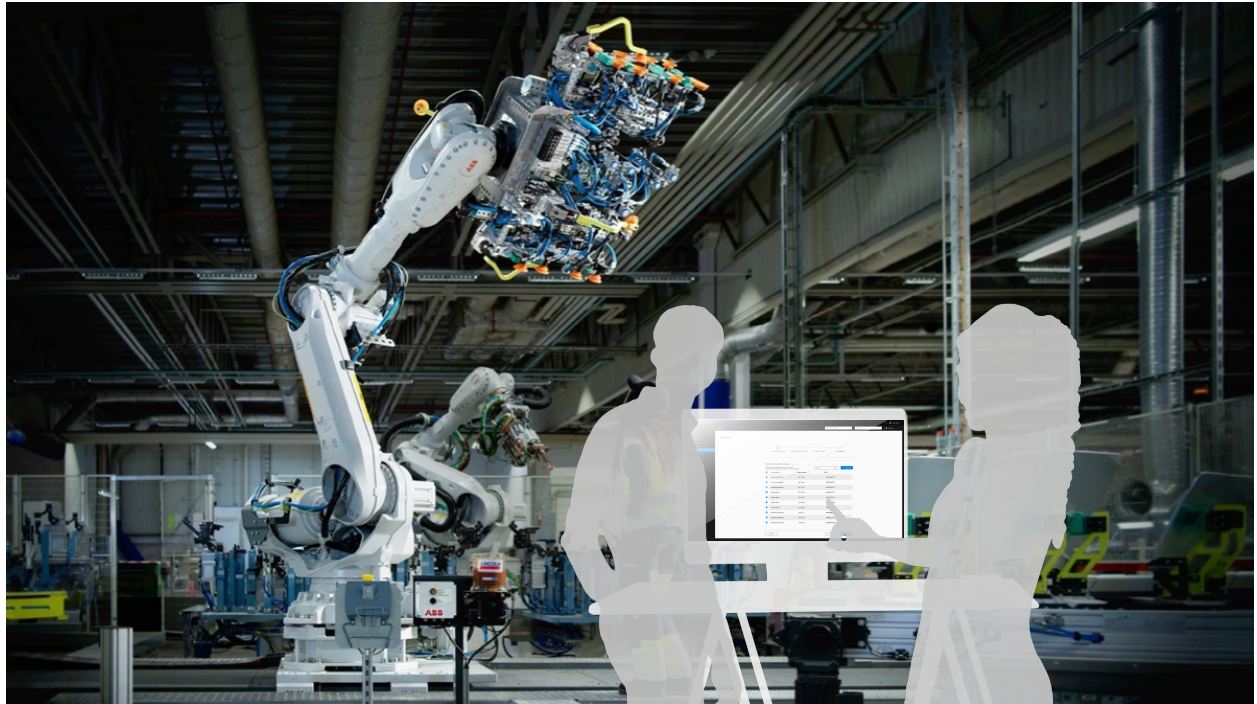




CHALMERS
UNIVERSITY OF TECHNOLOGY



The user experience of a private cellular connectivity solution

Connecting assets to a private cellular connectivity solution for the manufacturing industry

Master's thesis in Industrial Design Engineering

LINNEA OLSSON AND STINA WENGER

MASTER'S THESIS 2020

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Department of Industrial and Materials Science
Division of Design and Human Factors
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020

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STINA WENGER

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Supervisor and Examiner: Dr Pontus Wallgren, Industrial and Materials Science

Master's Thesis 2020
Department of Industrial and Materials Science
Division of Design and Human Factors
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

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LINNEA OLSSON AND STINA WENGER

Department of Industrial and Materials Science
Chalmers University of Technology

Abstract

The manufacturing industry is in a state of change, with the possibility of completely automated and connected factories around the corner. As companies start to move in this direction, new connectivity solutions are evolving. This thesis looked at a private cellular connectivity solution and resulted in a concept for how to add and connect assets to this cellular network.

Assets that are registered and connected to the network are most likely also registered in a separate asset management system. The qualitative study in this project was conducted to understand how asset management is used in industrial environments to provide an understanding for the persons involved and their needs. Problem areas, journey maps and personas were developed to define the data accumulated in the study. The knowledge gained from this study was used to develop the user flow of adding assets to the cellular connectivity solution. The final concept is presented as an entire flow from asset acquisition to asset decommission. Within this flow, an interactive prototype was designed to visualise the flow of adding assets to the cellular connectivity solution, with focus on the user experience of adding multiple assets at once.

Lastly, suggestions for improvements were stated for future development of this design. It was found that it is important to be abundantly clear when it comes to layers of virtuality and reality - meaning that users should always feel certain that they are performing an action virtually in the system, or physically in reality.

Keywords: Concept Development, User Experience, Cellular Connectivity, Asset Management, Industry 4.0.

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We only wish we could have worked closer to you all during this spring.

The image shows two handwritten signatures in black ink. The signature on the left is 'Linnea' and the signature on the right is 'Stina Wenger'.

Linnea Olsson and Stina Wenger, Gothenburg, May 2020

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Abbreviations

AMS - Asset Management System

An asset management system is commonly a software where companies can document assets within certain functions in the organisation. The functions are for example, maintenance, calibration and storage.

APN - Access Point Name

An APN is a gateway between a mobile network and the public Internet. When a mobile device tries to connect to a network the carrier examines the APN to determine what type of connection should be made. Which APN is used determines, among other things, which security measures should be used and what IP addresses the mobile device should use.

ERP - Enterprise Resource Planning

Enterprise resource planning is the integrated management of main business processes, but ERP often refers to a business management software where different parts of the organisation are integrated in order to track, analyse and manage data from all business areas and activities.

ICCID - Integrated Circuit Card Identifier

The ICCID is a unique identifier for the SIM card, or, more accurately, the actual SIM chip itself. The ICCID is stored in the SIM card and is commonly engraved on the SIM card body.

IMEI - International Mobile Equipment Identity

The IMEI is a unique identifier for a mobile device. Cellular networks use the IMEI to identify valid devices in a database, and IMEI numbers can also be blocked from a network in the same way. Usually it is only devices with a SIM card slot that have IMEI numbers.

IMSI - International Mobile Subscriber Identity

The IMSI identifies the user or subscriber of a cellular network, including the country and mobile network of the subscriber. The IMSI is stored on the SIM card and can be seen as the logical representation of a SIM card, as it is the IMSI information of a SIM card that determines if a device with a particular SIM card can connect to the network.

IoT - Internet of Things

The vision where physical objects are connected to a network and can transfer information to and from each other via the Internet.

IIoT - Industrial Internet of Things

Where industrial assets, such as machines, engines and sensors are connected to a network.

LTE - Long-Term Evolution

It is a standard for 4G wireless broadband communication for mobile devices.

NMP - Network Management Portal

This is the user interface of Industry Connect, where the users can manage the private cellular network.

1

Introduction

1.1 Background

In recent years, terms such as Industry 4.0 and Smart Factories have become increasingly prevalent in the industrial development context. However, Industry 4.0 began as a research project in Germany in 2011, as a part of the government's high-tech strategy (Bundesministerium für Bildung und Forschung, n.d.; Jasperseite, 2012a).

Industry 4.0 refers to the fourth industrial revolution where automation and digitisation will take a step into factories and manufacturing floors (Jasperseite, 2012b). This philosophy contains Industrial Internet of Things solutions (IIoT), enabling factories to monitor performance and other measuring parameters of their assets such as vehicles, machines, tools and equipment, in order to send this data and process it in cloud solutions. The possibilities that appear when introducing these solutions in the manufacturing industry are production optimisation and more efficient use of equipment (Jasperseite, 2012b).

1.1.1 Future of the Industry

Ericsson is gearing up to help customers face the new challenges of a digital and automated future. They have a number of solutions aimed at different aspects of the future of business, from 5G to cloud infrastructures and voice services (Ericsson, 2020). Another new solution of Ericsson's is called Industry Connect and it is a private cellular network for industrial environments such as factories and warehouses. According to Ericsson Industry Connect data sheet (Ericsson, 2019) it "*enables high device density, predictable latency and reliable coverage throughout the factory or warehouse*". Devices can be connected to the network using SIM cards that the client, the factory, writes themselves. Using Ericsson Industry Connect, various physical assets in factories can be connected to the private cellular network. Ericsson claims this "*enables smarter factories with smarter connectivity*". Assets connected to Industry Connect's private cellular network can be managed through a Management Portal that Ericsson provides (Ericsson, 2019).

1.1.2 Managing Assets

According to Bokföringsnämnden (2013/2017), all companies in Sweden should keep an asset register, which lists the companies immaterial and physical assets (“BF-NAR 2013:2”, section 4.2). In many cases this is done using an asset management system, especially in cases where the company is medium sized or larger. An asset management system allows users to register and keep track of equipment and inventory. Some asset management systems can be integrated with other softwares such as ERPs, Enterprise Resource Planning systems, which cover business critical areas such as finance, planning, human resources and so on.

As Ericsson Industry Connect visualises its future, some questions arise. One assumption is that upon acquisition, assets are registered in the clients internal asset management system and a subset of these assets will later also be connected to Ericsson Industry Connect. This leads to the question; how can Industry Connect facilitate users to connect assets in an efficient and convenient manner? The way companies use their asset management systems is important to know in order to decide how to best adapt Industry Connect in the future, in order for Industry Connect to fit into current standardised processes. Furthermore it is critical to find out what key stakeholders are involved in the context and to empathize with them, in order to create a valuable design for these people.

1.2 Aim and Objectives

This thesis investigates how asset management of physical assets is carried out at different factories and to conduct a user study about the process and the users involved. The study will map the user flow of asset management including the needs and requirements of the people in the target group. Following the results of the user study, the project will assess how the service of Ericsson Industry Connect can be adapted to cooperate with asset management systems. The aim of the thesis is to increase the user experience of connecting assets to Ericsson Industry Connect and the objective of the thesis is to develop a concept for a way to register assets in Industry Connect.

Two main research questions were set to guide the thesis work throughout its completion. The answer to these questions will correspond to the main outputs of the project: key findings from the qualitative study and the concept based on these findings.

Research question 1

How is Physical Asset Management of equipment such as tools, machines, vehicles etc. done at relevant factories and what user needs and requirements exist in the process?

Research question 2

How can Ericsson Industry Connect be adapted to increase the user experience of

connecting assets to the network when considering companies' asset management systems, and what could such a flow look like?

1.3 Scope and Demarcations

The scope of the thesis includes investigating the practice of asset management and the user needs involved in the process. The asset management process is considered to start when the need for a new asset is discovered and the process ends when said asset is decommissioned and no longer in use. This process was investigated as a starting point, before narrowing the focus to understanding the part of the process where wirelessly connected devices are handled.

The scope of the thesis also includes suggestions of how Ericsson Industry Connect can cooperate and coexist with the asset management process identified in the research study. An important note is that the project was not conducted in order to optimise the user flow of asset management in general. Instead the scope was to understand and map out the general asset management flow of today, in order to optimise the user flow of connecting assets to Industry Connect.

The main focus for the concept development relates to how assets could be connected to Ericsson Industry Connect in a way that creates an improved user experience compared to the current use of Industry Connect. The solution should therefore align with the rest of Industry Connect, both regarding current interaction patterns and the look and feel. Thus the wireframes of the final result were based on the Ericsson Design System (EDS) and they followed the praxis already set in the Industry Connect Network Management Portal.

Assets of Interest

The study is limited to physical asset management, meaning that other types of assets such as financial or immaterial assets are inconsequential. It should also be noted that only physical assets that serve a purpose in the manufacturing of goods or are of use in a warehouse facility are part of the scope. Examples of such assets could include tools, machines, instruments and AGVs. Given that Ericsson Industry Connect allows assets to be connected to a mobile network, it was of great interest to learn how wireless assets are dealt with today.

Target Group

The target group consists of persons who manage the asset management systems and who have an active part in the deployment of new assets. These persons include production engineers and maintenance technicians. Additional key persons are IT personnel who manage assets connected to a network and who are in charge of network stability and security. Other persons of interest have an overall responsibility of asset management strategies and objectives at the company.

Company Segment

The relevant company segment for the thesis includes companies and factories in the manufacturing industry as well as warehouse facilities. Also relevant in the segment are companies that operate in a business to business fashion, in the sense that they are hired by other companies to manage maintenance at the plant. Especially relevant are companies which already implement wireless assets in their manufacturing processes, even if such companies are rare as of yet.

2

Asset Management and Connectivity

This chapter presents theory about assets and asset management in industrial environments. Theory regarding the future of the industry is also presented along with a description about the private cellular connectivity solution Ericsson Industry Connect.

2.1 Asset Definitions

All companies deal with a multitude of assets in their operation. The “ISO 55000:2014” standard defines an asset as *“an item, thing or entity that has potential or actual value to an organisation”* (“ISO 55000:2014”, clause 2.3). The standard further explains that assets can be financial or non-financial and tangible or non-tangible. Hastings (2015) specifies further five types of assets that are usually found in organisations; Physical, Financial, Information, Human and Intangible Assets. A few examples of what Physical Assets can be includes buildings, aircraft and railways as well as machinery, vehicles, wires and communications equipment.

Hastings also points out the fact that asset management is closely linked to the financial aspects of an organisation. In the world of accounting there are different definitions of types of assets, due to the way they are treated when it comes to taxation. In accounting, assets are spilt into fixed assets and current assets. The difference between them is the time frame over which they generate value for the company (Hastings, 2015).

Fixed assets, also known as non-current assets, are physical items that are used and provide value for longer than one year (Hastings, 2015). Fixed assets are items that an organisation uses in actually carrying out their business. When buying a fixed asset, the cost can not be registered as an expense for the year it was purchased. For tax reasons, fixed assets are payed off during the span of their lifetime in the organisation. Examples of fixed assets are vehicles, machines, property and other items that are kept in the organisation for over a year. Current assets, however, are normally used up by the organisation within a year. They are faster moving assets,

such as cash, raw materials, spare parts, and products that are still being made.

2.1.1 Asset Life

The “ISO 55000:2014” defines asset life as the time period from when an asset is created or manufactured until it is defunct. That means that an asset’s life is not necessarily the same as the time frame where it is of value to a company. Indeed, the standard proclaims that an asset may provide value for several companies over its asset life, and that the value of an asset may vary depending on what company it resides with and what context this company operates in. Hastings (2015), however, describes the asset life cycle from a more business centered point of view, where the six steps are shown in figure 2.1. This life cycle begins with a business need or opportunity being identified at the organisation. The following pre-acquisition analysis includes selecting the appropriate asset, looking at physical specifications as well as financial. The asset is then acquired and set up in the operations. Logistic support includes making sure there are maintenance facilities, spare parts and such available for the asset. The asset then remains in operation where it receives regular maintenance until it is disposed of.

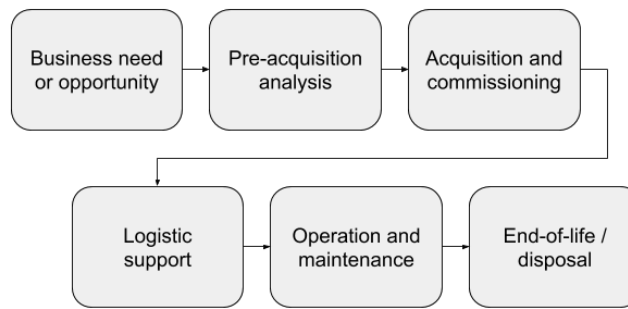


Figure 2.1: An asset life cycle according to Hastings (2015).

2.2 Asset Management

Asset management is the practice of realising the value of an organisation’s assets (“ISO 55000:2014”, 2014). It involves weighing the risks, costs and opportunities against the performance wanted from the asset. It is a balancing act where the focus is not on the asset itself but on the value it provides to the business. Hastings (2015) provides a more structured definition of asset management. He argues that asset management is comprised of the following activities to effectively reach the desired organisational objectives: identifying the needed or required assets as well as their funding requirement, actually acquiring said assets, arranging maintenance and support for them, and finally disposing the assets.

The “ISO 55000:2014” standard explains a few key points that asset management is based on. The first is *value*, as mentioned above, and the fact that an asset is ac-

quired to provide additional value to the organisation. Further, asset management is a tool for organisational *alignment*. Through asset management one can make technical and financial plans and decisions from high level organisational goals. In order to realise the value of an asset it is important that *leadership* and the workplace culture allows employees to operate and improve asset management in the organisation. The list ends with *assurance*, as the standard claims that asset management will provide the organisation with assurance that an asset is used to its full potential.

In order to ensure that assets provide the maximum possible value for an organisation, there needs to be a structured way to go about things. An asset management system helps with this, as it is used to coordinate and control the asset management in the organisation (“ISO 55000:2014”, 2014).

2.2.1 Benefits of Asset Management

According to Bokföringsnämnden (2013/2017) all companies in Sweden should keep an asset register, which lists the companies immaterial and material assets (“BFNAR 2013:2”, section 4.2). Some companies that only have a small number of assets do not need to keep a register if the regular book keeping is done in a way that allows an overview of the assets. Otherwise, all companies should construct an asset register, where certain information should be found for each asset. This information includes a way to identify the asset, the date and value when it was acquired and the time span of its useful life, amongst other things.

Beyond the pure legal reason, there are some additional benefits to using asset management according to “ISO 55000:2014” (2014). In of itself, the purpose for asset management is to realise the maximum value of all assets. These benefits include more informed investments and managed risks, which in turn can provide better return on investments (Hastings, 2015; “ISO 55000:2014”, 2014). If assets are managed correctly it can also improve both the efficiency and effectiveness and it allows the organisation to be responsible regarding its resources.

2.3 Industry 4.0

Industry 4.0 is indeed a buzz word in this day and age, but it has in fact been around for a while. In 2011 the German government set up a long term high-tech strategy, which Industry 4.0 was a part of (Bundesministerium für Bildung und Forschung, n.d.; Jasperseite, 2012a). With Industry 4.0 comes the fourth industrial revolution, where automation and digitisation steps into manufacturing processes (Jasperseite, 2012a). The researchers explained that the first industrial revolution introduced mechanical machines in production at the turn of the 19th century, while the second industrial revolution brought the mass production techniques and electricity at the turn of the 20th century (Bundesministerium für Bildung und Forschung, n.d.). The third industrial revolution has been ongoing since the 1970s and has been marked by further automation by use of IT and electronics.

With Industry 4.0 comes many other buzz words, such as Smart Factory, Smart Manufacturing, Machine Learning and the Internet of Things. The concept of the Smart Factory is based on intelligent automation, where the systems can automate processes based on the data received from sensors and connected machinery throughout the factory (Mathew, 2019).

2.3.1 Internet of Things - IoT

The Internet of Things is defined by Merriam-Webster (n.d.) as *"the networking capability that allows information to be sent to and received from objects and devices (such as fixtures and kitchen appliances) using the Internet"*. It is a vision where physical objects are connected to the virtual world, using sensors and actuators to interact (IEEE, 2020; Mattern & Floerkemeier, 2010). When IoT devices are connected via a cellular network, it is known as cellular IoT.

IoT has been applied in all manner of areas, from personal and commercial use to industrial settings (Boyes et al., 2018). When used in an industrial environment, it is referred to as IIoT - Industrial Internet of Things. Helmiö (2017) explains IIoT as follows:

"Industrial Internet or Industrial Internet of Things (IIoT) is built for bigger 'things' than smartphones and wireless devices. It aims at connecting industrial assets, like engines, power grids and sensor to cloud over a network."

The area of IIoT is of great interest for Industry 4.0 and the Smart Factory, where the aim is to have a factory full of objects sending and receiving data to automate the processes.

2.4 Industry Connect

Ericsson Industry Connect is a solution meant to face Industry 4.0 and its demands for connectivity and security. Industry Connect is a private cellular network solution for industrial environments, such as factories and warehouses, see Figure 2.2.

The Industry Connect network uses LTE technology and will be upgradable to 5G, which means it is both secure and reliable. Normally, wireless solutions would have dead spots or hand-offs where a device would switch connection from one access point to another. Instead, Industry Connect provides coverage throughout a factory and a higher device density than a Wi-Fi-network. For instance, LTE technology is used in cell phones all over the globe.

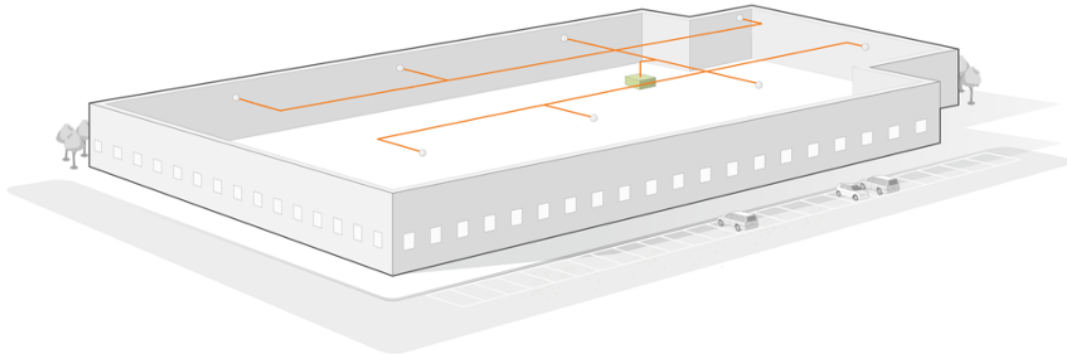


Figure 2.2: An overview of Industry Connect in an industrial environment (Ericsson, 2020).

Figure 2.3 shows a simplified visualisation of how the network of Industry Connect is related to a company's asset management system and the assets in the manufacturing environment.

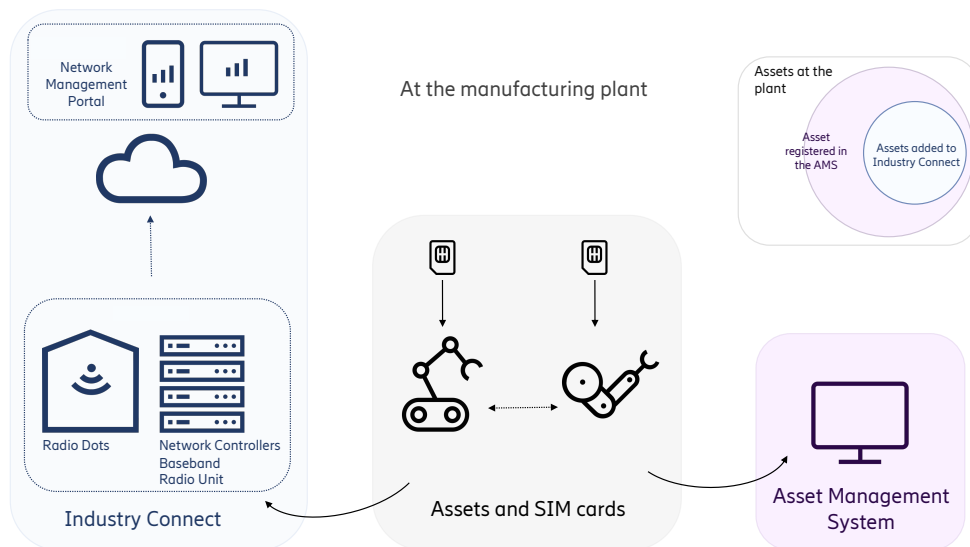


Figure 2.3: A simplified system visualisation of Industry Connect in relation to AMS and the physical environment.

In general, Industry Connect can briefly be visualised in the left blue area. It consists of Network Controllers, a Radio Baseband and an Indoor Radio Unit which together are placed in a rack on premises. The Network Controllers enables a connection between the Radio System and the customer's fixed site network. This enables the traffic to be routed between LTE devices and the site network. Antennas, also called Radio Dots can be placed in the ceiling or on poles, in order to cover the entire

production or warehouse area. Devices that are connected to Industry Connect communicate with the Radio Dots which in turn communicate with the hardware in the rack. This sets up secure connection to the cloud-based management and thereby provide self-management capabilities to the customer, or end user. The user interface where the customer can manage the network, devices, sites, users and more, of Industry Connect, is called Network Management Portal (NMP).

