards partnerships.
	Integration of technology	Songa Offshore, IFS, Hecla Mining, ABB, Volvo Cars as a user	Retrofitting old equipment, technology integration is costly, lack of standardization, not owning the architecture for the end-to-end solution, cooperation between departments and equipment providers needed	3	3	**9**	Acquire a solid infrastructure and technical architecture, and ensure that ownership of the solution is assigned. Proceed with tipping strategies, such as building brand and gaining control of the installed base.

7. Discussion

While conducting the research, several useful patterns have emerged, which may act as guidance to companies wishing to undertake a journey in IIoT. Several use cases for fueling innovation by IIoT have been presented, and these may serve as inspiration and set examples for firms wishing to implement IIoT. The potential benefits that firms can generate from IIoT have also been accounted for. By considering these benefits firms may decide on the level of value they believe IIoT can generate for them. In addition, the potential costs, risks and challenges have been compiled and weighted according to their potential impact and probability of occurring. Companies may further benefit from ensuring they use the mitigation strategies presented, in order to minimize the potential negative impact of these challenges and risks. A complete overview of these patterns and associated actions can be seen in table 5 and some of these will be discussed and linked to each other below.

7.1 Management of an IIoT implementation

In the following section, a guide for organizations wishing to undertake an IIoT implementation is presented. The guide is relevant for the internal, as well as the external, IIoT perspectives.

1. Research and plan thoroughly

Organizations undertaking any form of IIoT should focus on thoroughly planning and research the implementation in advance. By doing so, they are likely to avoid the risk of having an inadequate focus on generation of value, and can instead allocate their resources more efficiently.

2. Start small

Organizations should initiate the implementation by conducting projects of small scope, in order to generate trust and knowledge of IIoT whilst increasing the chance of proving a viable business case, as the benefits thus have been demonstrated. These projects should preferably be carried out together with those who are interested and excited in the project, rather than focusing on convincing those who initially oppose IIoT. The success of these small projects will then spread to other employees, hopefully increasing the acceptance of IIoT in the organization.

3. Align the organization

It is crucial that the top management drives and supports the IIoT initiative, while simultaneously uses the employees' input and energy. The employees are the ones who need to accept the implementation of IIoT eventually, and when actively engaging them in the process, the probability of them doing so greatly increases. This is especially important as an IIoT initiative constitutes a transformation of the whole organization. In order to successfully engage in the technology, the entire organization needs to be aligned and unified.

4. Acquire a suitable IoT platform

Disparate silos should not exist within the organization. The IoT platform used should further benefit and contribute to the unified approach. It should suit the needs of the firm and allow for standardization, centralization and integration of all technology throughout the firm. If using multiple IIoT solutions, the organization should ensure that they have a common infrastructure and proper linkage, and most importantly – that the ownership of the system is assigned, i.e. a responsible party ensuring that the entire system is functioning properly.

5. Focus on the end user

When implementing the IIoT technology, organizations should focus on the end user and the value it should generate for them.

6. Plan for possible cyber attacks

It is important to consider cyber attacks and the leakage of sensitive data. Regarding cyber attacks, it is not only important to focus on the prevention of them, but also consider corrective actions once an attack has occurred. This is because an organization will never be 100 percent secure, no matter how many preventive plans they have established. It is hence crucial to have an action plan in place as well, in case a cyber attack occurs.

7. Write contracts for data sharing

Concerning leakage of sensitive data, it is not possible to refrain from sharing access to the data, as this is needed to generate value from IIoT. However, the organization should be careful to always write considerate and thorough contracts to protect ownership and access of the data, and prevent any leakage of it.

7.2 Final commentary

After having studied several use cases and compiled an extensive list of benefits and challenges, the question whether other companies in fact should undertake an IIoT implementation or not, can be raised. Throughout the research it has become apparent that there are several large and potentially detrimental challenges and risks that organizations pursuing IIoT initiatives will face. This may hold especially true for those operating in old and conservative industries, where large shifts in the mindset of all stakeholders need to occur. However, it must be noted that IIoT does have a very large potential, and that it can be said to constitute a new wave of IT-driven competition. Thus, it is crucial to act on it as it will influence all industries and organizations sooner or later. When that occurs, those who have acted on it earlier will have a large competitive advantage compared to those who did not, as they will have earned much experience and knowledge concerning mitigation of the prevalent challenges and risks.