Physical assets, such as machines, robots, tools, vehicles and other equipment exist in the physical environment of the production plant as well as the digital environment in the company's internal asset management, as visualised in the middle grey area and the right purple area. Not all of these assets are relevant for Industry Connect because there might not be a need for all assets to be monitored and thereby there is no need to connect these assets to a network. The Venn diagram in figure 2.3 shows that a subset of the assets in the asset management system will be added to Industry Connect. These assets can be connected to this private network using SIM cards. More practically, assets that are to be connected to Industry Connect are equipped with modems in which the SIM cards are inserted. The modems allow the assets to be connected to the network. For simplicity in this report, this procedure will be referred to as inserting a SIM card into an asset.

Assets are not recognised as separate entities in the NMP currently. The digital SIM card is given a name of the physical asset it will be inserted to and this is displayed as a Device in the Network Management Portal. This means that a company's physical assets have virtual representations in an AMS as well as in Industry Connect's NMP. The physical SIM cards also have a virtual representation in the NMP.

When a company's assets are connected to Industry Connect, data can be transferred between assets and the network and could be used together with other IIoT solutions. For example, as illustrated in the grey area in figure 2.3, two mobile assets can be connected to Industry Connect which could be used for collision avoidance.

3

Design Methods

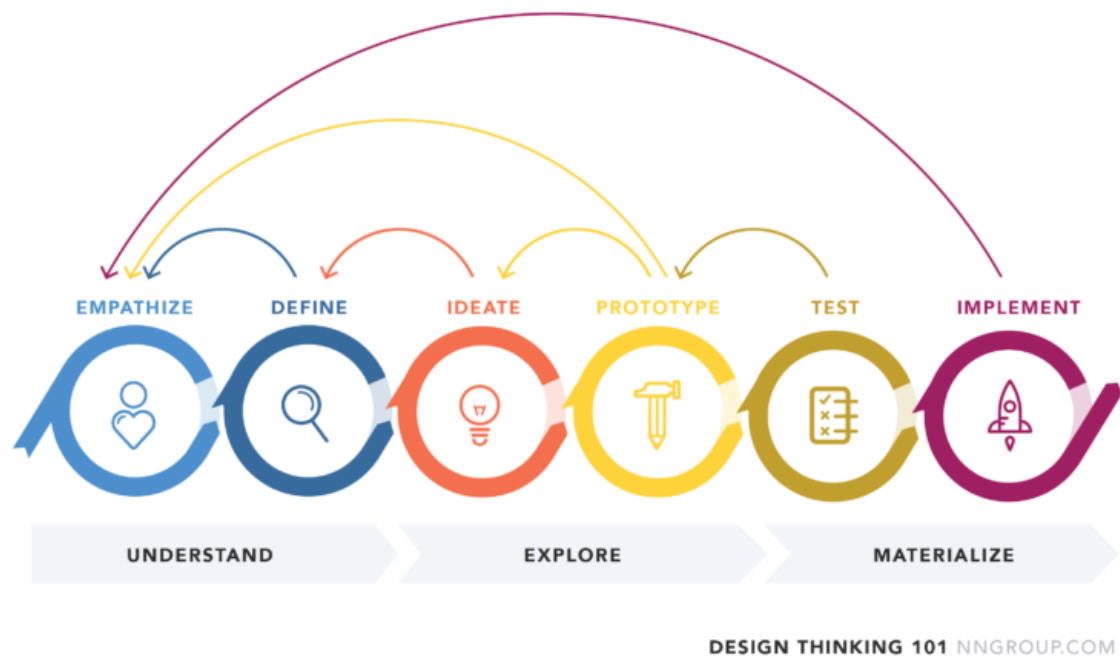


Figure 3.1: The Design Thinking process according to Gibbons (2016).

3.1 Design Thinking

Design thinking is the overall framework for the design process in this project. Figure 3.1 visualises the Design Thinking process as having three overall flows; *understand*, *explore* and *materialize* (Gibbons, 2016). These flows contain the six phases *empathize*, *define*, *ideate*, *prototype*, *test* and *implement*. Design Thinking is an iterative process, which means that designers should continuously return to previous phases throughout the process. It is described as a hands-on, user-centred approach to problem solving. It enables designers to reach innovation in products and services which are differentiated on the market and maintain a competitive advantage. By using design thinking in the design process, the project can focus on involving users

throughout the study and enable designers to develop an understanding of the users in the context while also empathizing with them.

This project involves several stakeholders, different software systems that people interact with as well as a rather extensive context. To enable designers to fully grasp the whole system, i.e. all relevant stakeholders and their needs, while also consider different touch points, engineering constraints and other limitations, Systems Thinking should be balanced with Design Thinking as the overall framework (La, 2019).

3.2 Qualitative Research

3.2.1 Interviews

An interview in the design process is a meeting between people with the purpose of learning about a person's experiences, opinions, attitudes, motivations and behaviour when using a certain product or service (Wikberg Nilsson et al., 2015). By conducting interviews, the researcher can get a better understanding of the context and the people involved (Pernice, 2018). In a more general point of view one can divide qualitative interviewing into different types, depending on resources and the objective of the interview (Knox and Burkard, 2009).

The first type is *unstructured interviews*, which resembles a friendly conversation rather than an interview with a narrow focus. The interviewer asks open ended questions to the interviewee to gather broad data about the context. This method is suitable in the beginning of the research before the focus of the project scope is refined. The second interview type, *semi-structured interviews*, also consists of open-ended questions but are more aligned with focus of the study than unstructured interviews (Knox and Burkard, 2009). Semi-structured interviews enable comparison between interviews while also leaving space for probing.

The interviews can be held in the context of use, on a neutral ground or at the client's ground. (Sanders and Stappers, 2018, pp.170-171). In this project, the client's ground is Ericsson's office. Holding an interview in the context of use can generate additional information to the study, by including more people or conduct observations. However, it is usually more time consuming and is more costly for the project. Researchers can also conduct interviews remotely, by phone call or a video communication tool which enable researchers to interview people independently of their geographical location (Knox and Burkard, 2009).

3.2.2 Generative toolkit

Using different combinations of research methods can enable the researcher to access different levels of knowledge about the context in focus and the people in it (Sanders and Stappers, 2018, pp.66-73). In order to access latent and tacit knowledge, the researcher should aim for triangulation in the study by using tools to explore what

people *say*, what people *do*, and what people *make*. Examples of methods in the *say* and *do* categories are traditional interviews (*say*) and observations (*do*) where the researcher observes people executing something. The *make* category includes methods where participants get to create something with their hands. One technique to get participants to *make* something is to create a toolkit including paper, pens, scissors and sticky notes, things that enables the participant to create something (Sanders and Stappers, 2018, pp.66-73). This is a generative technique that can be combined with other *say* and *do* methods, by for example having the participant create or visualise something that they are talking about in an interview.

3.3 Context Analysis and Visualisation

3.3.1 Affinity Diagram

Affinity Diagramming is a tool to organise and analyse qualitative data from the research study, often also referred to as the KJ Method (Naylor, 2019). The data is analysed, interpreted and categorised in iterations in order for the design researchers to identify patterns, themes and problem areas in the qualitative data. It is common to use sticky notes, on which quotes and interpretations from the qualitative study are written. The sticky notes can then be re-arranged and categorised on a blank wall in order to get a holistic view of the data and the affinities that exist. An Affinity Diagram can also be constructed virtually by using a digital tool. With a digital tool, the accessibility of the diagram increases because it is not dependent on a certain physical place. The board of sticky notes is visualised in the digital platform instead.

The purpose of this method is to process the unstructured qualitative data in order to generate defined categories, patterns and problems as an output. Further on in the design process, the design researchers can use this output to solve the problems by developing design solutions.

3.3.2 Journey Mapping

Journey mapping can be defined as a visualisation of the process a person or persons go through in order to accomplish a certain goal (Gibbons, 2018a). Another definition is that a journey map is a visualisation of people's experiences when interacting with products and services, in order for each moment in the process to be evaluated and improved (Martin & Hanington, 2012). According to Martin and Hanington (2012), a user journey map should be created in conjunction with personas and scenario documentation.

Gibbons (2018a) claims that the following elements should be included in a journey map: Actor, Scenario, Expectations, Journey Phases, Actions, Mindsets, Emotions and Opportunities. The journey map, also called user journey map, describes the journey of an *actor* which could be a persona or a relevant person on the context of the scope. This person acts in a *scenario*, which the journey map addresses, and

this scenario can be a real scenario of the context or a scenario describing the future use of a product or service. The journey map can be divided in *journey phases* which groups certain steps in the journey together to get a better overview of the process. Behaviour and *actions* made by the actor are visualised in specific steps in the process. *Mindsets* and *Emotions* should be displayed in the different steps which are connected to the steps made by the user in the phases. As a summary or conclusion from the journey map, *opportunities* should be defined which help the researcher or designer to move forward in the design process. The opportunities can be interpreted as suggestions for a future solution or a current problem.

3.3.3 Personas

Personas are fictional archetypes of people in the target group of a product or service and they are described as a *typical* person in the target group, not an actual living human being (Harley, 2015). Harley argues that the description of a persona should include the persona's needs, goals, concerns, background information such as age, gender, behaviours and occupation. These aspects along with quotes and a photo of the persona should be visualised in an image describing the persona. The purpose with this method is to gain empathy towards the people one is designing for and to remove the focus from the mindset of "designing for everyone".

By designing for everyone, the solutions run the risk of being unfocused and incoherent (Martin & Hanington, 2012). The use of personas enables people in the organisation to understand who they are developing their product or service for, provided that the personas are based on qualitative research. Data from quantitative methods, such as surveys, can lead to dehumanised personas which reflect demographics of the user segment rather than needs and behaviours.

3.4 Ideation

3.4.1 Braindumping

Braindumping is an individual ideation method with the purpose of releasing mental blockages caused by unexplored ideas that only yet exists in one's mind (Friis Dam & Teo, 2020). This method enables freethinking and lets ideas from "quiet people" come forward. A braindumping session should be based on the insights and problem statements from the research study, which should be clarified in the beginning of the session. During the braindumping, each individual writes or draws as many ideas as possible on pieces of paper in silence during 3-10 minutes. Afterwards, the participants collectively discuss the ideas in order to group ideas together and to select the best ideas.

3.4.2 Brainstorming

Brainstorming is an ideation method with the purpose of generating new ideas without any criticism from other people (Friis Dam & Teo, 2020). The idea with this

method is arrange a session with participants where everybody ideate new ideas and build on other participants' ideas. Many ideas can be created and combined with each other in order to become new ideas. With this method, designers aim to reach new, wild ideas by creating a safe space in the session where people feel comfortable sharing and discussing all ideas without any limitations or judgements from others.

3.4.3 Brainwriting

Brainwriting is an ideation method similar to Brainstorming (Friis Dam & Teo, 2020). The fact that there are multiple participants ideating new ideas in a session without criticising each other, is what these two methods have in common. What differentiates Brainwriting from Brainstorming is that the participants individually write down their ideas on a piece of paper and after a certain amount of time, each participant passes along their ideas to the next person. By using this technique, the participants are able to build and develop new ideas without being criticised for them.

3.4.4 Crazy 8's

This ideation method is meant to encourage people to come up with crazy ideas under a limited amount of time (Murphy, 2019). In a Crazy 8's session, the participants fold a paper sheet in eight parts and get a total of eight minutes to sketch eight ideas on the eight parts of the paper. The participants are encouraged to come up with as crazy ideas as possible and to aim at sketching eight ideas in total, which can be challenging. The output from this method are ideas that are "outside of the box".

3.4.5 Random Links

By using this method, the members of the design team get the chance to think more broadly about a problem and to stretch one's imagination to reach new possibilities in the solution space (Mortensen, 2020). Firstly, a random item is picked on which the participants will force connections to. Everything that one can associate to this item should be written down during a set amount of time. The next challenge is to force connections from the associations to the relevant issue in the project. The goal is to come up with new ideas that are triggered by unrelated items, to solve the problem.

3.4.6 Mash-up

Another ideation method that is based on associations is Mash-up, a method that enable the design team to focus on quantity when it comes to ideas (IDEO, n.d.). The Mash-up session begins with formulating a well-framed "How Might We" statement which should be broad enough to allow many solutions but defined enough to know starting point. After the How Might We statement is set, the participants choose two categories and lists of elements that they associate with each category. The next step is combining these elements from the two categories to create as many

ideas of solutions as possible. The aim is to get the design team to think past the obvious ideas and come up with new solutions.

3.5 Evaluation

3.5.1 Now Wow How Matrix

This is an idea selection method which evaluates an idea's viability and innovation (Friis Dam & Teo, 2019). The Now Wow How Matrix consists of two perpendicular axes, where the horizontal axis represents the level of innovation of the idea and the vertical axis represent the difficulty of implementation. The ideas, written on sticky notes, are placed in the matrix and the placement should be dependent on where on each axis the idea fits. Before the notes are placed in the matrix, each participant gets to vote on where the ideas should be put on the scale.

When all ideas are placed in the matrix, the ideas are categories in each quadrant. Ideas in the Now quadrant are labeled as normal and easy to implement and could therefore be implemented in the near future. The Wow ideas are considered original and easy to implement which is the category with the most potential. The ideas that are original but more difficult to implement go into the How quadrant where ideas are considered to be interesting to explore further but have the drawback of requiring more resources to implement. The fourth quadrant consists of ideas that are normal ideas while also being difficult to implement and this is the category with the least potential. Based on the method, ideas can be selected for the next phase in the design process.

3.5.2 Prioritisation Matrix

The prioritisation Matrix is quite similar to the Now Wow How Matrix, but it allows for greater flexibility. Gibbons (2018b) explains that the two criteria, or axes, are freely determined based on what is important for the project in question. The four quadrant created in the matrix are labeled Yes, Maybe, No and another Maybe and they are placed a makes sense depending on the axes chosen.

There are five steps to creating a prioritisation Matrix (Gibbons, 2018b). First, the items or ideas which are to be prioritised are written down and the criteria in question are decided. Then all team members are given a number of votes and they vote based on their expertise, where each expertise should vote in a different colour. After the vote, the items are placed in the quadrants with very little discussion. After all items are in the matrix, a discussion and negotiation takes place while comparing the placement of items. After items are moved to positions that all team members agree on, the activity is finished. The only thing left to do is to document it for future reference.

3.5.3 PUGH Matrix

This is a form of decision matrix invented by Dr. Stuart Pugh (Silverstein et al., 2017). It allows scoring concepts against the current product, based on a number of criteria. For each criteria all ideas are given a +1 if they meet that criterion better or to a greater extent than the current product. If they are worse than the current, they receive a -1. If an idea is on par with the current, it receives a 0. This way, concepts are scored and when the totals are calculated it allows for comparison between the concepts as well as the original.

The PUGH Matrix is usually not weighted, but in order to allow the more important criteria greater impact, the criteria were indeed weighted. Many other decision matrices are often weighted, such as the Weighted Matrix described by Martin and Hanington (2012). The concept evaluation would benefit from a comparison of today's design of Industry Connect, and so a hybrid method was used.

4

Design Process

The overall design process in this project is based on Design Thinking. Figure 4.1 below is a visualisation of the design process and the methods used have therefore been selected and arranged according to the three main flows during the project; *understand*, *explore* and *materialize*. Design Thinking is based on iterations in the design process and even though the project had entered the exploring or materialize phases, iterations back to the understand phase were made throughout the project. In this project, however, the phases in the materialize flow has been re-named to *Develop* and *Evaluate*. The reason for this is, even though the concept was tested with participants, more focus was put on idea development. In this project, the final concept were not to be implemented in the current Ericsson solution, so an evaluation of the concept became one of the outcomes of this flow instead. A literature study in focus and a pilot study in the context with key stakeholders were the starting point of the project.

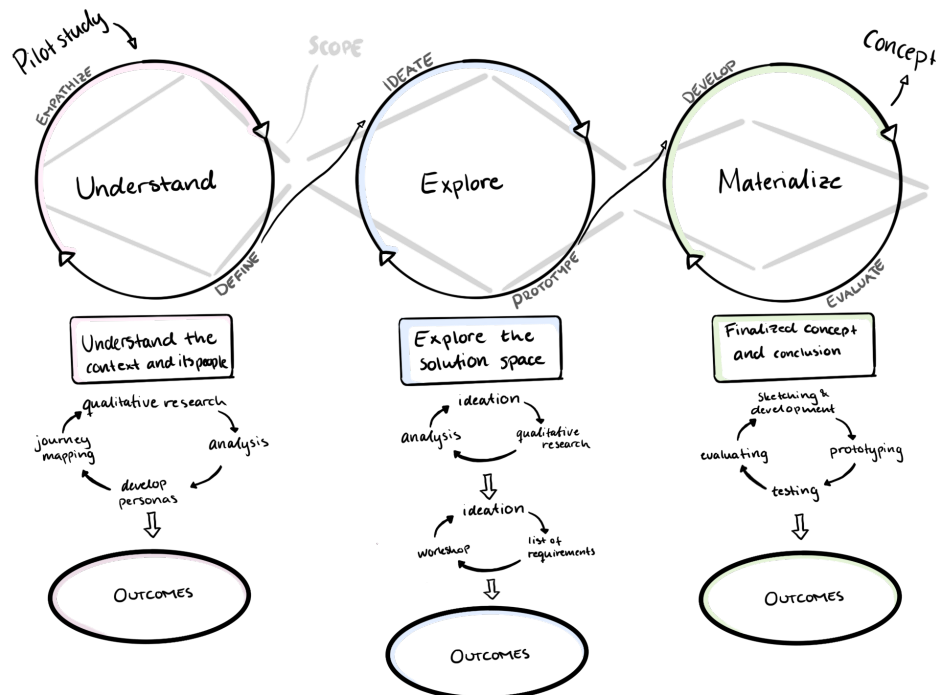


Figure 4.1: An overview of the design process and the methods used in each phase.

4.1 Initial Study

In the beginning of the project, a preliminary study was executed with the purpose of exploring the context and gain knowledge before contacting stakeholders. A literature study about asset management, the manufacturing industry and Internet of Things was conducted in order to gain basic knowledge about the context. During this early stage, the preliminary aim and research questions were set, a time plan of the project was made and the activities that should be included in order to achieve the project aim were defined. Hypotheses of which stakeholders that would be relevant for this study were also set, to facilitate the starting of the understand phase. The pilot study was the main contributor to the initial study as it enabled an opportunity to see the context and to collect useful, qualitative data from relevant stakeholders.

4.1.1 Literature Study

The literature study started in the initial phase of the project and continued in all Design Thinking stages. Initially, the knowledge gained from literature about industrial IoT and Asset management in the manufacturing industry gave a solid knowledge base when reaching out to stakeholders in the manufacturing industry. The literature study continued during the course of the project to complement the collected data from interviews with key stakeholders. While the interviews focused on context and needs of each individual, the theory give more information on what people said during interviews and in that way, trigger new questions for future interviews.

4.1.2 Pilot Study

The pilot study was constructed to be exploratory. The literature study had given plenty of theoretical knowledge, but little was discovered on how asset management was in fact used on a daily basis and who the main users of the asset management systems were in a company. Thus, the pilot study was conducted in order to verify the gathered information on the subject and, more importantly, to understand the people in the asset management process.

A set of open questions with possible qualifiers and probing questions were constructed as a guide for the interview. The interview was semi structured, and the questions were used as overarching guidelines in the conversation to make sure all topics were covered. The interview was conducted with an interviewee who had an overall knowledge of the asset management practice at the company. Once questions turned more specific about the Asset Management software, another interviewee was brought in to supplement the answers. The second interviewee was a calibration/production technician who worked in the asset management system on a daily basis. Data from the pilot interview was written on sticky notes as quotes to allow for affinity diagramming. The output from the pilot study was guidelines for upcoming interviews and an Affinity Diagram containing identified problem areas.

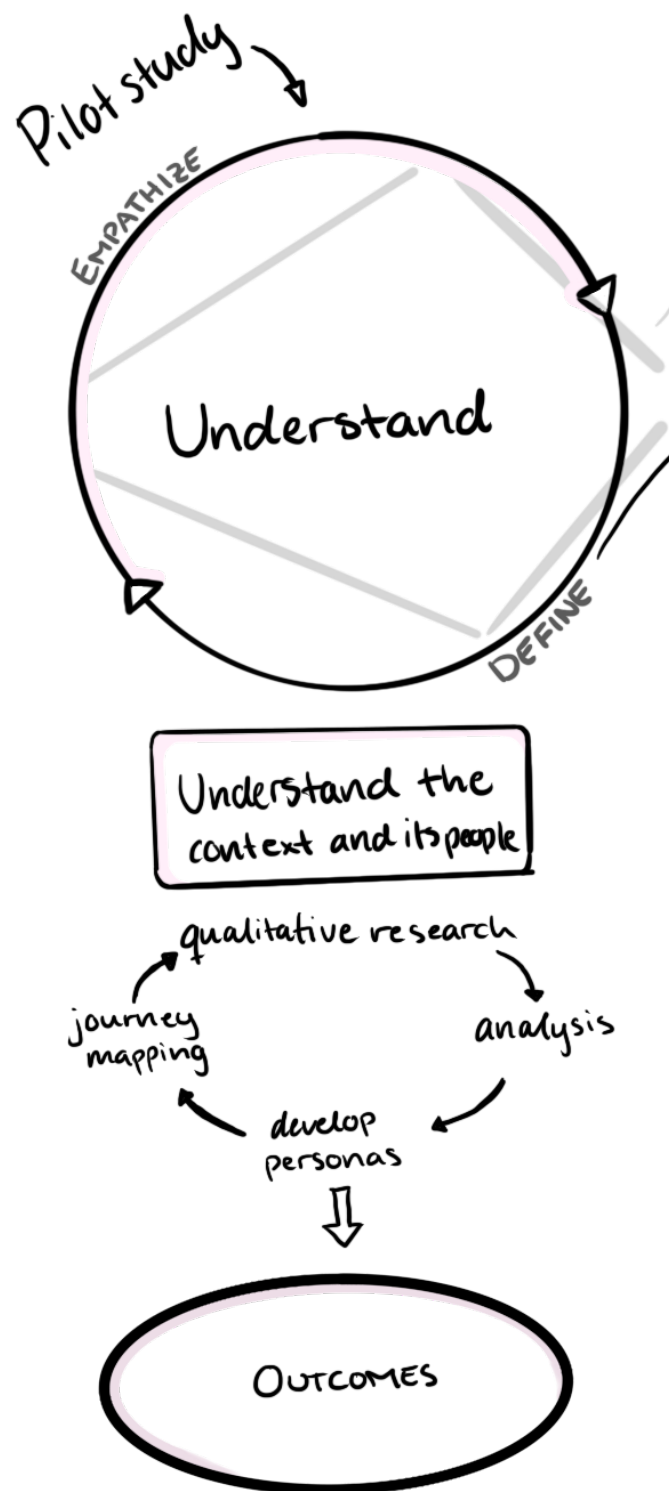


Figure 4.2: An overview of the understand phase in the design process.

4.2 Understand

The objective of the understand phase was to *empathize* with the primary stakeholders and understand how they operate, *define* their needs and problems in the context of the project scope. See figure 4.2 for a visualisation of this phase. In order to achieve this, activities such as qualitative data collection, data analysis along with defining new knowledge of the context were conducted. After iterations with data collection and analysis, at the end of the understand phase, the project scope were narrowed down.

4.2.1 Qualitative research

The procedure of sampling the participants in the study focused first on quantity and then on quality. This means that the initial aim in the sampling process was to reach out to as many people as possible in the manufacturing and warehouse industry. To ensure that only relevant stakeholders were participating in the study, phone interviews were initially held with prospective participants. The quality focus comes into the process during these phone interviews. The information gathered was used to decide if that specific company was relevant within the scope and whether the interviewee was a key stakeholder or not. Examples of criteria on which these decisions were based on are:

- Their asset management procedure when it comes to physical assets in factories and warehouses.
- Do they have an asset management software where they document their physical assets?
- Who is responsible for the asset management of fixed assets?
- Do they outsource maintenance and other management of their assets?
- Do they have assets that are connected to a wireless network?

The phone interviews were semi-structured where a limited amount of questions were set while letting the interview be exploratory. If the decision was made that the company would be relevant for this study, an interview on their premises or a video interview was conducted, depending on the accessibility of their premises.

In figure 4.3 all participants in the study are listed along with information about what company they work in and what their roles are. People who participated in usability testing in the materialize phase is not listed here. Each interview generated new data and the information from this data was used to design the next interview. The general design of each interview was consistent throughout the study but the focus of each interview was influenced of the information from previous interviews.

Stakeholders/companies involved in the study:

IT/Telecom industry, testing, repairing products and prototypes and calibrating instruments.	Manufacturing industry, global company, automotive industry, low use of wireless equipment, active in trials in IIoT	Manufacturing industry, components for the automotive industry, low use of wireless equipment	Manufacturing industry for clients only, electronics industry, no use of wireless equipment	Integrated automation solution provider, global company, moderate use of wireless equipment
Manufacturing industry, pharmaceutical packaging, no use of wireless equipment	Provider of IoT solutions for industries, experience with wireless equipment	Provider of IoT solutions for industries, experience with wireless equipment	IT/Telecom industry, global company Industry Connect team in both development and offering.	

Person	Company	Research activity	DT phase
1. Head of repair cleanroom and NPI		Semi structured interview in context	Pilot study
2. Hard ware make support/calibration tech		Semi structured interview in context	Pilot study
3. Person in Smart Factory Lab		Phone interview	Understand
4. Production engineer, earlier project leader		Semi structured video interview	Understand
5. Person responsible for trucks		Phone interview	Understand
6. Production Engineering Manager		Phone interview	Understand
7. Maintenance Manager		Semi structured interview in context	Understand
8. Tech Manager		Semi structured interview in context	Understand
9. Systems Operations Nordic		Semi structured video interview	Understand
10. Site Manager/ Maintenance planner		Semi structured video interview	Understand
11. Finance and precurement		Phone interview	Understand
12. IT and security		Phone interview	Explore
13. IT and security		Phone interview	Explore
14. Tech sales		Semi structured video interview	Explore
15. CEO		Semi structured video interview	Explore
16. Inhouse experts		Participatory video workshop	Explore

Figure 4.3: Table of the interviewees participating this study.

As an addition to the verbal communication in the interviews, timelines were created with the participants to communicate the chronological order of their work tasks. By drawing a timeline and add sticky notes for each task, the participants could use this tool as a mediating tool to talk about their work processes.

Three interviews were made on the interviewee's premises. The remaining interviews were conducted through video conferences or as phone interviews.

4.2.2 Context analysis and visualisation

To analyse the qualitative data from the interview sessions, the Affinity Diagramming method was used in iterations, see figure 4.4. The process of the Affinity Diagramming started after the pilot study and was continuously developed during the understand phase. After each interview session, notes with new data were added to the Affinity Diagram . The input to this method was raw qualitative data and the output was interpreted data arranged in categories of problems, patterns and opportunities. The list of requirements was later based on the output from the Affinity Diagram.

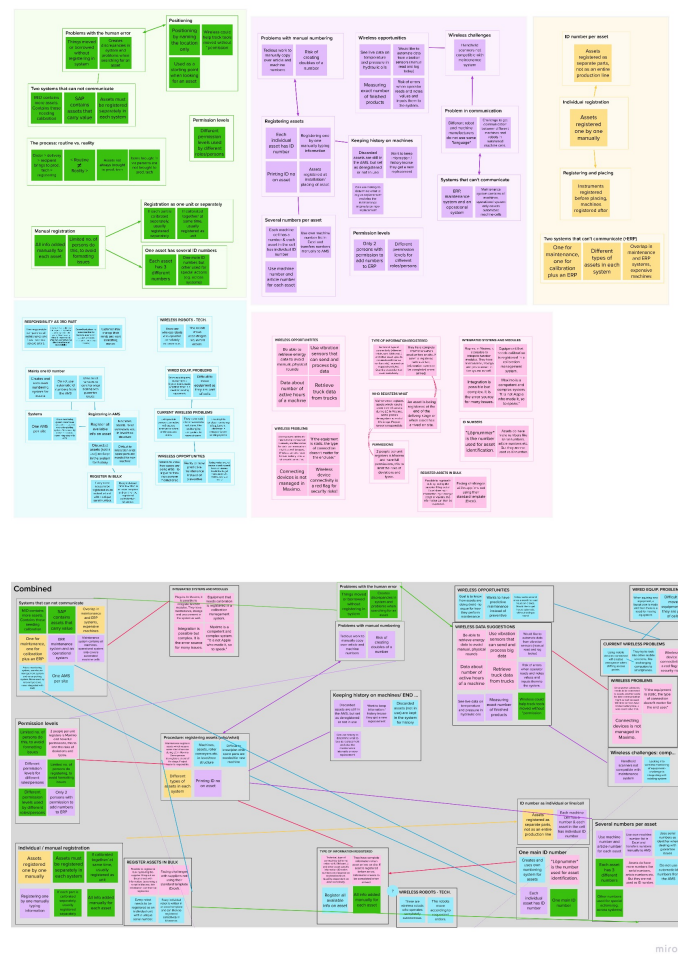


Figure 4.4: Affinity Diagramming process displaying different iterations.

Adapted journey maps were created to visualise the work process of asset management. In order to compare processes between companies, one journey map was created for each company. To visualise when different people were active in the process and how they interacted with each other, the adapted journey maps were made to include multiple people. When a journey map had been created for each company, all journey maps were compared to each other in order to find patterns and similarities. One journey map representing the general flow of asset management was created, see Appendix C. This general journey map gave an overview of the process at different companies and it was used in the materialize phase of the project to distinguish where in the process problems could be solved by way of different designs.

During the analysis, there were also a number of personas constructed. These personas acted as representatives in the journey map. The qualitative data was used to define the key people in the process in order to understand who the primary users were. Visualisations of the personas were developed to describe their characteristics, experiences, goals and motivations. The IT persona Ivar was put together by the information gathered from the interviews at the companies and was also influenced by an IT persona constructed by the Ericsson team developing Industry Connect. This IT-persona shared several key characteristics with what had already been discovered about Ivar and therefore it was deemed close enough to be used as an influence and point of reference of sorts.

The outcomes from the understand phase was problem statements extracted from the Affinity Diagram, the journey map and personas.

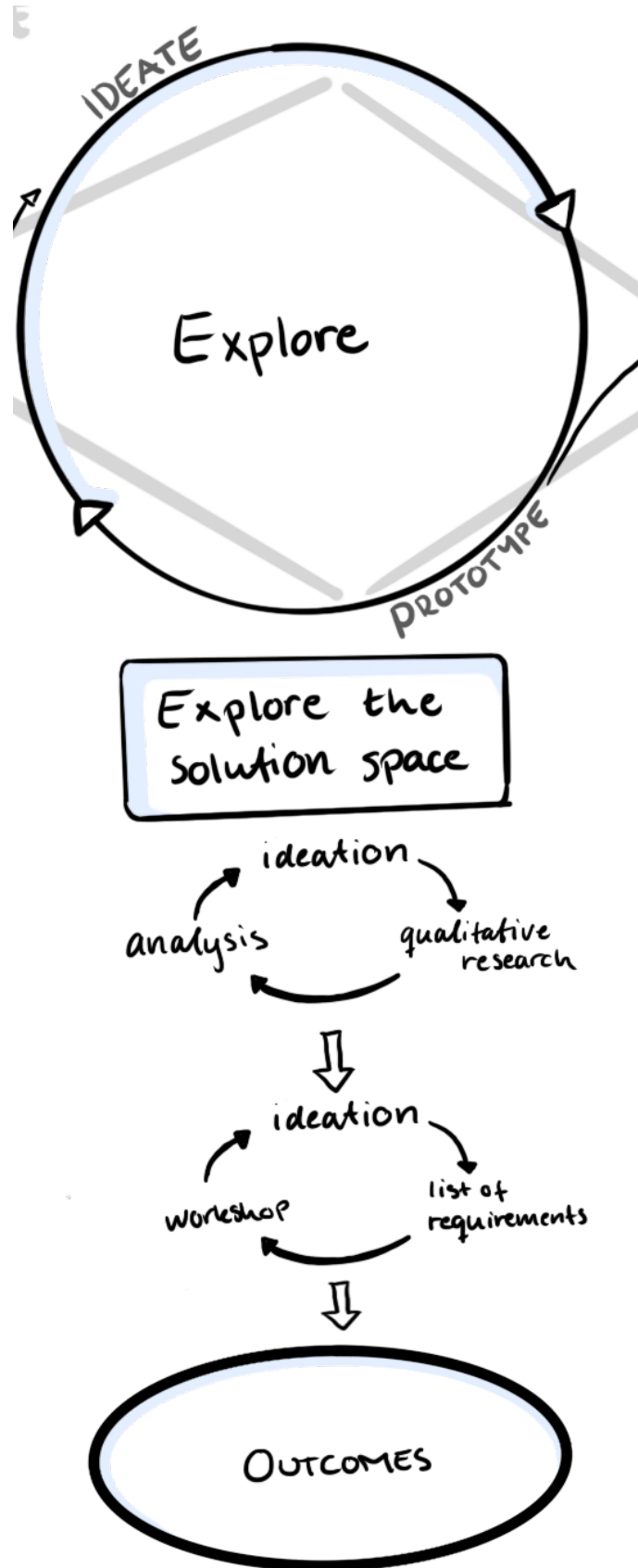


Figure 4.5: An overview of the explore phase in the design process.

4.3 Explore

In this phase of the project, the objective was to explore the solution space, see figure 4.5 for a visualisation. The initial focus was to generate many ideas and to get them on paper. This focus changed during the process to developing concepts which would solve problems and meet the needs that were found in the understand phase. However, since this was an iterative design process, additional interviews were held to gain more knowledge to use in the development of the concepts.

4.3.1 Ideation

The solution space diverged early in this phase and then converged at the end. This means that the initial focus during ideation was quantity of ideas and to explore the solution space as wide as possible. The reason for this was to release tension by getting all ideas one might have onto paper. Two methods, Braindumping and Crazy 8's, were used for this purpose where each team member ideated individually during a limited amount of time. To further the exploration of ideas and to develop each others' ideas in the team, Brainstorming and Brainwriting sessions were held. During these sessions, the defined problem areas were involved in order to align the ideas with the existing problems that were to be solved and to maintain empathy for the people that would use the design.

Parallel with the ideation sessions, additional interviews were held in order to get a deeper knowledge. As new ideas were generated and developed, more questions kept appearing. It was clear that more knowledge about the IT persona was needed and therefore more interviews were held with people whom the persona represented. Questions also appeared about the role that other providers of IIoT solutions play in the flow that was being developed. Therefore, interviews with two different IIoT solutions providers were held. A workshop with Ericsson Industry Connect team members was held in order to get insights from experts in areas such as cellular technology, UX and product strategy. In this virtual workshop, the participants collaborated and communicated using a digital board with sticky notes on which they could write down ideas and comments on. This method enabled the possibility of visualising ideas and to enable the participants to actively take part in the workshop practically and verbally.

The knowledge gained from the interviews and the workshop helped developing ideas further and facilitated decision making during the explore phase. By involving more insights and data in the ideation the focus went from quantity to quality of the ideas.

After the workshop, more ideation sessions were conducted with the purpose of generating some more crazy ideas to broaden the solution space. One session was conducted using the Random Links method and one session using the Mash-up method as both methods use words and elements unrelated to the project focus in order to trigger new ideas. The output from these methods were new ideas and

perspectives that might not have come to light if they had not been triggered when using these methods.

4.3.2 Evaluation and Concept Decision Making

The next step in the process was to decide which ideas had the most potential and would be developed further. These decisions were based on the outcome of using evaluation methods such as Now Wow How Matrix and Prioritisation Matrix. Using these methods, the ideas were categorised in matrices based on parameters that were considered valuable to this project. The ideas in categories with the most potential were selected to develop further in the materialize phase. The outcome from the evaluation was four concepts and four general ideas which could be combined and applied to the different concepts.

4.3.3 List of Requirements

The list of requirements was initiated in the understand phase and included the output from the Affinity Diagram. During the explore phase, the list of requirements was developed further with input from the ideation, development of concepts and knowledge from stakeholders that were interviewed in this phase.

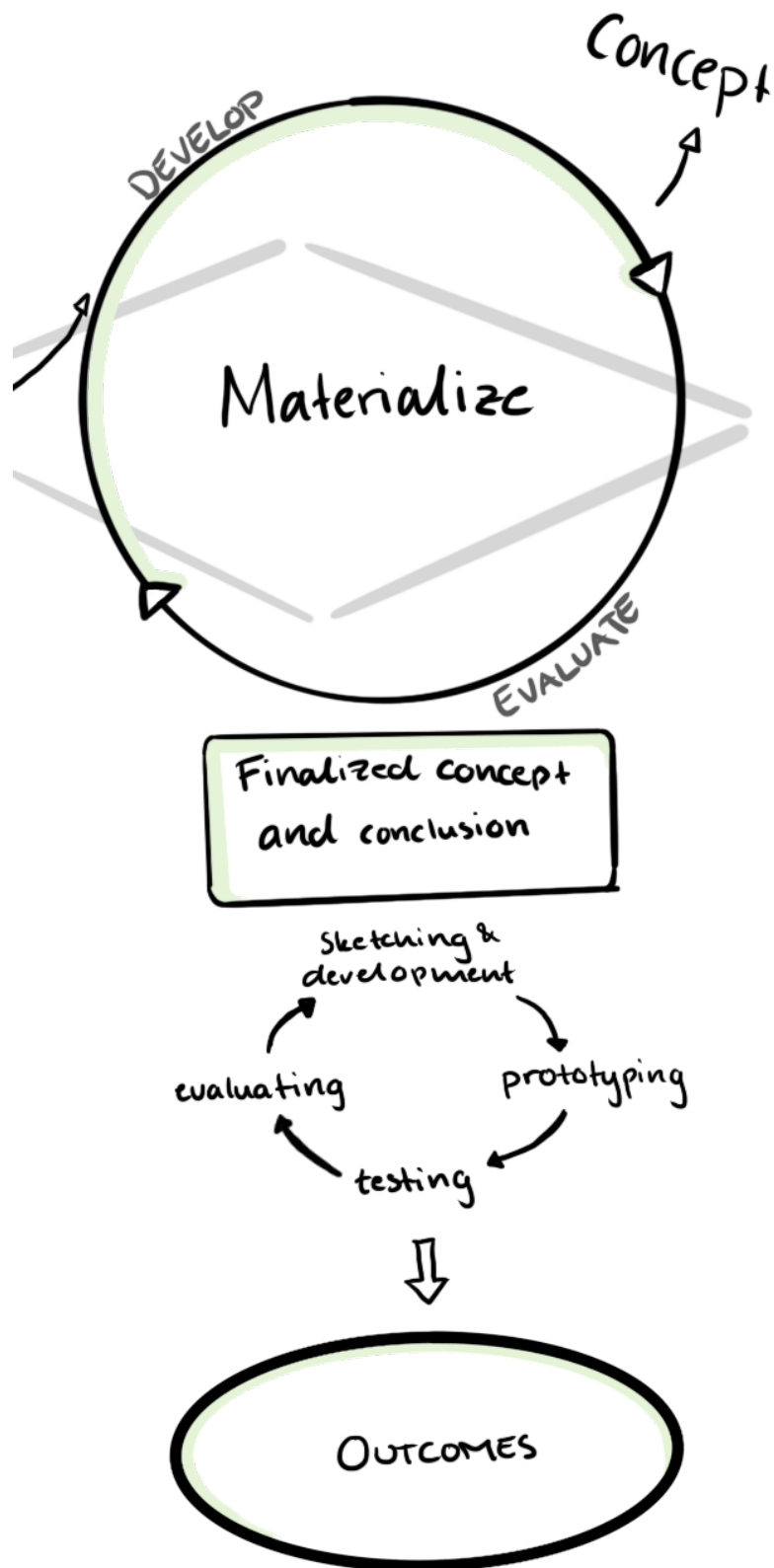


Figure 4.6: An overview of the materialize phase in the design process.

4.4 Materialize

The objective of the materialize phase was to develop and create an interactive prototype of the final concept, see figure 4.6. During the development process, design decisions were based on the list of requirements and the needs of the personas. The usability and experience of the concept was evaluated by letting novice users test the prototype. The scope of this project, however, does not include the implementation of any concepts in the current Industry Connect solution.

4.4.1 Concept Decision Making

The four selected concepts were further developed by using Brainstorming while also combining each concept with variations of the four additional ideas. The next milestone in the project was to decide which of the four general concept ideas to proceed with. This decision was made using the theoretical evaluation method PUGH Matrix where all concepts were evaluated. The evaluation criteria were based on requirements from the list of requirements and other key values such as *innovation*, *possibility to implement* and *value to Ericsson*. Several criteria were also extracted from the personas in a bid to keep the users and their needs in mind. The different criteria were weighted to enable important criterion to influence the result more, see Appendix A. How much one criterion was worth was based on the result from the qualitative study. The concept with the most points after using this method was the concept that was selected for further development.

4.4.2 Concept Visualisation and Prototyping

The development of the chosen concept consisted of visualising the user flow and defining where in the journey map the solution would act. With a set user flow, the decision of what elements in the concept that would be visualised in a tangible prototype could be made. At this point, it was decided that a clickable prototype of a graphical user interface would represent the part of the user flow considered the most important in the concept. The reason for this was to set demarcations in the concept visualisation part of the project and to set the focus on developing a good visualisation to be tested. This means that the final concept was visualised as a user flow representing the whole concept and a clickable prototype of graphical user interfaces representing the most central part of the concept.

The design of the graphical user interface and the clickable prototype was created in the digital user interface design tool Sketch. The internal Ericsson Design System components were used as a basis in order to make the design more useful and valuable for Ericsson, since a future aim was that the solution would be implemented in their existing software solution. When the flow and the design of the interfaces had been created, a clickable prototype was set up in order to show a tangible and realistic representation of the flow of the solution.

4.4.3 Usability Tests and Evaluation

The prototype was also used to test and evaluate the concept in a usability test. The purpose of the usability test was to gather feedback on the usability and the overall experience of using the prototype. Six participants were sampled that were considered novice users to this solution with little to no experience with cellular networks. To counteract this, the participants were given a cheat sheet with explanations of various terms and concepts relevant to the test, such as a short description and scenario of Industry Connect and the differences and uses of ICCID, IMSI and such. Given the restrictions of proximity in place during the spring of 2020, the tests were mostly done remotely using a video chat program. Participants were given remote access to the prototype and shared their screens so the test facilitator could watch.

The result from the usability provided data about the most common errors and how many of the participants who committed the errors. The design got an average score from the participants which gave an indication on the perceived user experience of using the design. The parameters *easy to use*, *easy to learn* and *trust* were measured by having the participants rating statements about the experience on a scale from one to five.

Based on the verbal feedback from the participants during the usability tests and on the observed errors made by the participants, suggestions for improvements were made. Some of these suggestions were implemented in the design and some suggestions were listed as design suggestions for future work.

5

Results

This chapter is divided into the same three phases as in chapter 4, Design Process. Firstly, the key findings from the pilot study are stated. Under *Understand*, the results from the main research study are presented, including problem areas, personas and the journey map. The *Explore* section includes a list of requirements and some ideas that were evaluated, before the final concept decision was made. Finally, the *Materialize* section presents the final concept visualisations and descriptions along with the results from the usability tests that were conducted with participants.

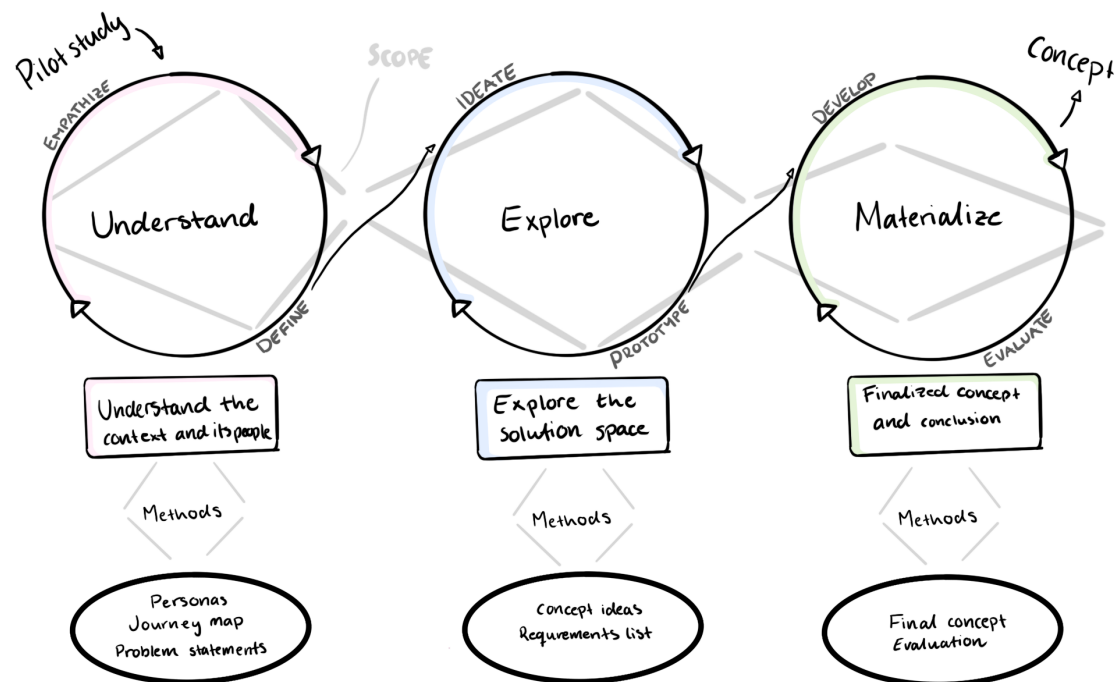


Figure 5.1: An overview of the design process and the results from each phase.

5.1 Pilot Study

Key findings from the pilot study are described in this section, which generated basic knowledge about the context and the problems in it. These findings are the outcome and were used to construct questions for the upcoming interviews in order to explore these findings further.

Problems with having multiple non-intercommunicating software systems

At the pilot site, there were two software systems in use for registering assets. One system being the ERP system used as the overarching business system and the other was the asset management system which solely managed equipment in need of calibration. These systems, which served two different purposes, were used by different people in the organisation and could not communicate with each other. This were considered as a problem because information about assets existed in both systems and as a consequence of this, one asset got two different identification numbers. This issue with having different identifiers for the same asset could cause confusion for the people involved in the management of the asset.

Registration of assets: who and how

Registering a new asset in the AMS was done manually by the production technician, who had full access to register assets and edit assets in the AMS. Other access levels were not able to edit assets in the system in to limit the risk of errors. Each asset in the AMS had to be added one by one, even when multiple assets purchased in bulk. The technician who was interviewed had just spent an entire week on registering new assets in the AMS, which was a monotonous work task.

Problems that occur when people do not follow set routines

The most common problem, expressed by the interviewees, were that people misplaced assets at the plant which created a problem where the physical location of the asset did not match the digital location in the AMS. Each asset was assigned a physical location in the AMS and if the asset were to be placed somewhere else, this had to be manually registered in the AMS. The technician spent much time on searching for missing assets, especially during inventory. This problem is linked to the aspect of having a set routine of the work processes and problems occur when people do not follow the routine in reality.

Journey Map

To visualise the flow of the process when an asset is purchased, registered, in operation and eventually decommissioned, a journey map was constructed as seen in appendix C. This journey map also visualised the persons involved in the process and how they interacted with each other and the asset.