When an organization has made the decision to implement IIoT, another question might be raised whether they should focus on utilizing it internally, or on providing it to their customers externally. At large, it can be said that IIoT provision to customers largely focuses on finding new revenue streams and creating a differentiation advantage, i.e. increasing customer value, while internal use in general focuses on increasing efficiency and decreasing costs. For some organizations, the choice may be simple as only one of the perspectives might be feasible. This may for example be the case for an organization selling a certain physical product for which connectivity would not add customer value. One example is Hecla Mining, who is applying an efficiency-based business model. They would not benefit from increasing the product prices of their commodity metals by incorporating IIoT, but does benefit from increasing their operations efficiency with IIoT. However, the question concerning which perspective to direct the firm's efforts at, remains for those organizations who would be able to implement both. The answer to this question may be dependent on the characteristics of the industry that the organization is operating in. If a differentiation strategy is of importance to the industry, and if a connection of the products would add customer value, even though it might increase the price of the product, IIoT provisioning might be the superior approach. Further, it might be investigated whether the organization would benefit further from using the connected products as a step to move towards a servitization business model. In contrast, if a cost leadership strategy is of importance to the industry, and an organization would be at a competitive disadvantage should they not be as efficient as possible, then internal use of IIoT might be preferred. The same logic can be applied for the notions of value-based versus efficiency-based business models. Thus, it depends on the industries' characteristics and basis of competition, and there are various opportunities and challenges related to the qualities and prerequisites of the organization. However, if the organization would benefit both from applying IIoT internally, and providing it externally, the organization should pursue both paths. One organization demonstrating that such an approach is possible is Volvo Cars. There are in addition potential synergies of using the two perspectives simultaneously, such as the required technological knowledge, human resources and skills, IoT platform, technological infrastructure, and organizational alignment and transformation it requires. Organizations aiming to implement both perspectives can thus benefit from a simultaneous effort, should they make sure to transfer knowledge and align the initiatives.

8. Conclusions

In the following chapter, the conclusions of the study are presented.

The research aimed to discover and explain the associated benefits as well as costs, risks, and challenges associated with either utilizing IIoT in direct operations or providing IIoT products and services to customers. The benefits and the costs, risks, and challenges were analyzed by comparisons across the cases and expert interviews, and in reference to the literature review. Firms providing IIoT generally obtain benefits related to increasing revenues and customer value, while firms using IIoT in their operations rather tend to focus on increasing efficiency and decreasing costs. Moreover, the firms providing IIoT tend to encounter challenges related to changing the business model and data sharing, while the firms using IIoT in their operations are more likely to be impeded by organizational challenges and technical complexity.

In addition, the research aimed to propose strategies which may be used to overcome the challenges associated with IIoT. It can be concluded that one should consider the importance of planning and researching thoroughly prior to initiating an IIoT project, initiating small projects with employees who are evidently interested in the technology, gaining support for the project from the top management, engaging employees, integrating all technology to reach standardization and centralization, assigning responsibility and ownership of the architecture, and considering cyber attacks and data sharing.

Moreover, it is important to acknowledge that IIoT constitutes a competitive advantage and will become a necessity in the future. Hence, the firms initiating IIoT projects early will have an advantage in mitigating the prevalent risks and handling the projects with success. Further, the firm aiming to implement IIoT needs to contemplate whether to use it internally, or provide it to customers externally. The choice depends on the nature of the firm, and the industry in which the firm operates. However, implementing IIoT both internally and externally simultaneously may generate synergies for the firm.

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Appendix

In the following appendix, the semi-structured interview guide used as a basis for all of the interviews is presented. In accordance with the characteristics of semi-structured interviews, the guide was allowed to change and evolve during the course of the interviews. This was dependent upon the answers of the interviewee.

Interview guide

General questions regarding the company

- What is your role at [company]?
- Can you tell us about [company]?
    - What is the business model?
    - Can you describe what you do for your customers?
    - How do you work with IIoT?
    - Do you buy the equipment or do you make it yourselves?

Questions regarding the IIoT project

- How does the technology and analysis work in the IIoT project?
    - Do you have sensors on all equipment?
    - Are the sensors already integrated in the equipment by the manufacturers or do you do it yourselves?
    - What do you measure with the sensors?
- Do you believe the IIoT project has been successful?
- What are the main reasons you are deploying this technology?
- What are the costs, risks and challenges associated with it?
- How do you use the cloud in your operations and in the IIoT project?
- Who owns the data generated?
    - Do other parties get access to it?
    - Do you write contracts for data sharing or how do you manage it?
- How do you decide on what data to gather and what to do with it?
- In what way was the IIoT initiative implemented?
    - Who initiated it?
    - Did you start small or did you implement the entire initiative at one?
    - Was the project implemented top-down or bottom-up?
- Do you think the technology is reliable? Do you trust it fully?