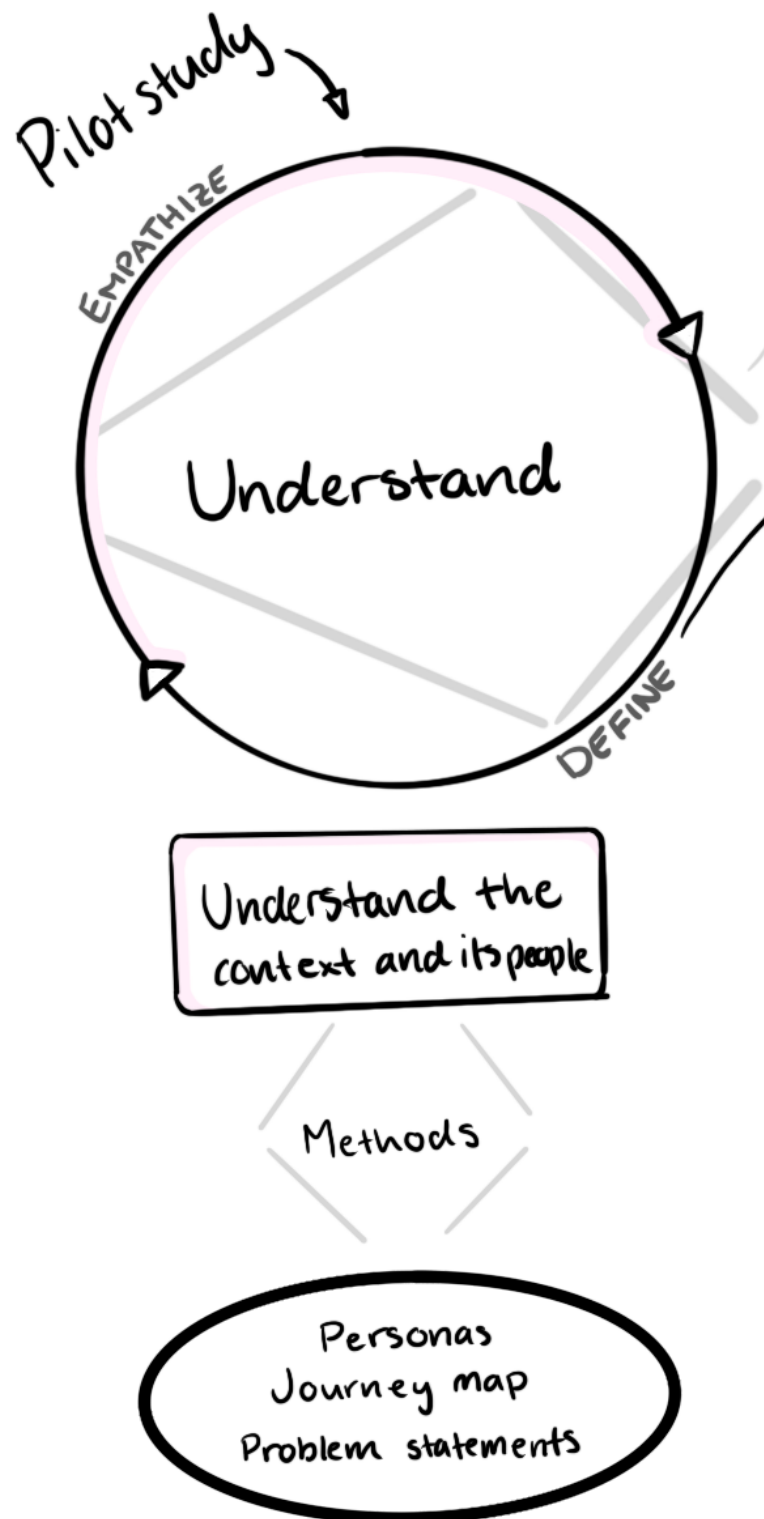


Figure 5.2: An overview of the results from the understand phase.

5.2 Understand

The purpose of this phase was to understand and define the persons and the context of the asset management process as well as the problems that exist. This was achieved and summarised as a number of problem areas. The key personas were identified and they were also included to visualise the different roles and responsibilities in a journey map.

5.2.1 Problem Areas

The analysis of all interviews could be summarised in a number of problem areas, found in figure 5.3. Many of these were already discovered in the pilot study, although the understanding phase brought more weight to the findings. The problem areas most relevant to the project and Industry Connect are described below.

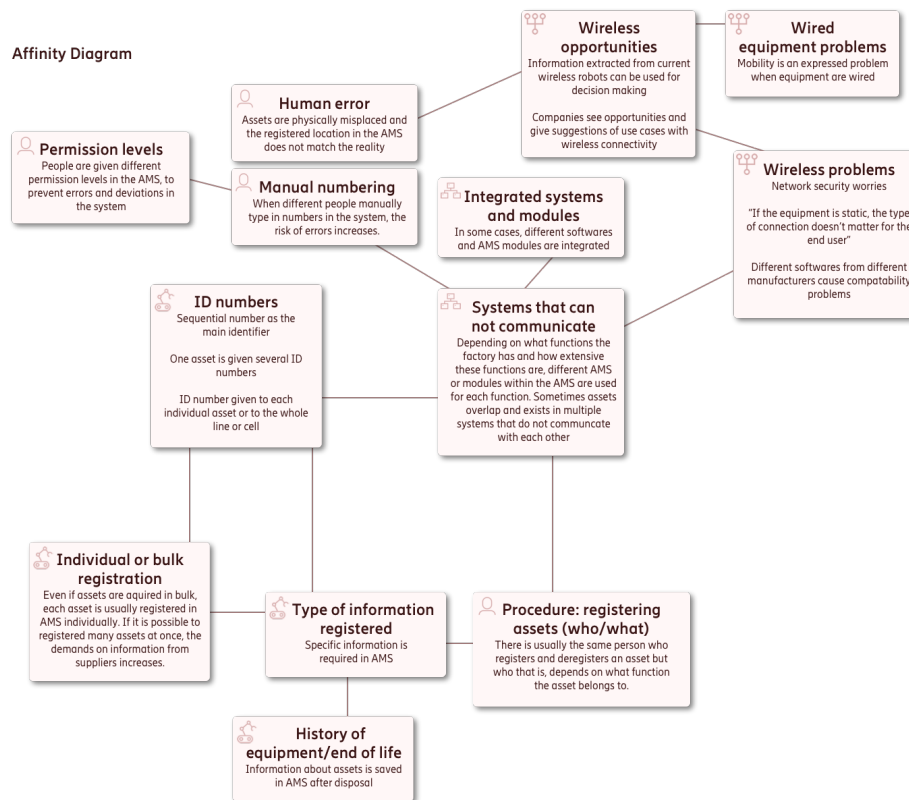


Figure 5.3: Identified problem areas.

ID Numbers

This area describes the multitude of identifiers each asset could have. Most sites had one or two AMS in use in addition to an ERP, which led to each asset having at least two identifying numbers. Commonly, an asset was given one identification number per system it was registered in, since the systems were usually not integrated. Usually, one of these identification numbers would be used as a main ID-number at a site.

In addition to these identification numbers, an asset also possesses other identifiers as well, such as an individual serial numbers and an article number from the retailer. Such identifiers were also important to identify an asset and they were used in special actions, such as dealing with guarantee issues. Assets were sometimes part of a larger entity, such as a machine cell or a production line. In such cases assets could have their own machine number number as well as cell number and a line number, in order to identify the asset in the grand scheme of things. These numbers were often added onto each other, as 11222333, where 11 is the production line, 222 is the cell number and 333 is the machine itself.

Manual Numbering

From the interviews, it was obvious that when people had to keep track of various numbers without the help of the AMS, there was a risk of errors. One example of this is a production technician reading the value off of a machine, writing the value down and later inputting it into the AMS. Another example is when a company keeps their own separate sequential list of machine numbers. When adding a new asset in the AMS, ID-numbers were copied from that separate list and added to the AMS.

Take-away: Identifiers

A key take-away from from these two problem areas regarding identifiers and ID-numbers, is that Industry Connect should not complicate this issue further. A recommendation would be to not create further identification numbers unless absolutely necessary.

Systems Communication

There were often two or three different systems that could not communicate. What systems were used depended on what kind of company it was.

If the company used measuring instruments that needed regular calibration, an AMS with a calibration focus was used. Machines and other equipment that needed maintenance were registered in a maintenance focused AMS. Whether a company chose to use a calibration system or a maintenance system depended on the kind assets they had. Sometimes they used both kinds of AM systems, in which case there was often very little overlap between the two systems. The reason for this lies in the fact that they are used for different kinds of assets.

All companies interviewed had some kind of ERP system as an economy and overall business system. The overlap between an ERP and an AMS was often quite large, as the AMS contains assets in need of calibration or maintenance while all assets that carry value were registered in an ERP. As the ERP and asset management systems usually could not communicate, assets that were registered in multiple systems had to be added all over again in each system. This meant that all information had to be added multiple times in different systems.

Some companies also kept a list of all possible machine numbers. They copied numbers from the list and input them to the AMS when registering a new asset. This was often done when the AMS did not create ID numbers automatically, and it is another example of how the systems do not communicate.

Integrated Systems and Modules

Some ERP systems had different modules or plugins, such as maintenance, storage or procurement. Systems with a multitude of such modules were often highly competent but complex. In such cases the maintenance system can be integrated with the ERP. However, such integration or plugins from other softwares, is often complex and can create many errors and issues. One user described it as *"It is not Apple who made it, so to speak."* This quote referred to that the user interface was rather hard to navigate in and was not always easy to use.

Take-away: Communication

It was deemed important that Industry Connect can communicate or integrate with asset management systems in order to minimise the need for adding asset information to yet another system. It is also important that users find it easy to use and to avoid the complexity that often comes with integrating several systems with the AMS.

Registering Several Assets

When registering a new asset there is a lot of information needed. All individual assets need to be registered with their unique serial number and information about the asset and its required maintenance or calibration. This goes for assets registered in a maintenance or calibration module of an ERP or in any other system.

Even if one type of asset were to be acquired in bulk, each asset would still need to be registered separately in the AMS. Registering multiple assets in the AMS was perceived as time inefficient and as a repetitive and monotonous work. At some of the larger companies interviewed in this study, it was possible to list all new assets in an Excel sheet. This was done either by the company or by their suppliers. Listing assets and their information in an Excel sheet was seen as a more efficient way when dealing with many assets. They could then run a script on this Excel sheet in order to register all assets at once into the AMS, while maintaining the individual information on each asset. This was rarely done when dealing with just a few assets because it was generally more efficient to register them directly into the AMS in that case.

The problem with inputting all information to an Excel sheet first was to fill out the information according to the correct format of the sheet. Suppliers usually wanted to use their own templates which did not work for the company if they were to run the script in the AMS. Using an Excel sheet also did not avoid the problem of manually adding all information in the first place.

Take-away: Registration

When adding several new assets, Industry Connect should allow for these assets to be added in bulk.

Wireless Issues and Opportunities

From the interviews it was discovered that connecting devices to a wireless network is not currently done in the ERP or AMS. Connecting devices to a network was not done by the same persons that register the device in the AMS either. Configuring devices to a network is done by IT personnel as opposed to the production technicians that manage the AMS. It was also pointed out that software made by different manufacturers often have trouble working together. One company had the problem that handheld scanners were not compatible with the maintenance system they used. Another company mentioned they were looking into wireless monitoring of equipment, but the challenge was integrating it with their existing system.

Wireless assets were not common at the factories visited. When asked to imagine what they could use wireless assets for, a common response was that having wireless connection to assets could provide the knowledge of how assets are doing. That could help when planning or arguing for the way maintenance is performed. Another common answer was the possibility to read various values, data and measurements from machines that otherwise might be missed. Another big perk was to be able to retrieve data wirelessly and thereby avoid manual, physical rounds of the factory.

5.2.2 Personas

A number of personas were constructed as a basis for understanding and relating to the users and their needs in the asset management process. Three main personas were identified: Sam, who registers assets in an AMS; Moa, the site manager; and Ivar, the IT manager. These personas had central roles in the asset life cycle. An overview of Sam, Moa and Ivar is given in figure 5.4. There were also three secondary personas identified: Bo, who is Sam's counterpart in calibration; Theo, a production development engineer; and Pete, a manager at the economy department. An overview of these three is given in figure 5.5. All personas can be found in greater detail in Appendix B.

Moa is a site manager and she is the one in charge of the long term planning of resources and equipment. She is involved in the planning before a new asset is acquired. Ivar, it turned out, would very much like to be involved early in the planning stages when acquiring assets. He would like to specify the connection protocols for new assets and ensure that the asset can be securely connected to the network. He argues that anything connected to the network is a security risk and therefore in his domain.

Sam has a leader role in the maintenance function and she is responsible for all equipment and machinery that requires maintenance. She is the one in charge of the

maintenance system, either a maintenance focused AMS or a maintenance module in an ERP. This means she is also in charge of registering new assets in the system, along with the asset's information and maintenance plan. As a counterpart to Sam there is also a persona named Bo, who is in charge of the calibration system. Bo is a secondary persona, as it was discovered that on most sites there is either a Sam or a Bo present and it turned out that Sam was more common.

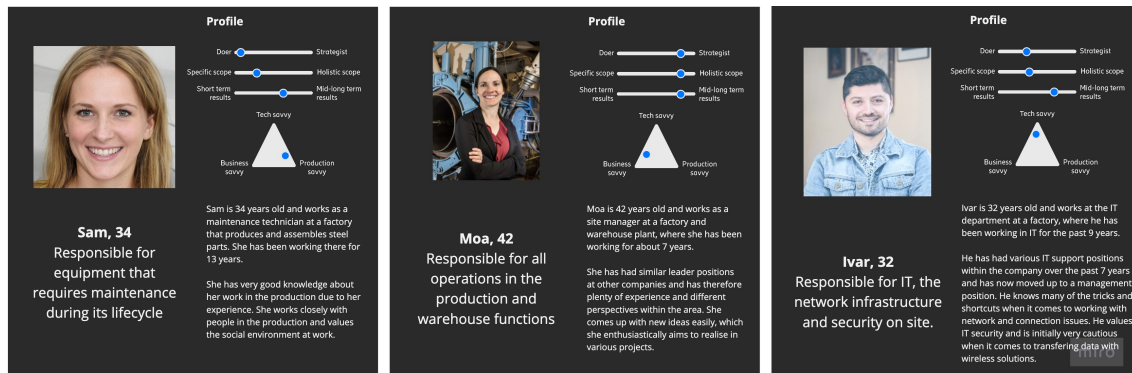


Figure 5.4: An overview of the main personas.

Theo is an engineer who is involved in the product development process and he needs to plan ahead and set up the production flows for the factory. Pete works in the economy department and deals with communication between clients, management and production. He and Moa work together, in part, when dealing with quotation management.

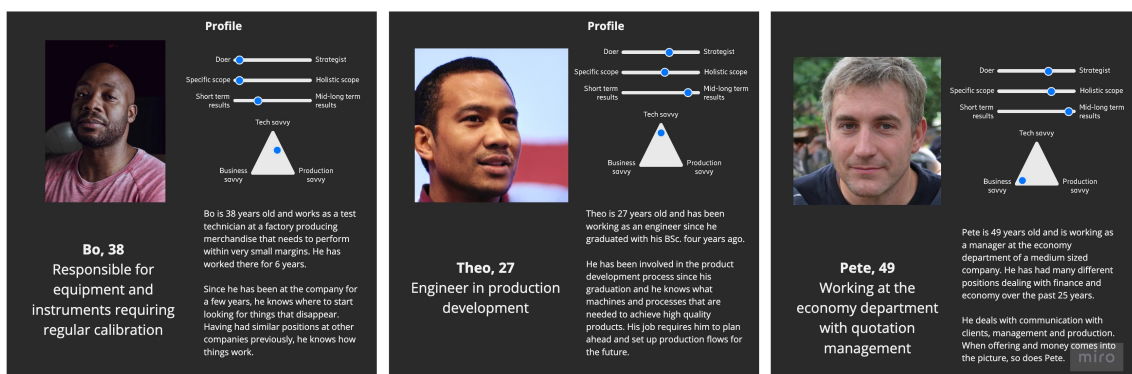


Figure 5.5: An overview of the minor personas.

5.2.3 Journey Map

From the data gathered at interviews, the journey map was divided into five phases: Initiation, Delivery, Registration and Setup, In Operation, and End of Life. Within these phases were various activities. The full journey map can be found in Appendix C.

The first phase, in figure 5.6, begins with identifying a need for a new asset. Before acquiring an asset specifications are made, and this is where Ivar would wish to be more involved than he currently is. Pete and Moa then work together on quotation management and acquisition. Once an asset is purchased, Pete can register it in the ERP software, along with its value and its time of depreciation.

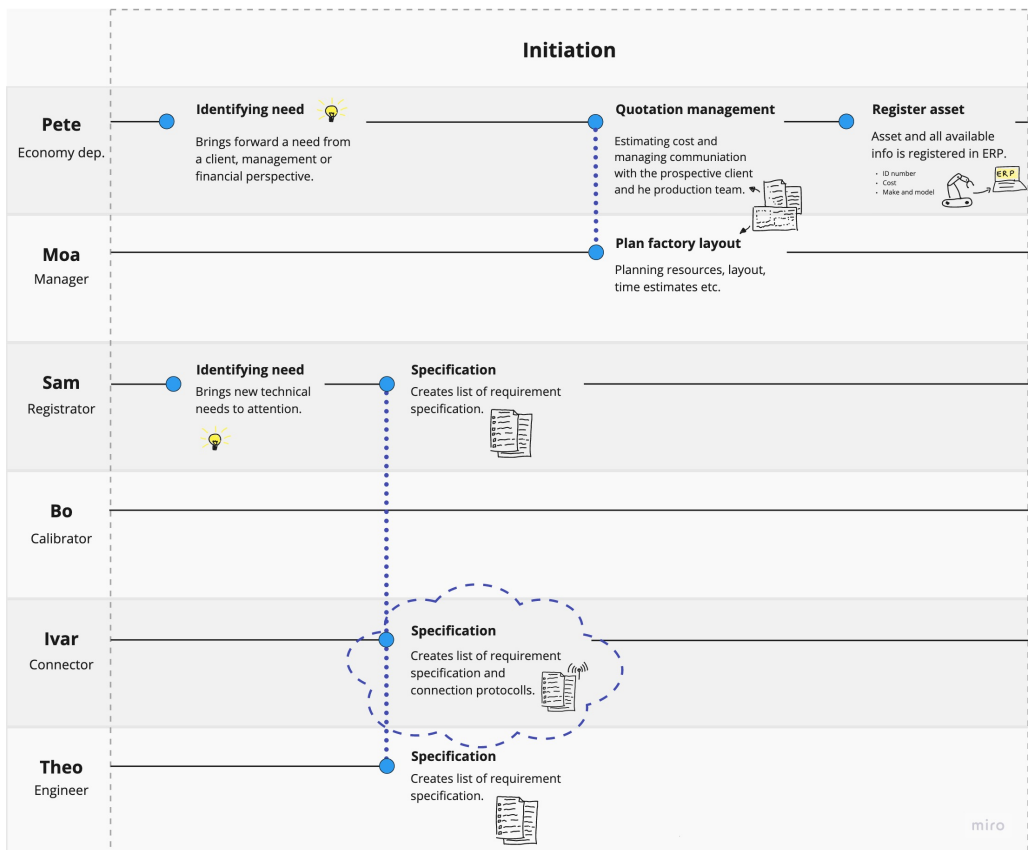


Figure 5.6: The initiation phase of the journey.

Then the asset is delivered and registered, in figure 5.7. Once it arrives on site it taken care of by either Sam or Bo. They perform similar duties as they both register and manage assets their respective AMS. Smaller organisations will likely only have a Sam who may take on Bo’s calibration responsibilities. In the organisations that do have a need for both maintenance and calibration of sensitive instruments, Sam and Bo will likely not work in the same systems. Sam will work in an AMS that is tailored for maintenance and Bo will use one that is used for calibration. The systems will have similar features, and the basics will be the same. In some cases, they might use different modules of the company’s ERP system. Sam and Bo will also deal with different kinds of assets, as Sam will take care of machinery, conveyors and other equipment that require mechanical maintenance such as greasing. Bo on the other hand will deal with more delicate equipment, measuring instruments and other equipment that is in need of regular calibration in order to give accurate measurements. Bo might perform the actual calibration of these himself, or he might hand them over to a second party do the actual calibration. In either case,

Bo is in charge of the assets and making sure they are calibrated correctly and on schedule.

Bo or Sam will register the new asset in the AMS and they will set up a maintenance plan or calibration intervals for it. Such planning is made on the recommendations of the supplier as well as know-how that has developed over the years. The asset is then taken to its place in the factory and any required installation is performed. In parallel with this, Ivar will change the network settings to safely configure the asset to network.

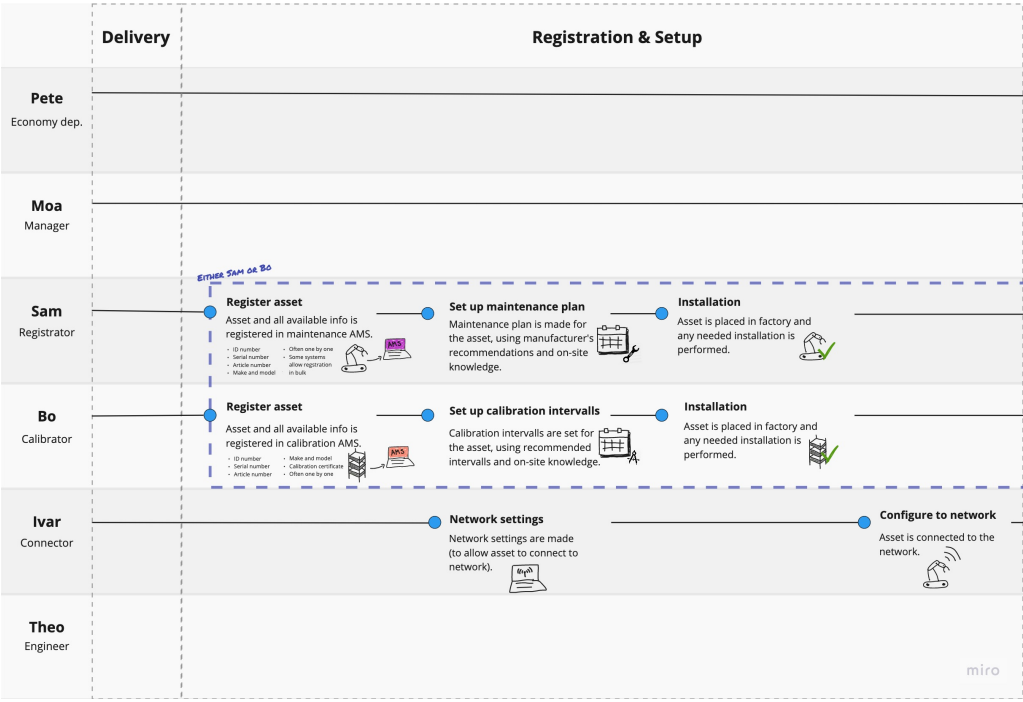


Figure 5.7: The delivery phase and the setup and registration phase of the journey.

While the asset is in operation, Sam and Bo continue their attentions and perform the maintenance or calibration according to plan, as seen in figure 5.8. They might also perform supportive services if the asset breaks down. The same goes for Ivar, who might be needed to fix network and connectivity issues for any assets that are connected to the network. Once an asset reaches the end of its life however, Pete and Moa are usually involved again. Pete needs to make sure the asset has fulfilled its depreciation requirements and that it is deactivated in the ERP system. Sam or Bo will also need to deactivate the asset from the AMS. When an asset decommissioned, it is not entirely removed from the AMS, it is simply moved to a section in the system where assets that are not longer in use are stored. That means that if the company purchases a new version of the asset, they can still benefit from knowing the maintenance history of the old one. Perhaps a machine needs to be lubricated twice as often as the manufacturer claims, and by keeping track of such knowledge there is less wear and tear on the assets.

Ivar will also need to make sure the asset no longer has access to the network, seeing as it is no longer in use. Some assets are broken or worn out enough that they have to be scrapped entirely and it is either Sam or Moa who arranges for this. Some assets, however, can be sold in second hand. Perhaps they do not pass the standard for the company's tolerances any longer, but other companies might not have such low tolerances and may have use for the asset anyway. In such cases it is often Pete who makes the arrangements, even if he might be helped by people from the offering team or the after-market team as they often have contacts at other companies.

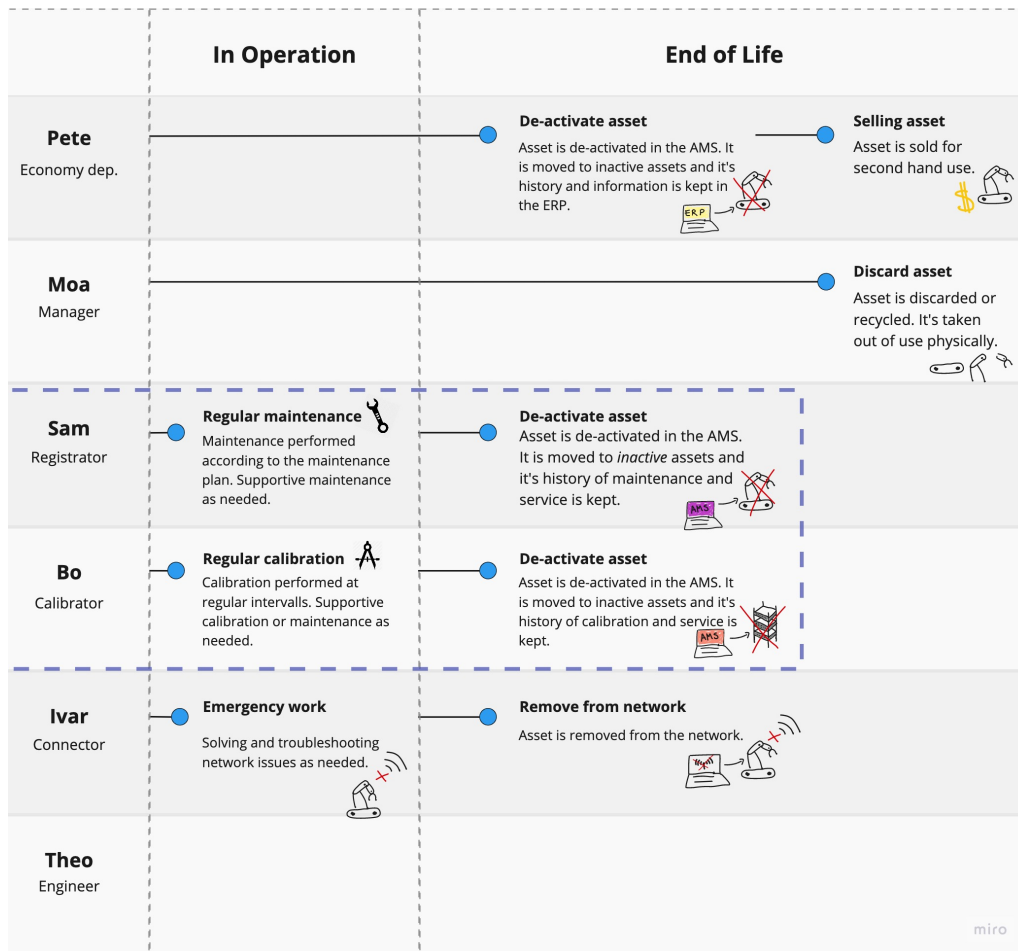


Figure 5.8: The operational phase together with the end of life phase of the journey.

The journey map was created to reflect a summary of all companies that were part of the study. It is interesting to note that many of the steps in the journey map coincide with the steps of an asset life cycle as defined by Hastings (2015, pp. 11-12), see figure 2.1. Hastings cycle begins with *business need or opportunity* and *pre-acquisition analysis* which fall under the initiation phase of the journey map. The *acquisition and commissioning*-step falls partly under the initiation phase, but also the registration and setup phase. *Logistic support* and *operation and maintenance* corresponds with the operational phase, while *end of life / disposal* naturally fits with the end of life phase.

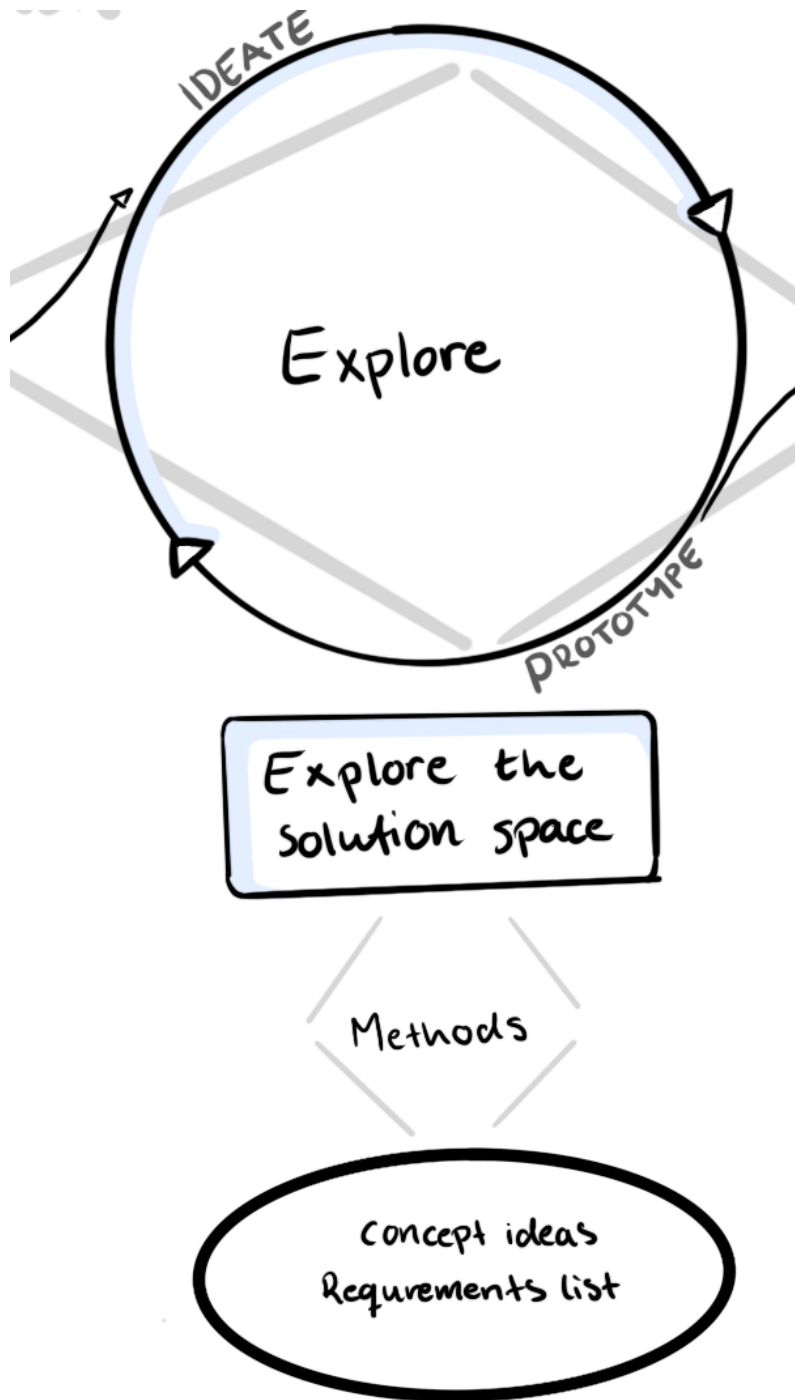


Figure 5.9: An overview of the results from the explore phase.

5.3 Explore

This phase explored the solution space and resulted in a list of requirements and a number of concept ideas. The ideas were evaluated and boiled down to four concepts as well as four more general ideas that could be combined and added to the concepts in the next phase.

5.3.1 List of Requirements and Concepts

The list of requirements framed the needs and requirements of the future solution and can be found in Appendix D.

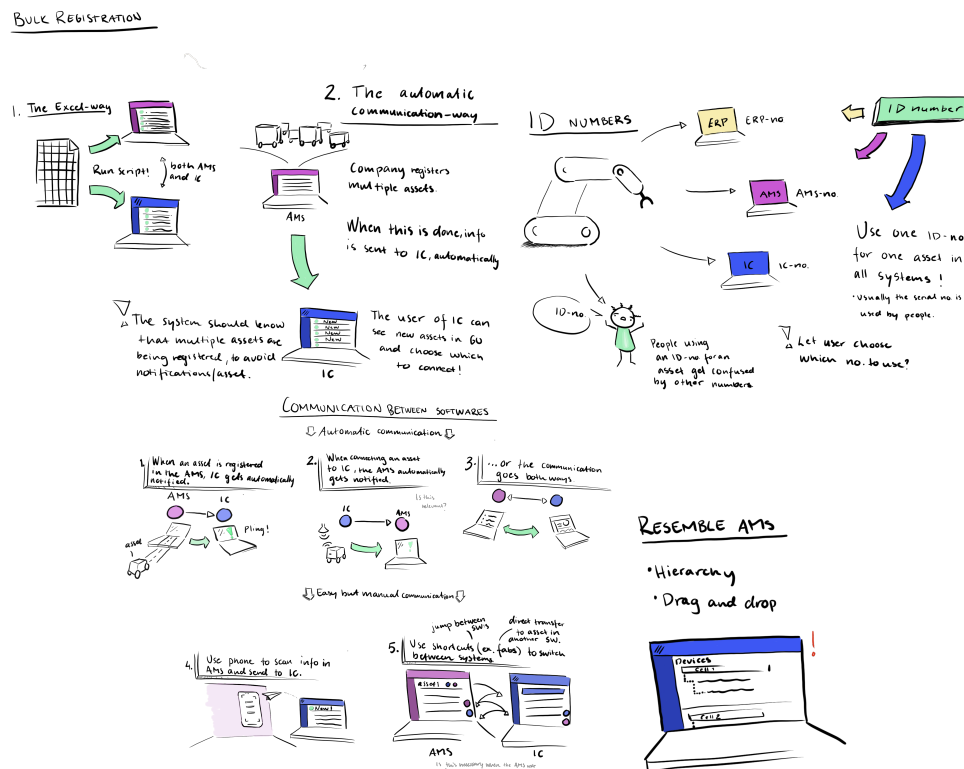


Figure 5.10: A selection of early ideas.

After several ideation sessions followed by evaluation sessions there were thirteen ideas sorted into three groups: No, Maybe and Yes. Out of those thirteen ideas, four were selected to explore and develop further.

- One idea involved a smartphone to scan asset information off of the AMS screen and sending the info to Industry Connect.
- Another idea was that Industry Connect would automatically be informed when new assets were added to the AMS.
- A rather different idea was to integrate all management systems and create a wizard for the entire process, where all persons in the process would be notified when they would need to interact with the asset.

- The last idea involved writing SIM cards in advance and using different APN segments of Industry Connect's network to secure them. The general idea was that when a SIM card tried to connect to the network, Industry Connect would send a request to the AMS, asking if the assets IMEI number was stored in that system. If it was, then that asset was safe to connect to the network, and the SIM card was moved to a trusted APN segment which had internet access.

In addition, four more general ideas were also selected. Those were not so much ideas in themselves, but could very well be combined and incorporated into the four main ideas.

- Explore if gamification could be implemented in the solution in any way.
- Most AMS showed a hierarchical view of assets, to show which assets belonged to which machine cell etc. The idea was that structuring the assets in Industry Connect in a similar hierarchical manner could help give structure in the Industry Connect Network Management Portal, and it might also help locate assets in real life as it gave assets a connection and context to each other.
- Communication between the systems should go from the AMS to Industry Connect, seeing as there is a load of information that needs to be added to the AMS and only a small part of that information is needed in Industry Connect. If looking only at a time line, it also seemed like the AMS was used prior to Industry Connect in the process.
- Keep from adding yet another identifier in the mix. If Industry Connect could collect asset information from the AMS, then it would also be prudent to use the asset identifier as well instead of having Industry Connect give a new name and identifier to each asset.

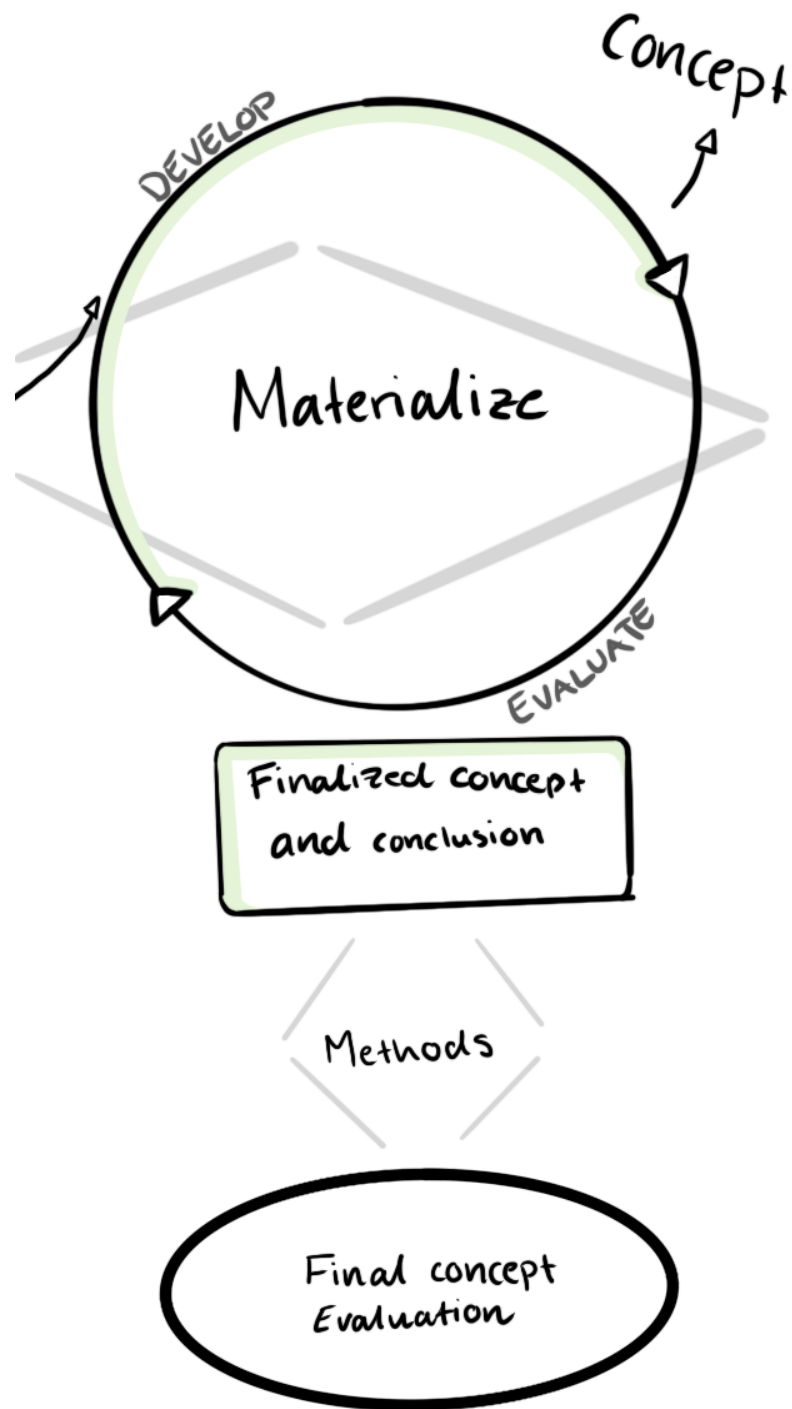


Figure 5.11: An overview of the results from the materialize phase.

5.4 Materialize

In this section, the final concept is presented by describing a user flow and showing designed user interfaces for the flow of connecting assets to Industry Connect. Results from the usability tests of this flow is also presented here.

5.4.1 Testing

After further ideation and evaluation, the ideas above were refined and boiled down to four concepts that together created an entire flow for Industry Connect. For the main part of this flow, an interactive prototype was created and tested with users. In figure 5.12, the result from the usability test is compiled and shows scores on the parameters *easy to use*, *easy to learn* and *trust* along with a compilation of the most common errors.

The participants rated high points for *easy to learn* and gave an average score of 28.3 out of a maximum of 30. *Easy to use* and *trust* was given medium high points. One aspect that affected this was that most participants struggled on the step where they saw on overview of the selected assets with assigned SIM cards. The participants did not know what their next action should be which caused confusion and a decreased sense of control of the system. Another reason for these scores were the naming of the different elements in the interface, more specifically Device, Asset and SIM. It was difficult to comprehend that the term Device served as an umbrella term for both Asset and SIM in this design which made it difficult for the participants to locate the *Add Asset* and *Add SIM card* functions.

The total average score of the experience was 77.1 out of a maximum 100. A conclusion drawn from this score was that user experience was rather high when using this solution but there are elements in the design that can be improved in order to enhance the user experience more. The most common errors along with some comments made by participants during the test can be found in figure 5.12. Errors made by five or more participants were considered as severe problems, errors made by two to four participants were considered as moderate problems and errors made by one or less participants were not considered as problems.

A selection of improvements were immediately implemented in a bid to solve the severe problems identified in the error matrix, figure 5.12. The final concept is described below, along with the design improvements which are accompanied by a user story each.

Q #	SUS Sentence	P1	P2	P3	P4	P5	P6	
S1	I think that I would like to use this system frequently	4	4	5	3	4	4	
S2	I found the system unnecessarily complex	1	2	2	1	2	2	
S3	I thought the system was easy to use	3	4	4	4	4	4	
S4	I think that I would need the support of a technical person to be able to use this system	2	4	3	1	1	1	
S5	I found the various functions in this system were well integrated	3	4	5	4	4	4	
S6	I thought there was too much inconsistency in this system	2	2	3	1	1	2	
S7	I would imagine that most people would learn to use this system very quickly	5	5	5	5	5	5	
S8	I was struggling using the system	3	1	3	2	4	3	
S9	I felt very confident using the system	2	5	5	4	2	4	
S10	I needed to learn a lot of things before I could get going with this system	1	1	1	1	3	2	
TOTAL		70	80	80	85	70	77.5	77.1 / 100
Easy to Use (S3, S4, S8)		17,5	20	17,5	25	20	22,5	21.7 / 30
Easy to Learn (S2, S7, S10)		30	27,5	27,5	30	22,5	25	28.3 / 30
Trust (S5, S6, S9)		15	25	25	25	20	22,5	22.0 / 30

Task	Errors	P1	P2	P3	P4	P5	P6	
1	"Add or select SIM to asset" misunderstood the title and did not understand that each asset already had an assigned SIM card. Did not immediately press the "Save" button	1	1	1		1	1	5 / 6
1	Believed that the Device list contains the ones in need of connecting. Goes to add SIM cards and believes the assets are then connected.						1	1 / 6
1	Did not use the alert, felt the information there was unimportant. Had trouble finding where to add assets. Found Add Device by it lighting up.					1	1	2 / 6
2	Device list - Trouble finding the "Add SIM" function.	1	1		1	1	1	5 / 6
2	Does not understand that "Add SIM" leads to writing a SIM card					1		1 / 6
2	"Summary" for write SIM. When one SIM card was written, they immediately pressed the "Finish" button and did not press the "Add another SIM" button for the second one	1		1				2 / 6
3	"Add or select SIM to asset/no sim" misunderstood that a new SIM card has to be written in this step.		1		1		1	3 / 6
3	"Add or select SIM to asset/no sim" Doesn't understand that new new SIM card has been added to the third asset.			1				1 / 6
3	Did not see that SIM card could be added, insted backed out and went to Add Device and added a SIM card. Then went back and added assets the normal way (not the C route)					1		1 / 6

Comments	
The title confuses them. Think they have to exit the wizard to add SIM. Some had major issues with this, because of the title. "Add new SIM card" But where do I do that?	
Made new SIM cards and believed they would auto connect the assets in the device list that had red connection symbols.	
Tried the menu on the left, found the Add Device by it lighting up. "Add device... Noo, I don't think so? *clicks* Aha, add assets!"	
"Is a SIM card a device?". Looks in the left menu. Don't associate "+Add Device" to add SIM. "Device - that's not what I want"	
"Add SIM? No, I want to write a SIM" backed out to the device list, then went back and read the small info symbol. That text mentioned "write".	
Clicks on finish button quickly, points out that they got no feedback in the device list afterwards	
"Okej, så den här snubben har inget SIM-kort". "Next step? I just made a SIM... Ahh but there is nothing written on it..."	
"Aha, I need to write a SIM first. I made two, they got automatically assigned. I'll go back and make another SIM"	

Figure 5.12: Results from the usability tests, measuring *easy to use*, *easy to learn*, *trust* and the most common errors made by the participants.

5.4.2 Concept Flow

The entire flow of the final concept is visualised in figure 5.13. The flow starts with assets and their information being automatically imported to Industry Connect. Then comes the new way of adding SIM cards and connecting assets to the network. During the period where asset is in operation there are no changes made, instead the last part of the flow involves the AMS informing Industry Connect whenever an asset is taken out of use and decommissioned.

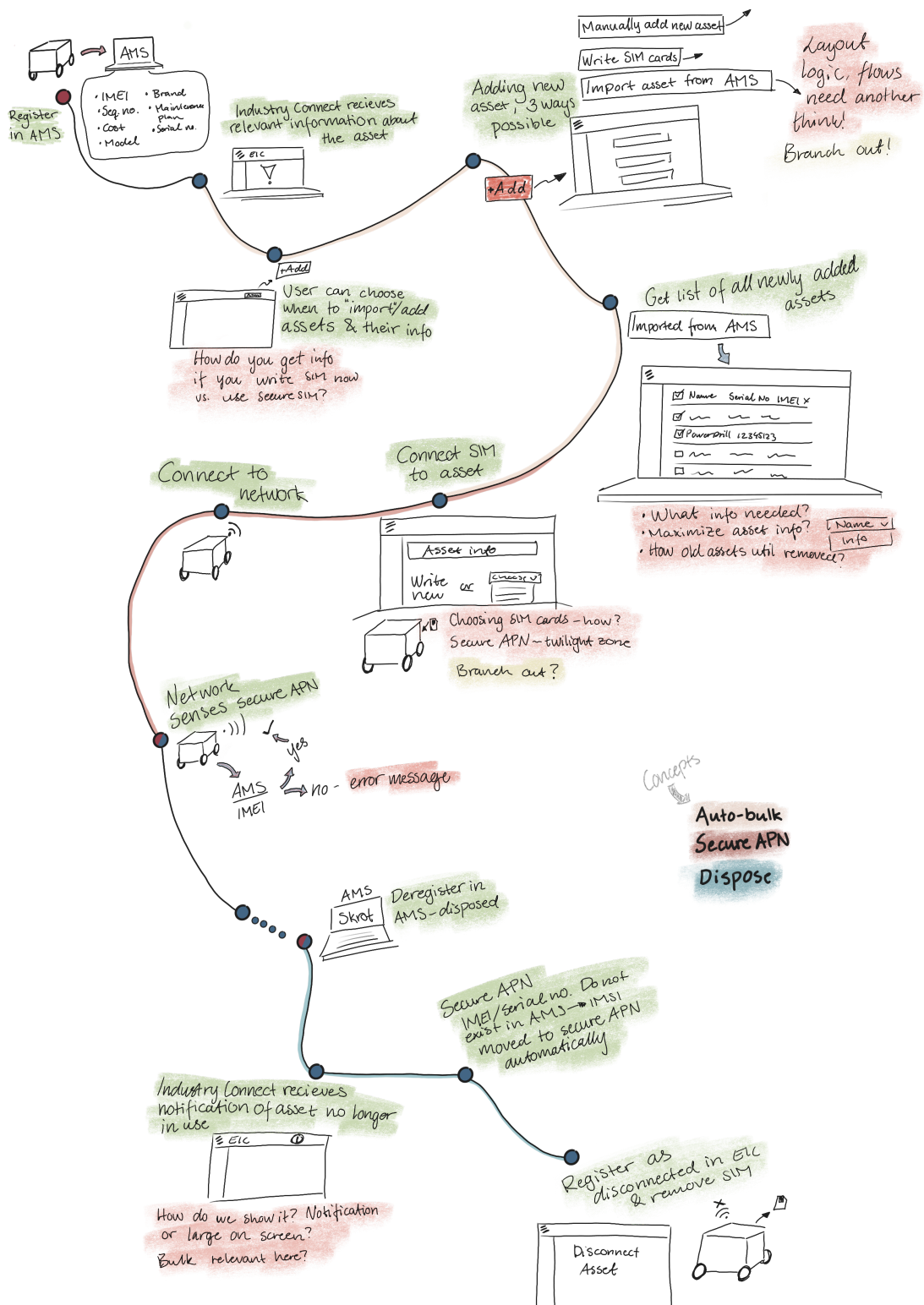


Figure 5.13: The flow for Industry Connect.

Assets Imported Automatically

The first part of the flow describes the communication between the AMS and Industry Connect. Whenever a new asset is added to the AMS there is a lot of information recorded about the asset, such as price, manufacturer, suggested maintenance intervals, etc. All this information is not needed for the purposes of Industry Connect, however. Only the asset's name, serial number and IMEI (if it has one) are sent to Industry Connect. In the Network Management Portal of Industry Connect, a snackbar notification appears to inform the user that a number of new assets have been imported from the AMS, see figure 5.14. The user can follow this notification to a list of all the newly imported assets.

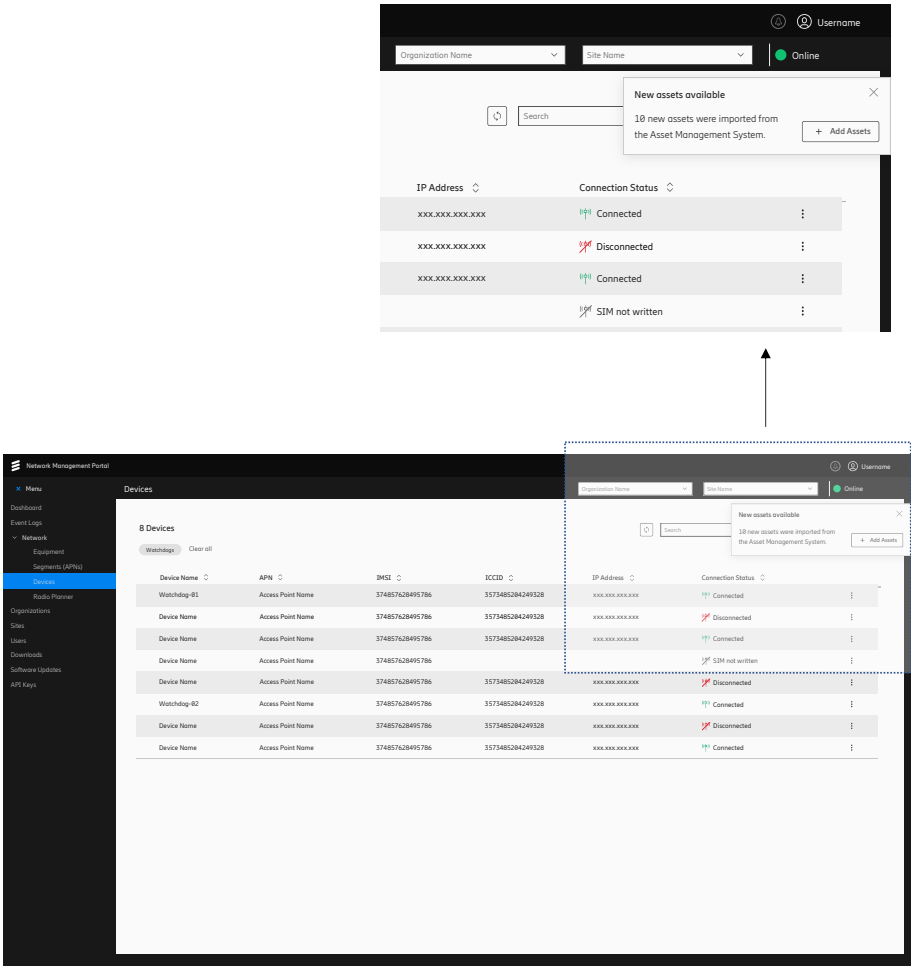


Figure 5.14: A snackbar notification with a magnification of it.

There are two things to take notice of here. Firstly, Industry Connect should have a filtering system in place, either a blacklist or whitelist so that only relevant assets are imported. Otherwise the Network Management Portal might be overrun by assets that are not of interest for Industry Connect. Secondly, imported assets are not automatically connected to the network. That an asset is imported only means that its data has been transferred and is waiting for the user to fully add and connect

it. To connect an asset to the network, there needs to be a SIM card inserted to the asset. As of today, the Network Management Portal does distinguish between devices and SIM cards, as it is still in development. For the sake of this thesis, however, there needs to be a difference in the Network Management Portal between an asset and a SIM card. In order to connect one of the imported assets, a specific SIM card needs to be linked with a specific asset in the system as well as in real life.

Writing SIM Cards

With the current flow of the Network Management Portal, a SIM card must be paired and placed in a physical device as soon as it is written. An integral part of the new user flow allows users to write SIM cards well in advance. Such pre-written SIM cards can then be stored until they are needed. The pre-written SIM card is placed in a secure APN, which is not allowed access to the internet. That means that even if someone were to get their hands on one, it does not provide a way into the network.

Two buttons for adding SIM cards or adding Assets are placed next to each other, see figure 5.15. So as to not confuse users by presenting them with two primary buttons, the SIM button was made white, while the Asset button is blue. This is partly due to the fact that there is some ambiguity as to how much pre-written SIM cards would be used, an issue which will be discussed further in subsection 6.3.2, What is a Device?. The main reason for the colours of the buttons is that the Asset button must always be used to connect new assets to the network, and it is considered the main purpose of Industry Connect. To add new SIM cards, the user presses the **Add SIM** button and follows a three step wizard. The graphical user interface in this wizard is essentially unchanged from the current Industry Connect solution. The change is in essence that the user can write SIM cards in advance.

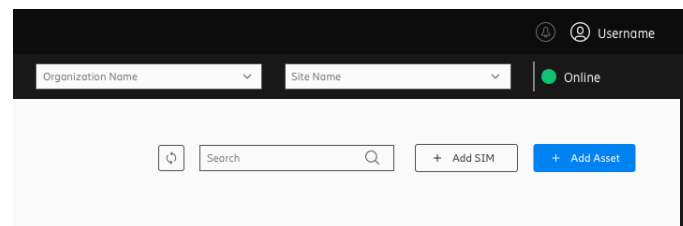


Figure 5.15: A magnification showing the two buttons for adding SIM cards and Assets.

Based on the result from the usability tests, the following design improvement was implemented to the design in the *Add SIM card* wizard. *"As a user of the Industry Connect Network Management Portal, I want to find the 'Add SIM' function so that I can write new SIM cards."* During the tests, the participants struggled with finding the *Add SIM card* function because they did not associate SIM card with Device. They did therefore not come to the conclusion that the adding SIM cards could be found after pressing the **Add Device** button on the main screen. The improvement

implemented to solve this problem was to add two different buttons on the main list screen, **Add SIM** and **Add Asset**.

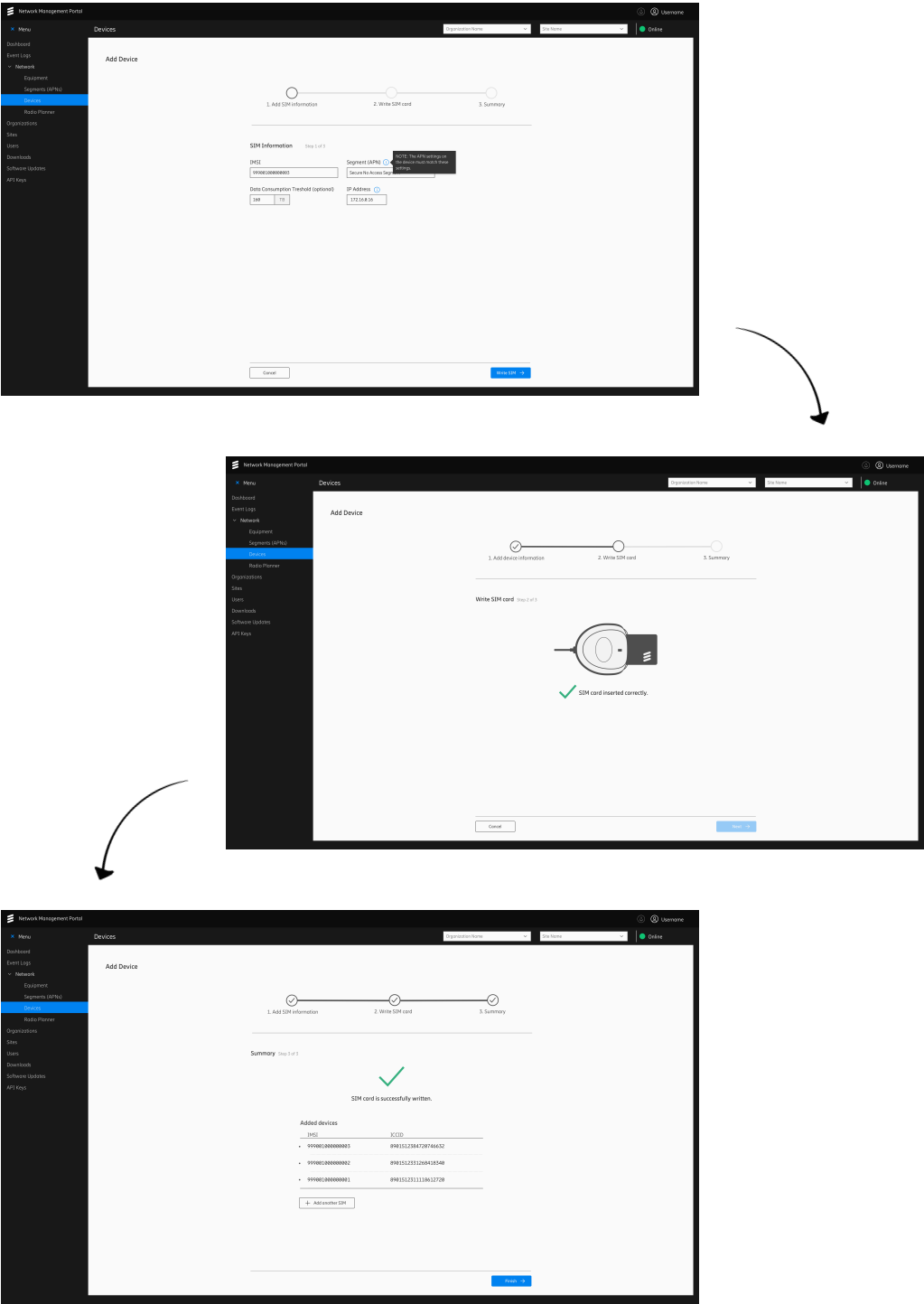


Figure 5.16: The flow of the Add SIM card wizard.

Connecting Assets to the Network

To connect new assets, the user can go via the snackbar notification or via the **Add Assets** button. When clicking the **Add Assets** button, the concept allows users to add assets manually if they want - in which case they fill in the required information themselves. Otherwise, since multiple assets and their relevant information have been imported from the AMS, it is now possible to select several of these assets to connect at once to the network. This is the first step in the wizard, see 5.17. If the user has pre-written SIM cards available, those can be used now. Each asset has automatically been assigned a pre-written SIM card but the user is still free to re-assign SIM cards between assets. If a SIM card is physically missing, for instance, the user can assign a different SIM card to the asset in the system. If all assets has been assigned a SIM card, the user can simply continue to the next step in the wizard immediately, see 5.17. If some assets lack assigned SIM card, the user can add new SIM cards in this step, by pressing the **Add SIM card** button. This flow is similar to the Add SIM card wizard described earlier.

The third step in the wizard displays a gif image which shows that the SIM cards now should be physically paired with the asset. To make sure to have the same match of physical SIM card to physical asset as in the digital system, information of the asset and SIM card pairs are displayed under the gif, as in 5.18. When all SIM cards have been paired with the correct assets, a summary of all newly added asset and SIM pairs is displayed as the fourth and final step of the wizard. This gives the user an overview of what has just been done and the user can thereby reassure that everything is correct before pressing **Finish**.

As mentioned above, pre-written SIM cards are placed in an APN segment without internet access. Once it has been paired with an asset, Industry Connect sends a request to the AMS to check if that asset's serial number or IMEI is registered in the AMS. If it is, then Industry Connect knows it is an asset which is safe to connect to the network and therefore the SIM card is moved to an APN which does have internet access. If the asset is not registered in the AMS, then Industry Connect would display a warning, asking the user if they really want to connect this asset to the network.

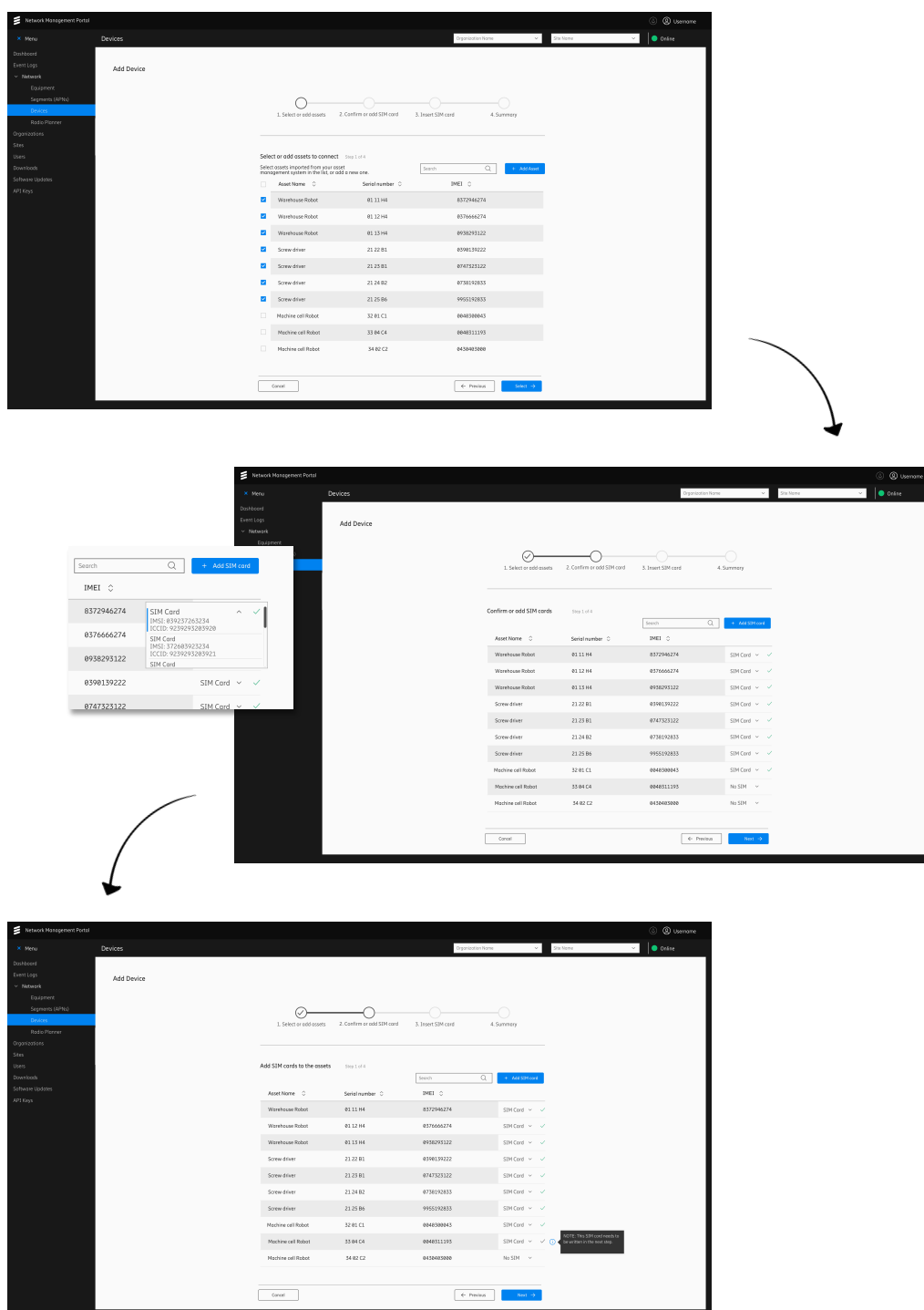


Figure 5.17: The flow of the Add Asset wizard when adding multiple assets (1/2).

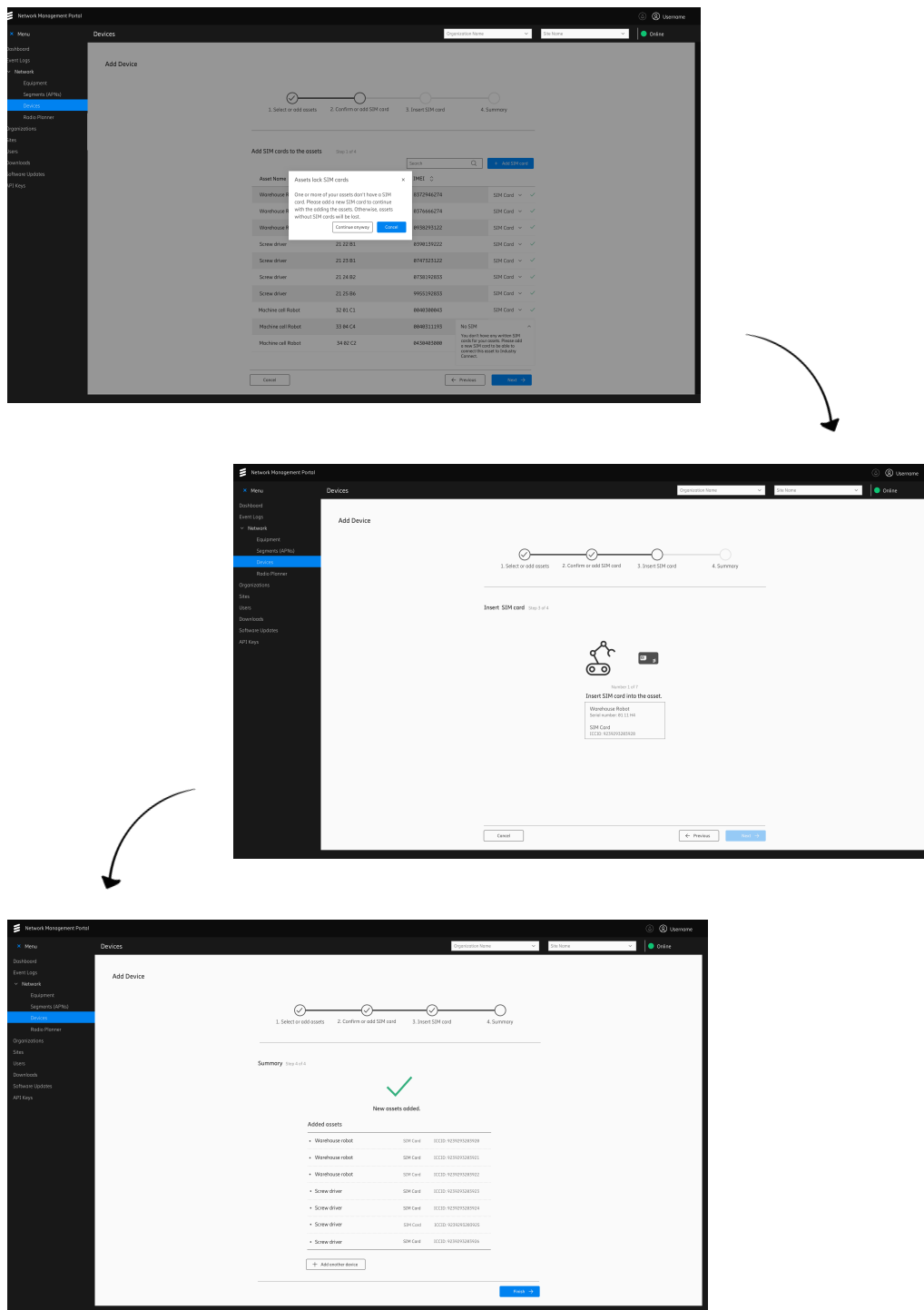


Figure 5.18: The flow of the Add Asset wizard when adding multiple assets (2/2).

Based on the result from the usability tests, the following design improvements were implemented to the design.

"As a user who adds new assets to Industry Connect, I want to assign each asset a SIM card so that the new assets can be connected to the network." At one point in the test, the user would not have enough pre-written SIM cards to match the number of chosen assets they wanted to connect. In this step many participants did not realise they had to press the "Write SIM card"-button. Another common problem here was that participants did not understand that the available pre-written SIM cards had been automatically assigned one asset each. The improvements implemented to solve these problems were to change the title of this step from "Select or add SIM card" to "Confirm or add SIM card". The naming on the button changed from "Write SIM card" to "Add SIM card".

"As a user who adds new assets to Industry Connect, I want to see which assets that are assigned written SIM cards so that new SIM cards can be written to the remaining assets." In the usability tests, assets which were assigned pre-written SIM cards had a green SIM card icon on the right side of the row and assets with no SIM cards or unwritten SIM cards had a grey SIM card icon. It was clear that the participants did not interpret these icons as intended. The conclusion was drawn that the SIM card icons, despite their colourings, did not give an understanding of "this one is done, finished". The icon was therefore changed to a check mark instead, given its clear connotation to "ready, done, finished".

"As a user who adds new assets to Industry Connect, I want to see a summary containing necessary information so that I can be reassured that assets and SIM cards have been added correctly." In the final summary step of the wizard, the SIM card information was added next to each asset to give more feedback to the user and to relate to the actions they had just performed.

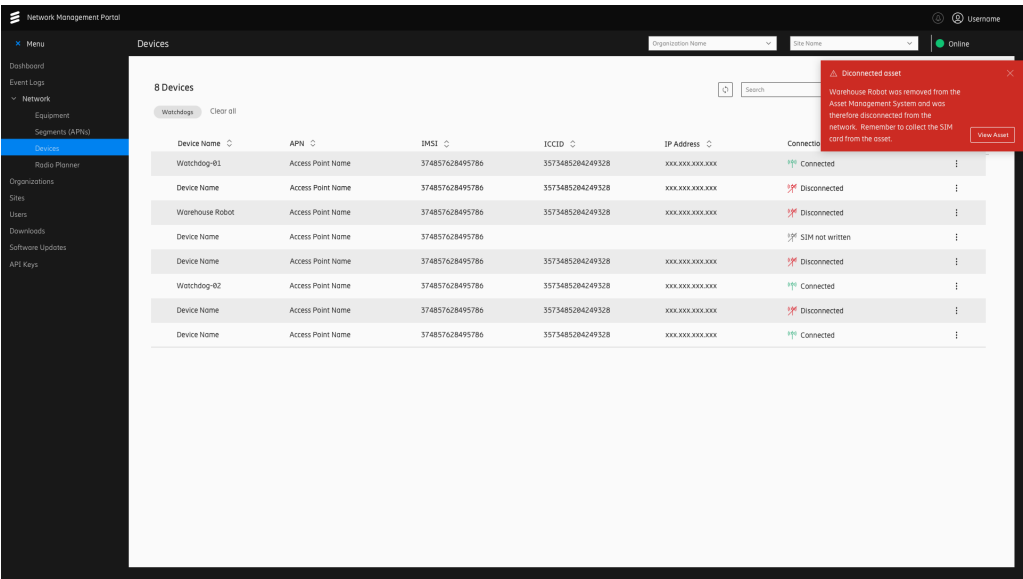


Figure 5.19: A snackbar showing when an asset is decommissioned from the AMS.

Decommissioning Assets

The last part of the new user flow involves the decommissioning of an asset. When an asset is taken out of use, it is not deleted from an AMS, merely de-registered as "out of use". Once an asset is de-registered, the AMS should share such information with Industry Connect - similar to how it informs when an asset has been added. When an asset is de-registered in the AMS, the SIM card paired with that asset is transferred to an APN with no access to internet for security reasons. Industry Connect also gives the user an alert that the asset is no longer in use, and that the SIM card should be retrieved so that it is not thrown away.

5.4.3 Design suggestions

In addition to the improvements made above, a number of suggestions for future improvement of the design are given. These suggestions would need of further testing in order to conclude whether the changes indeed are improvements as well as how they should be implemented.

"As a user who adds new assets to Industry Connect, I want to write a new SIM card so that I can add it to an asset without exiting the wizard." In the prototype, the participant would see a list of the assets they are wanting to connect. They then press a button that allows them to add the information for a new SIM card, but the SIM card is not physically written in this same step. Instead, the user is taken back to the list of assets, where the newly added SIM information has been paired with an asset. The SIM card is then written in the next of the wizard, in combination with it being inserted to its asset. One suggestion for improvement, which would require further testing, is to physically write the newly added SIM card in step 2 of the wizard, before it is assigned to an asset. This could make the user flow more consistent in relation to the flow of only adding new SIM cards. The challenge however, is to make sure the user still feels in control of where the user is in the interface. By adding more steps while remaining in one step in the wizard could cause a sense of lost user control.

"As a user who adds new SIM cards to Industry Connect, I want to add multiple SIM cards at once so that I can add SIM cards in an efficient way without looping the wizard." In the flow where the user only adds new SIM cards, the user experience could be enhanced by enabling the user to add the information of multiple SIM cards simultaneously. They would still need to be physically written one by one. Still, this would decrease the amount of clicks the user would have to do in order to add the desired number of SIM cards, compared to the current concept. However, this suggestion would require further testing to ensure that this change would be an improvement. Adding more information and actions in one step of the wizard, could lead to other consequences.

"As a user who manages assets in Industry Connect, I want to get notified when an asset has been decommissioned in the AMS so that the SIM card can be deactivated." A design suggestion for the SIM card management flow in the NMP is implement

a user flow for decommission of assets. When an asset is decommissioned in AMS, the user can be notified in the NMP and be led to a flow in the interface where the user can easily digitally separate the SIM card from the asset and decommission the asset in the NMP.

"As a user who manages assets in Industry Connect, I want clarity in the physical and digital representations of assets and SIM cards so I can sure which actions are done virtually and which are done physically." A design suggestion is to further investigate the relationship between an asset and a SIM card's physical representations and their digital representations in the NMP. This relationship is currently defined by how assets and SIM cards are named and identified digitally and physically. Often, participants were confused if they were supposed do something virtually or physically. Actions however are often a combination of virtual and physical actions, which add to the confusion. It must be clear when an action is performed virtually, eg. adding information in the NMP; physically, eg. inserting SIM card into asset; or both, eg. first inputting SIM information in the NMP and then physically writing the SIM.

"As a user of Industry Connect, I want the naming of elements in the portal to be easy to understand so that I can be sure how to execute my desired action." In the design developed in this project, the term *device* remains as a term for an asset which has been paired with a SIM card. However, many participants were very confounded by the term *device*, as they did not associate that word with either assets or SIM cards. Currently the concept flow is places under *Devices* in the NMP menu. If this is understandable for users, and whether the terms for assets, SIM cards or devices should be replaced or clarified needs further investigation.

6

Discussion

6.1 Target Segment

The study involved two types of companies which generally can be divided into companies with wireless assets and companies with little to no wireless assets. There were also two parts of the study: understanding asset management practice and then developing a concept. The first part of the study provided understanding of how asset management is performed today, what asset management systems looked like and how they were used. For this reason, most companies that were contacted were seen as relevant for this part of the study. The interviewees during this first part of the project would later be represented by the personas Moa, Sam or Bo who all gave insights of asset management practice as it is executed today. It became clear, however, that it was necessary to look for companies with more wireless equipment as well as people who work with IT or network security in the process in order to keep developing the persona Ivar.

It was, however, quite difficult to find a Ivar at the companies, as many of them lacked wireless assets. One of the interviewees expressed that the IT managers who ensure that the network is secure are not very knowledgeable within production or the equipment. The interviewee continued by saying:

"As automation and control systems and connected machine equipment becomes more and more common, a kind of production-IT role emerges, who would be the one at the company who owns the documentation and knows how the digital representation of the facility looks. Such things become more and more common."

6.1.1 The Evolving Production IT Role

The study is looking quite far into the future - as of right now Industry Connect is still in an early state and there are few companies that use cellular connectivity in their factories. Generally, many companies have wired assets, mostly because these assets are not mobile and consequently do not need to be wireless. Mobile assets in industrial environments can use via Wi-Fi, RFID or other wireless technologies for communication but in this study, the extent of these mobile assets were rather

low. As time goes on, it is likely that more companies will start using wireless technologies to a greater extent. As stated in the quote above, one prediction is that a new production-IT role will emerge and with it a set of other roles. These new, future roles in the manufacturing industry could perhaps be represented by personas with other goals, motivations and needs than what was identified today. If future roles would lead to new personas, they might be even more suitable for Industry Connect than the ones uncovered in this study, as their roles will adapt to the workings of connected factories.

6.1.2 Contacting Companies

It turned out to be quite difficult to get hold of people as the Covid-19 pandemic meant many companies furloughed staff. Physical meetings and interviews were canceled quite early in the project, only three interviews were held on company premises. Companies assumed to be the most relevant for this study was, as mentioned, companies in possession of wireless assets which generally are large, global companies who are active in competitive markets. The process of getting in touch with the right person for this project were significantly longer when contacting these larger companies, than with smaller business. The smaller companies were faster in the process of responding and setting up interviews. Once some of the elusive IT-persons were identified however, the Covid-19 pandemic caused a lot of uncertainty for most companies and helping graduate students with their master's thesis was not high on their priority list. Once things settled down, the larger companies wanted for interviews furloughed their staff, which meant even longer response time.

A new strategy, to talk with several people in each organisation in order to get different points of views, was adapted to get around the problem of not getting responses from many companies. This turned out to be of great use when constructing both the personas and the journey map. Talking to persons with different roles in the same organisation gave different perspectives and a great deal of insight to their cooperation and needs. Another unexpected advantage about the decreased availability of companies was that a new type of possible stakeholder was detected. Some companies, it turned out, were hired to manage maintenance or specific types of assets for an organisation. An example of this was a company hired by a warehouse facility to manage the maintenance of the warehouse machines and other assets. The warehouse company itself did not have the manpower or the needed competence, and so they outsourced the maintenance to a company that did. This meant that the maintenance company managed the AMS and in some cases, where they were given free reigns as part of their contract, they also made suggestions on what machines to purchase or upgrade. In other cases however, assets would just be delivered and they had to get them up and running and perform the needed maintenance. The warehouse facility did use a set of wireless packing robots, a kind of robots used in e-commerce, as well as a wireless voice controlled collect system for collecting and packing wares manually. There were two people interviewed at this company, one with thorough knowledge of the overall asset management process, and one with a more intimate knowledge of the site and systems in questions. If not both

had been interviewed, a great deal of valuable information would have been lost, as their different kinds of knowledge complemented each other. Getting information from several roles in a company generated insights from different perspectives which was valuable for this project.

Regrettably, the maintenance exhibition Underhållsmässan 2020 was also closed due to the prevailing circumstances of the pandemic. The plan was to mingle and talk with several companies with IoT solutions at the exhibition, in order to find new angles and more companies to interview. Instead, the list of the planned exhibitors was used to contact a handful of interesting companies. Spending a day talking to people would have given more value than reading a set of websites, as it would have allowed to set up an impromptu interview right then and there during the exhibition. In the end, some of the companies that were contacted did give a lot of useful information about device connectivity in the manufacturing industry from their perspective.

6.2 Methods and Process

An unforeseen challenge that we had to face was to adapt the chosen methods for this project on order to perform them digitally. The sudden conversion where both the client, that is Ericsson, and all stakeholders vacated their premises and started working from home, set new demands on the choice and execution of methods.

6.2.1 Working Remotely

As most people did this spring, we also started working from home. Fortunately, most of the work could very well be performed remotely. The greatest challenge with working from home was the video interviews that were conducted. In a phone call or video meeting, accessing latent knowledge became much more difficult. There was no viable way to conduct observations, and so instead, the interviews were characterised by a greater degree of probing. People were also encouraged to talk more freely about their work, what they usually do and how they do it. Whilst the interviewee would talk, probing questions were interjected and many questions were written down in order to re-visit them once the interviewee finished talking. Interjecting questions in video meeting is rather difficult, as it often leads to several people talking over each other, and no one hearing what anyone said. Normal feedback, such as body language, nods and hums of understanding disappear to an extent in video interviews, especially as some interviewees did not have a camera on. One approach to gain more latent knowledge was the participants were supposed to create a timeline using paper, pens and sticky notes in order to use it as a mediating object during the interview. The possibility of using other tools than just a verbal dialogue was more difficult in video interviews and did not work as well as we had hoped.

In the explore phase of the project, however, a workshop was conducted where a digital whiteboard tool was used. Using this tool worked well because all participants

could write, draw and move notes on the virtual whiteboard freely and it created an interesting dynamic in the workshop. Since a digital tool was used, feedback and new insights were continuously documented on this virtual whiteboard and it was thereby saved and accessible for the remaining part of the project. If the workshop had been executed on a physical whiteboard, the insights would not have been as accessible and might have been lost during the project.

6.2.2 Test and Test Subjects

The usability test was conducted with participants outside of the target group. This was partly due to the fact that expert users were hard to find, and the main thing that was tested was if users understood the flow of the concept. For this, novice users were a reasonable choice - the test could prove whether or not the flow was understandable for a novice and if they understood where they were in the flow and where they should go next. To offset the participants lack of knowledge of cellular technology, they were given a cheat sheet prior to the tests. The sheet provided summaries of what Industry Connect was as well as explanations and descriptions of the various abbreviations used in the interface, such as IMSI and APN.

Due to tests being done remotely, the participants had to imagine that they handled a SIM card writer since a real one could not be used in this test. Testing this would, however, have been interesting in order to find out if users would need or want an additional identifier for a SIM card, one that would perhaps be easier to read than the 15 digit ICCID. Although, after further hypothesising the conclusion was that such a test would need to be more elaborate than the circumstances allowed. A test of actually handling SIM cards would first of all benefit from being done in person, and also over a longer period of time in order to see if people would write SIM cards in advance and how many they would have in store in that case. All in all, a simpler test constrained to the whether labels, information and the flow were understandable were enough for the purposes of the thesis. It is however a strong recommendation to investigate further how pre-written SIM cards are handled, stored and managed.

6.3 Future Work

Industry Connect is still, in manner of speaking, in its cradle. It is still being developed, tested and changed. Therefore there are a number of things that could be recommended as future work, based on the discoveries made in this thesis.

6.3.1 Virtuality and Reality

One thing to take notice of, based on the usability tests, is to make it clear to the user what needs to be done virtually in the system and what needs to be done in reality. The participants were generally confused when it came to adding a SIM card and writing a SIM card - what is the difference? The same thing happened when participants were asked to connect a new asset to the network - is connecting different from adding, and where does the SIM card enter the process?

Granted, the testing prototype did use some of these terms interchangeably, which contributed to confusion for the participants. It was therefore one of the greater learnings of the test: the wording of these actions needs to be consistent, and it needs to be abundantly clear to the user if they are doing something in the system or in the real world. There are two layers in place in Industry Connect: the virtual layer and the reality. The difference, and the interplay between them, needs to be balanced and apparent to the user. A SIM card, for instance, is added to the system in its virtual form, where its inherent information can be stored and viewed. Yet it is also created, written, in real life at the same time. An asset is added to the system by way of its virtual asset information. In real life the asset may be in front of the user, or it might be several hundred meters away, or in another building all together.

Then there is also the act of pairing a SIM card with an asset, where it is important that a SIM card is inserted into the correct asset. The aspect of pairing the correct SIM card to the asset or just keeping track of pre-written SIM cards, were not in focus for the solution developed in this project. This is a complex problem to solve with design since it has to do with how organised a person or organisation is in their procedures and the behaviours related to this issue require further exploring and research. In the solution developed in this project, the wizard encourages the user to insert the correct SIM cards in to the asset immediately. The identifier which the user can use to pair the correct SIM card to its asset is the ICCID, a numbered which is labeled on the physical and virtual SIM card. If the user would follow the wizard concerning this aspect, SIM cards and assets should be paired correctly. Realistically, however, there could be surrounding circumstances at each company that would influence whether this procedure will be followed or not. The user would still be free to physically pair the SIM card and asset at another time, which could increase the risk of misplaced SIM cards or doing other lapses.

Given the complexity of having both a virtual and physical layer of things, it is important that the user gets clear feedback of when they have done something and what they did. If they added a new asset to the system, they need to be reassured that's what they did. If they inserted a SIM card into an asset, they should be assured they in fact paired the SIM card with the correct asset.

6.3.2 What is a Device?

In the same way the virtual and physical layers are separate yet combined, there is also a similar interplay between assets and SIM cards. Currently, Industry Connect does not distinguish between SIM cards and assets in the Network Management Portal. They are simply called devices, as all their devices essentially are virtual SIM cards with the name of the physical device they are to be inserted in. The concept presented in this thesis is using the term device as an asset which has been paired with a SIM card. Distinguishing assets and SIM cards as separate entities is a suggestion for the future.

With Industry Connect, data could be transferred from each connected device. Therefore, distinguishing assets and SIM cards as separate entities begs the question: do you want to track the data of a SIM card or the data of an asset? If a SIM card is placed in a forklift, for example, it could be possible to track how far it has driven in a period of time. If that SIM card is placed into a different forklift, what then? Would you want the total distance that SIM card itself has travelled in both forklifts or would you want the individual distances that each forklift travelled? To measure the distance is a very rudimentary example, but it illustrates the difference of the data if you were to track the SIM card or the asset. This needs testing and further research and likely the result will be that it depends on what kind of company it is and how they operate.

Identifying a SIM Card

It has been a great thought exercise during the later stages of the project whether or not a SIM card needs additional information in the Network Management Portal to aid users in matching the virtual SIM card with the physical one. Essentially, the question is whether you should name the SIM cards as well as the asset. Should there be a time stamp in the system to tell when each SIM card was written, or should the system keep a sequential numbering of the written SIM cards? If a naming scheme is used it needs to be crystal clear in the system which one is the asset and which is the SIM. Otherwise there might be a lot of confusion if the SIM cards had the same name as the assets they are placed in. Moreover, if an asset is decommissioned, the SIM name would likely need to be changed to. Admittedly, assets are often acquired on a basis of several years. It might not be so bad to name SIM cards, if the name only had to be changed every eight years or so on average.

Another idea to help the user pick the correct SIM card was to include a timestamp as an identifier for each SIM card in the system. The system would thus display the time stamp, IMSI and ICCID for each SIM. On the actual SIM card, however, there would still only be the ICCID as there is no more room to print anything on the SIM body. If you kept track of the order you wrote the SIM cards the time stamp might help you narrow down your search, if you would know that the oldest SIM you made is in, say, a certain bunch or box. However, this is heavily dependent on that the user would organise the SIM cards according to the date they were written, which may or may not be the preferable way to organise SIM cards for every company. If

the SIM cards were not organised based on when they were written, the time stamp would not help pairing the virtual SIM with the physical one since the time stamp is not printed on the actual SIM body. It would only help narrowing down the search.

Benefits and drawbacks with pre-written SIM Cards

All the ideas of an additional identifier of a SIM card came to be because the traditional identifier of a SIM card, the ICCID, is just a very long string of numbers. Displaying this in the Network Management Portal and then making the user look for the corresponding ICCID in very small print on the SIM bodies in front of them likely results in a tedious job. As mentioned above, the handling of the physical SIM cards was not tested in the project. How a user might choose to handle and store pre-written SIM cards is pure speculation at this point in time. There is a distinct possibility that it would in fact be complicated to write and store a bunch of SIM cards in advance.

The notion of writing SIM cards in advance came originally from Ericsson, as a speculation on different ways SIM cards might or could possibly be used. Industry Connect is designed to be easy to use and therefore the idea of simplicity for the user was carried on to this thesis. The idea of structuring your work in your own way, just popping SIM cards into assets and everything working automatically was a central vision for the concept development. Simplicity can also be manifested by allowing the user to work in the way they want, as opposed to forcing them to work in one specific way. Writing SIM cards in advance will not necessarily save any time in the grand scheme of things, but it will allow you to structure your time. The user can write SIM cards when it suits them and then keep them on hand. When the time comes to spend a day or two connecting new assets to the network, that tedious days work time is shortened by having asset information imported from the AMS as well as using pre-written SIM cards. Even though the total time of writing and inserting SIM cards may not be shortened, you do have the possibility to plan your work and time in a way not previously possible.

Another benefit with writing SIM cards in advance is the possibility of dividing this monotonous task. By enabling people to choose when to write SIM cards, they can plan when to execute this task with regards to their other routines and tasks during a work day. How SIM cards are managed in the physical environment is something we suggest to research and test further. It might turn out that only a few organisations would write SIM cards in advance. Depending on the outcome of people's behaviour in a future study regarding managing SIM cards, there is a choice to make the option more or less visible in the Management Portal. The most commonly used work flow should always be the easiest and most visible in an interface.

One final point on pre-written SIM cards is this: if it is possible to write SIM cards in advance, it should be an incredibly simple process to write several cards. As one of the design suggestions presented in section 5.4, Materialize, multiple SIM cards could be added without the need of going through the wizard several times. Since the SIM card information is automatically filled in, the user only has to approve it

and make any changes if they so desire. This creates the possibility of approving the information of multiple SIM cards at once in this step of the wizard, as opposed to one at a time as the current concept dictates. This solution would save the user a lot of clicks compared to the current concept. However, this flow would need testing in order to determine whether it would be an improvement or not. Then it is just a matter of writing them all, which of course would still take the same amount of time - that can not be avoided. However, the entire process could go as follows: approve the SIM card information, write the SIM, and then do that over and over for all SIM cards. Or it could go like this: approve the information of ten SIM cards, write the SIM cards and then it is done.

6.4 The Final Concept

The solution developed in this project is based on the needs of the person responsible of the asset management practice at a factory as well as the needs of the person who would be responsible for the connectivity of assets. This person is also the primary user of the solution. Functions in this solution that were implemented to meet those needs are; automatically send essential asset information from AMS to Industry Connect, enabling the user to add multiple assets to the network at once and to add SIM cards by writing them either prior to or whilst adding assets. We would argue that the developed flow and user interface meet those needs by enabling the user to plan when to write SIM cards and by reducing the amount of monotonous tasks when adding multiple assets to the network. Adding multiple assets to the network requires less time of the user to execute the task. The risk of deviations in naming of assets and identifiers used in the different systems, would also be decreased by automatically sharing information between the systems.

To view this solution with a more critical eye, this new user flow may not be more efficient when only one asset is to be added to the network. If the parameter *efficiency* would be measured in the amount of time or clicks required to execute the task. This solution relies on that the user would prepare with written SIM cards in order to make the process of adding new assets to the network more efficient. As it is now, the user has the freedom of choosing whether to prepare SIM cards prior to adding assets or not. That means that if the user chooses write SIM cards in advance, the developed user flow might not increase the efficiency.

However, the solution would still be as effective. One could also argue that the users themselves can choose the procedure for adding assets and still reach the goal of the task. By designing a user flow which can provide multiple secure ways of reaching the goal, enables the user to add assets in the way that suits how they operate at each individual company. This, while still maintaining a secure asset management when it comes to connecting assets to a network.

6.5 Societal, ethical and ecological aspects

Asset management in general is centered around getting value from assets and therefore taking care of them is important. Asset management provides knowledge of the entire life cycle of assets and can include specifics such as performance and needs. The knowledge of asset needs, life-cycle and performance means that maintenance can be administered only when actually required. This could lead to fewer assets breaking down due to poor maintenance as well as reduced waste in unnecessary maintenance. When an asset is being decommissioned it is often either sold or taken to be scrapped. The new concept flow for Industry Connect alerts the user that an asset is being decommissioned, and provides a reminder to collect the SIM card that is inserted in that asset. This spares the user from accidentally throwing away or losing SIM cards if their colleagues would neglect to inform them when an asset is being decommissioned.

As mentioned previously, the way pre-written SIM cards would be stored and handled needs further investigation. It is especially interesting to know how users would in fact store and keep track of a batch of pre-written SIM cards. A downside to writing SIM cards in advance is that it could lead to a waste of resources if they are not properly kept track of. Such SIM cards could be misplaced, overlooked or forgotten, in which case new SIM cards would be written unnecessarily. This could also lead to the user spending more time than strictly needed, if they keep having to replenish their stock of pre-written SIM cards.

The concept retrieves asset information automatically from the AMS. Given the high requirements of security often associated with wireless connection, this might not be the way to go. An organisation might not want to share data and information automatically with a third party such as Ericsson Industry Connect. To counter-argue this, an AMS is usually a third party software as well and they are commonly used. The difference may lay in the fact that the data shared with the AMS is manually entered and freely given. Despite signing up and installing Industry Connect, an organisation might want some control over the information which is shared with Industry Connect. One option to counteract this could be to allow Sam, who manages the AMS, to send or confirm the information that is to be shared with Industry Connect. However, Sam might not know which assets are relevant for Ivar and Industry Connect. Another solution could be to allow Ivar, who also works for the organisation, the possibility to select the assets that he wants imported to Industry Connect. That solution takes away from the ease and automation of the current concept.

7

Conclusion

A research study of the asset management process was conducted in order to understand the persons involved and their needs. A key point was to identify where Industry Connect would enter the process and how it could cooperate and co-exist with the AMS.

The research study of asset management practice provided a load of information useful for the context of Industry Connect, and allowed for six personas to be identified. Based on the problems discovered in the asset management process, it was determined that Industry Connect:

- should not create further identifiers for an asset unless absolutely necessary.
- should be integrated with the AMS in order to minimise the need to manually input asset information which is already registered somewhere else.
- should allow for multiple assets to be registered at the same time, in order to reduce repetitive work.

The main IT persona Ivar, who would manage assets in Industry Connect, would enter the asset management process during the Registration and Setup phase of the journey map created, in figure 5.7. Ivar would however also like to be involved earlier in the process, before an asset is acquired.

The concept development resulted in a concept flow for adding new assets in Industry Connect. The entire flow of the final concept is visualised in figure 5.13. The flow starts with assets and their information being automatically imported to Industry Connect. Then comes the new way of adding SIM cards and connecting assets to the network, where SIM cards can be written in advance if desired. The last part of the flow involves the AMS informing Industry Connect whenever an asset is taken out of use and decommissioned.

An interactive prototype was created of the concept and used for usability testing. Some key learnings from the test are listed below.

- There are two layers in place in Industry Connect: the virtual layer and the reality. The difference, and the interplay between them, needs to be balanced

and apparent to the user.

- Given the complexity of having both a virtual and physical layer of things, it is important that the user gets clear feedback of when they have done something and what they actually did.
- If it is possible to write SIM cards in advance, it should be an incredibly simple process to write several cards at once.
- Given the confusion of the terms Asset, Device and SIM card, distinguishing assets and SIM cards as separate entities is a suggestion for the future.
- A suggestion for further research is how people choose to handle and store pre-written SIM cards at different companies. Would the users of Industry connect prefer additional information about SIM card to facilitate matching the virtual SIM card with its physical manifestation?
- It is important to be consistent when using terms like Device, Asset and SIM card and the defined meanings of these words. Especially when it comes to what people call "things", in reality and virtually. This is also related to the question of whether the customer wants to track data of a SIM card, or data of an asset.

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A

PUGH Matrix

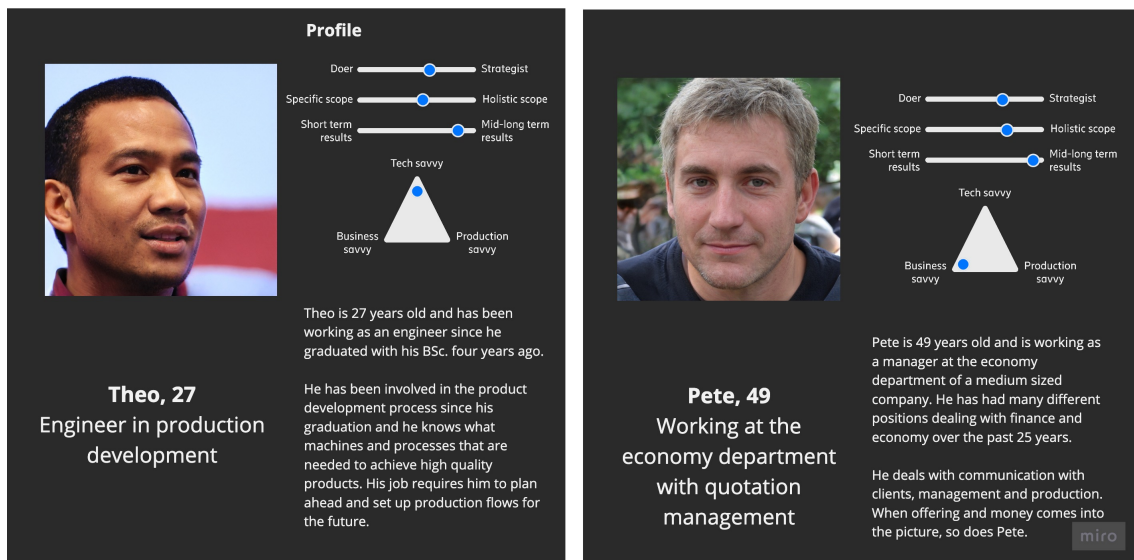
The PUGH matrix created in the project.

	Criteria	Importance	Industry Connect (today)	Automatic Bulk Communication	Phone Capture/ print screen	Slask-APN	Skrut IC -->AMS	Skrut AMS -->IC
Krav/ sta	Connecting X number of assets at once should equal less than the time and effort of connecting one asset X number of times.	5	0	1	-1	1	0	0
	User should be able to identify an asset using the main identifier in the company's systems.	3	0	1	1	1	1	1
	Numerical identifiers which are not being used as an ID number, should be displayed as additional information about the asset	1	0	0	0	0	0	0
	Prevent the user from using different variants of the same name	3	0	1	1	0	0	0
	User should be able to select the same name for an asset in Industry Connect's Network Management Portal as the asset is named in the company's Asset Management System	3	0	1	1	0	0	0
	Solution should minimize the risk of typos and other human errors	1	0	1	1	0	1	1
	Permission levels for Industry Connect's Network Management Portal should be compatible with permission levels in the company's Asset Management System	2	0	0	0	0	0	0
	Solution should be able to communicate with software systems which are managing the same assets, albeit for other purposes	5	0	1	1	1	1	1
	When setting up/disabling a new asset, the different systems should cooperate in order to make the process easy.	5	0	1	0	1	1	1
	Solution should display the hierarchical relationships between assets	3	0	0	0	0	0	0
Sam / Bo	Needs to know when an asset is ready be scrapped - that all necessary steps have been taken	5	0	0	0	0	1	1
	Needs a way to tell IT when an asset is paused	3	0	0	0	0	1	1
Moa/ Theo	Wants information in the right/consistent format	3	0	1	1	0	1	1
	Wants close collaboration across teams/departments	4	0	1	-1	1	1	1
	Wants to be up to date with IT technology -> Wants Ivar to have what he needs	3	0	0	0	1	0	0
Ivar	Assets connected to the network must be secured	5	0	0	0	1	0	0
	Assets must be disconnected from the network securely	4	0	0	0	0	1	1
	Wants assets to be added in bulk	4	0	1	1	1	0	0
	Needs to know which asset and where it is to troubleshoot issues if	3	0	0	0	0	0	0
	Would benefit from receiving asset info automatically	4	0	1	1	1	0	1
	Needs registering and connecting assets to be easy	3	0	1	1	1	1	1
	fun concept	4	0	1	1	1	0	1
Us	Innovative	3	0	0	1	1	1	1
	fits Ericsson	4	0	1	0	1	1	1
	workable idea	5	0	1	0	1	0	1
	Needs to know when an asset is ready be scrapped - that all necessary steps have been taken	5	0	0	0	0	0	1
Pete								
		Sums:	0	15	9	14	12	16
		Weighted Sums	0	56	27	71	55	59

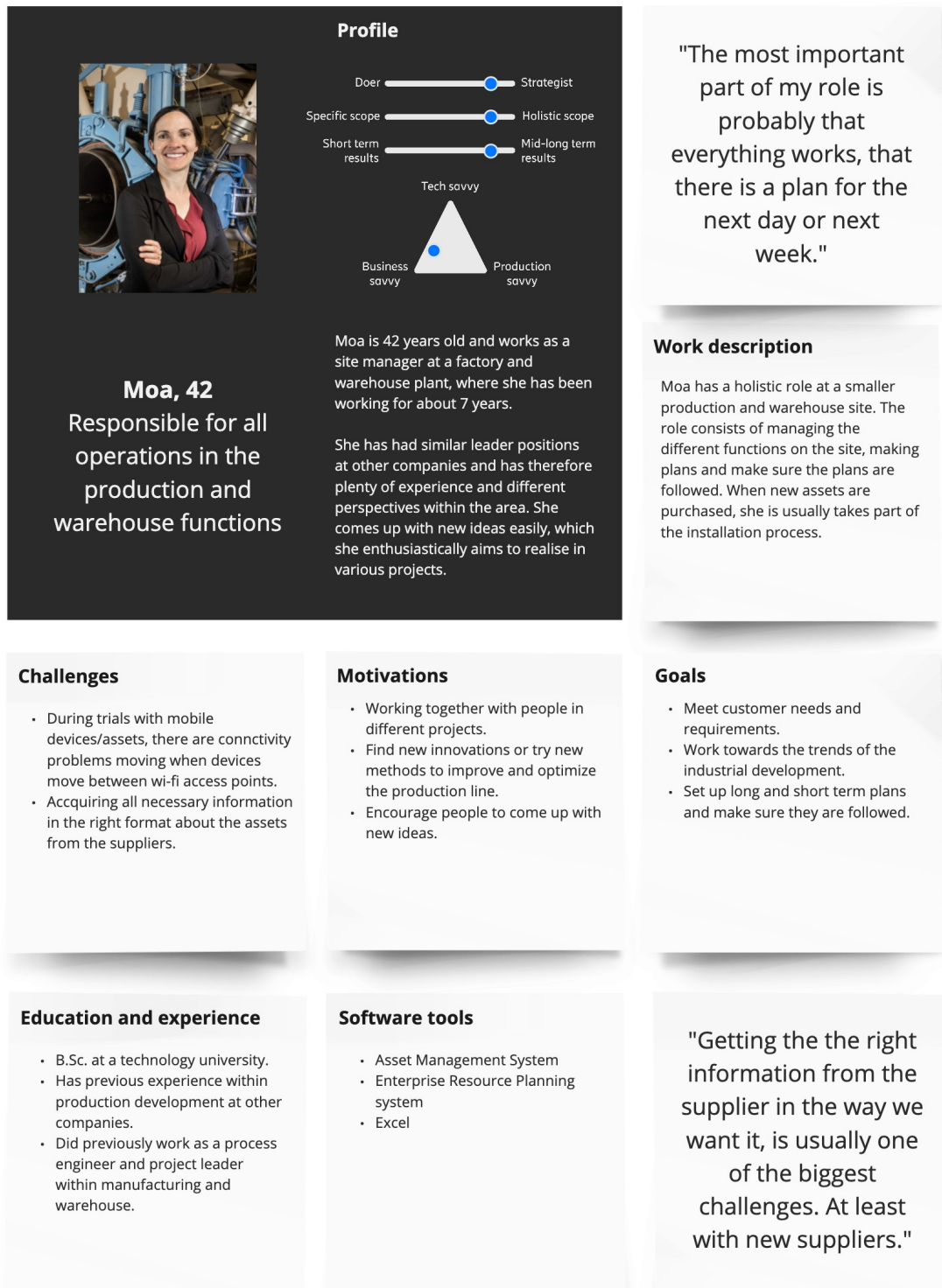
B

Personas

Six personas were created in the project.

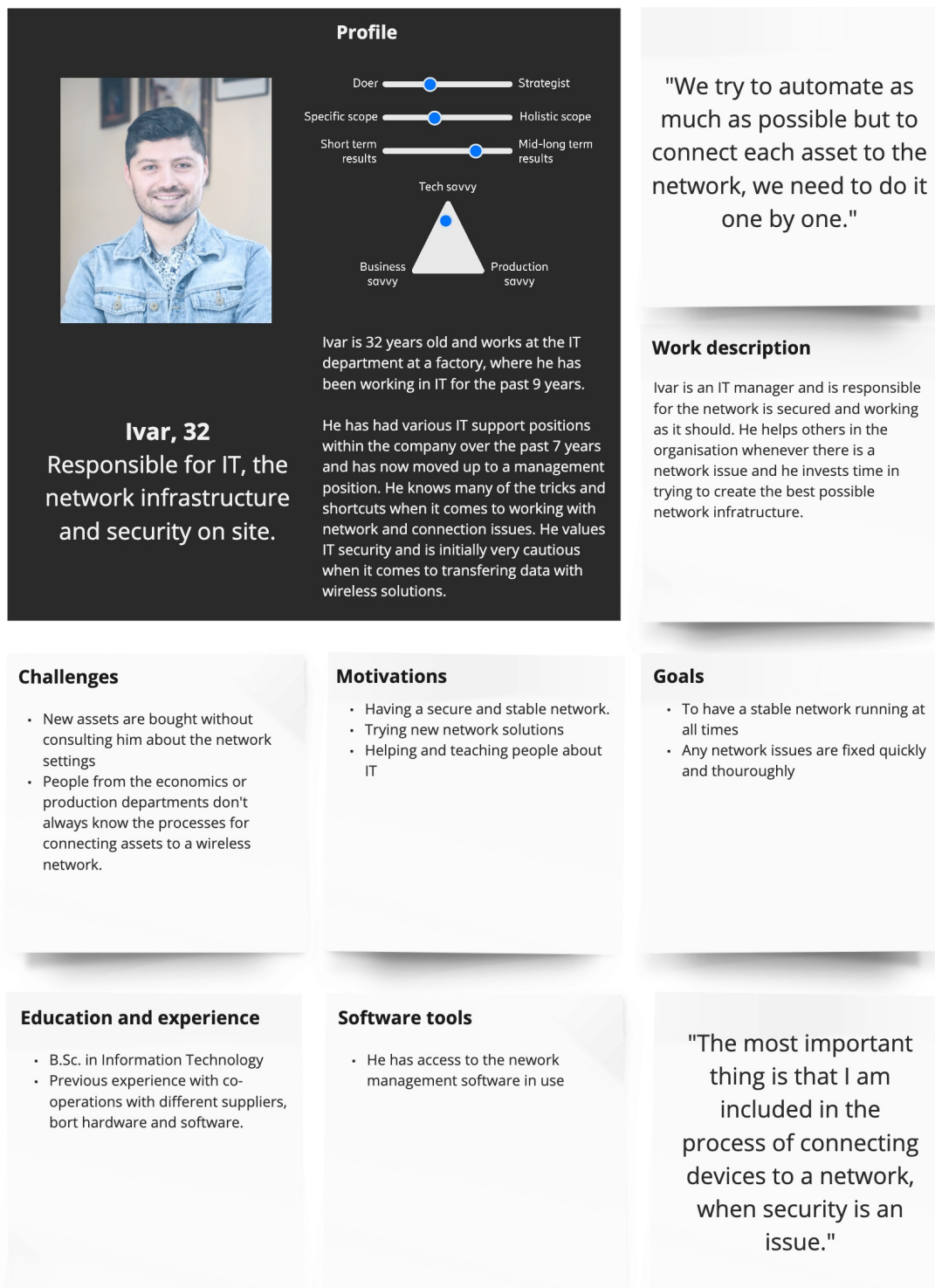


Engineer Theo and economy manager Pete.



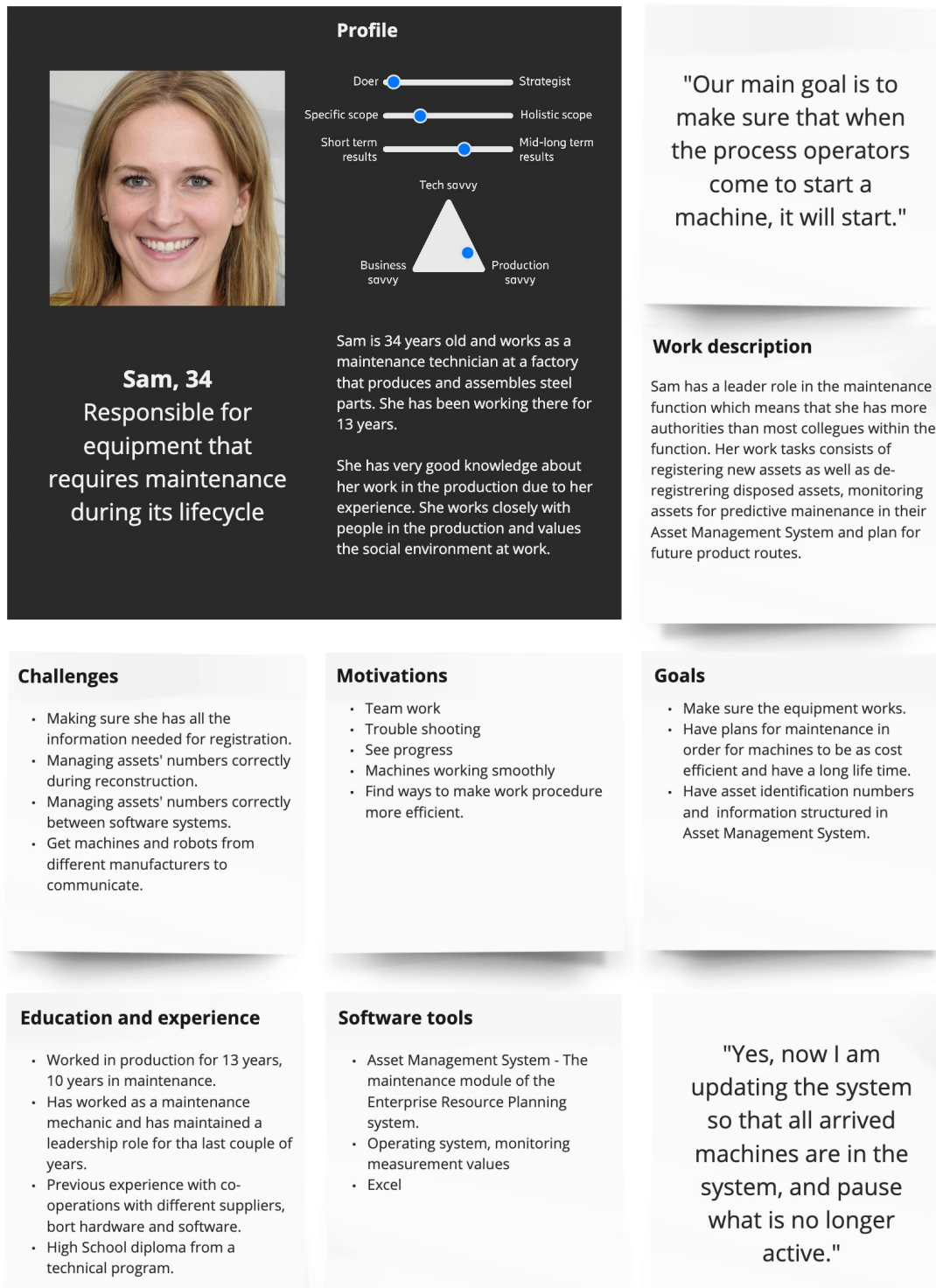
miro

Manager Moa.



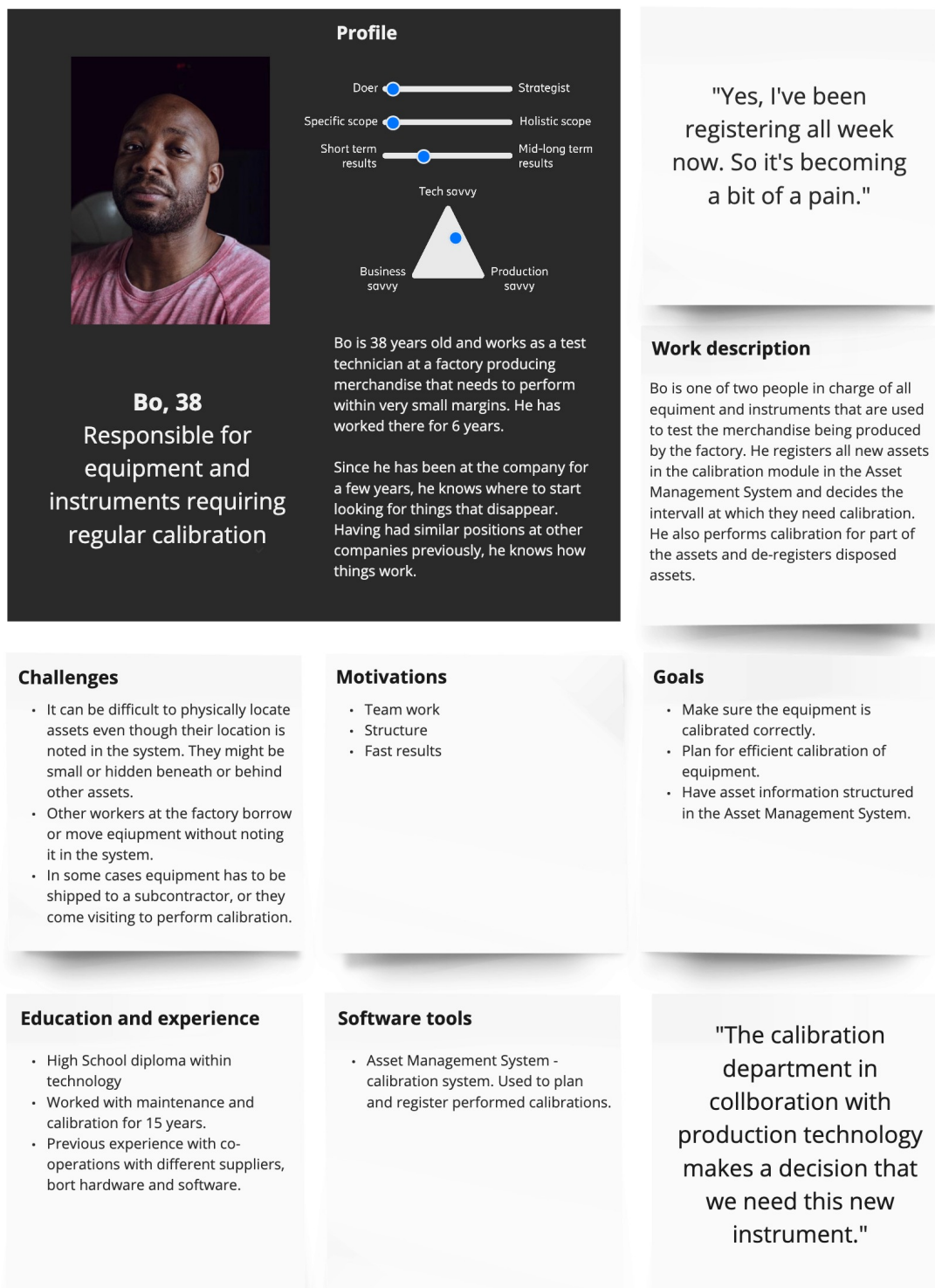
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IT manager Ivar.



miro

Maintenance manager and registrar Sam.

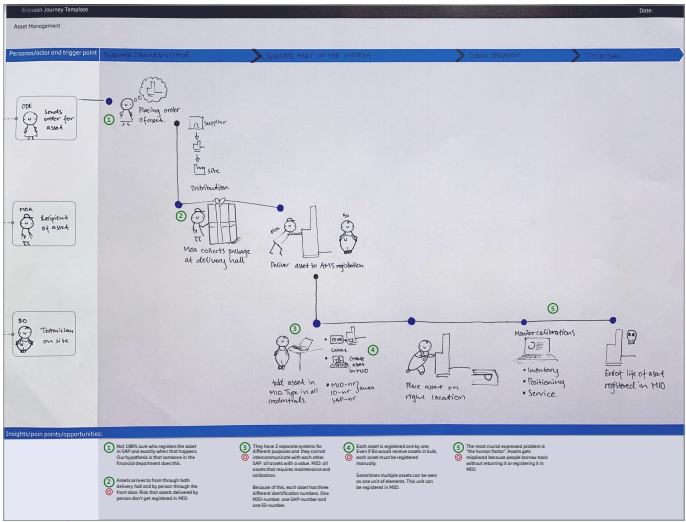


miro

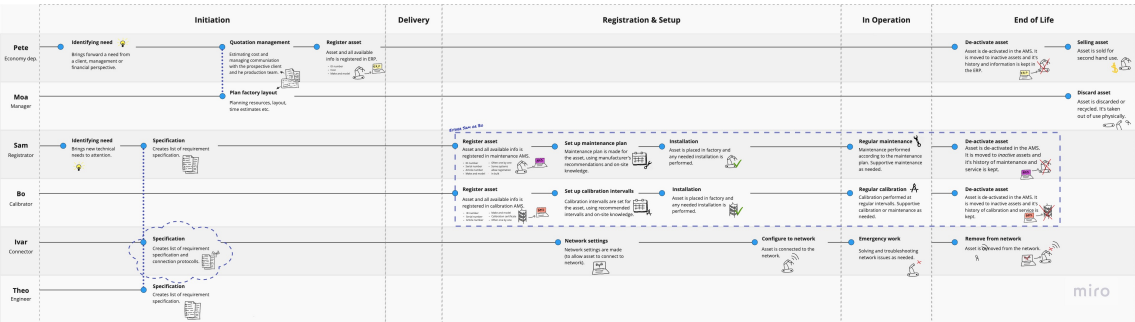
Calibrator Bo.

C

Journey Maps



The journey map constructed from the pilot study.



The journey map compiled from all visited companies.

D

List of requirements

Integration

1. Ericsson Industry Connect should be able to receive data from Asset Management Systems on the market.
 - 1.1. Solution should enable accessing asset information from the Asset Management System in a secure manner.
2. Solution should be able to import asset information automatically from the AMS.
 - 2.1. Asset information includes: asset name, serial number and IMEI (if existing).
 - 2.2. Solution should be equipped with a filter, to only allow wanted assets to be imported.
3. Solution should receive information automatically, when an asset is deactivated in the AMS.
 - 3.1. Solution should remind users to collect the physical SIM card from the asset.

Registration

4. Solution should enable the user to connect multiple assets at once.
 - 4.1. Connecting X number of assets at once should be less than, or equal to, the time and effort of connecting one asset X number of times.
5. Solution should enable consistent identification of an asset.
 - 5.1. An asset should be identifiable using its name, serial number and IMEI (if existing).
6. Solution should provide consistent naming for the assets in the system.
 - 6.1. Solution should use the same name for an asset in Industry Connect's Network Management Portal as the asset is named in the company's Asset Management System.
 - 6.2. Solution should prevent the user from using different variants of the same name.
 - 6.3. Solution should minimize the risk of typos and other human errors.

SIM cards

7. Solution should allow users to write SIM cards in advance, without immediately adding it to an asset.
 - 7.1. Solution should by default place pre-written SIM cards in a secure APN that has no access to the network.
 - 7.2. When connecting an asset with a pre-written SIM card, the Solution should check if that asset's serial number/IMEI is registered in the AMS, in which case the APN should be changed automatically to one with internet access.
8. Solution should allow users to mix pre-written SIM cards with writing new SIM cards when connecting multiple new assets at once.
9. Solution should allow for easy handling of SIM cards.
 - 9.1. Solution should make it easy to relate the physical sim cards with their digital representation in Industry Connect.
 - 9.2. A SIM card should be identifiable using its ICCID and IMSI.

Ericsson

10. Solution should follow Ericsson Design System guidelines.
 - 10.1. Solution design should be coherent with the rest of Industry Connect's design, flow and layout.
11. Solution must be technically viable.
12. Solution must use SIM cards to connect devices to Industry Connects Network.

Other

13. Users should be able to navigate and find desired assets in Industry Connect's Network Management Portal.
 - 13.1. Solution should display the hierarchical relationships between assets.
14. Solution should enable collaboration between IT, production and strategic teams during set up of new assets.
15. Solution should provide different permission levels for security reasons
 - 15.1. Permission levels for Industry Connect's Network Management Portal should be compatible with permission levels in the company's Asset Management System